

SPECIFICATION TD-101/7
REVISION No.7
150 kV COMBINED INSTRUMENTS TRANSFORMERS

index	Brief Description of Revision 7	Paragraph
1.	<u>Additional requirement for the secondary terminals box</u>	§ VII.10

I. SCOPE

This hereby technical description covers IPTO's requirements regarding design features, technical characteristics and testing of single-phase, oil-immersed, outdoor, 150 kV combined transformers.

II. KEY WORDS

Combined transformers, instrument transformers, measurement transformers.

III. STANDARDS

The combined transformers shall conform to the latest edition of IEC 61869-1, 61869-2, 61869-3, 61869-4 standard.

IV. USE

The combined transformers will be used for protection and metering clearing purposes, between Transmission and Distribution for 150 kV Transformer bays in 150/20 kV air insulated substations.

V. OPERATING CONDITIONS

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

VI. IPTO's 150 kV ELECTRIC SYSTEM CHARACTERISTICS

1. Nominal Voltage (phase to phase) : 150 kV
2. Maximum Operating Voltage (phase to phase): 170 kV
3. Nominal frequency : 50 Hz
4. Short Circuit level : 31,5 kA
5. Basic Insulation level : 750 kV
6. The Earthing (grounding) Method : The neutral is solidly
7. Number of phases and wires : 3-phase – 3-wire system

VII. REQUIRED DESIGN FEATURES OF THE COMBINED TRANSFORMERS

1. Type
Outdoor, single-phase, oil immersed combined transformers as below:

- 1.1 Current circuit

One (1) primary winding with two (2) sections and secondary windings in accordance with the **ATTACHMENT A, unless otherwise defined in the INQUIRY** for metering and protection purposes, each with its own magnetic core as shown Fig No 1 below (indicatively, for 3 secondary windings):

- 1.2 Voltage circuit

One (1) primary winding and) secondary windings in accordance with the **ATTACHMENT A, unless otherwise defined in the INQUIRY** for metering and protection purposes, as shown in Fig No 1 below (indicatively, for 2 secondary windings)

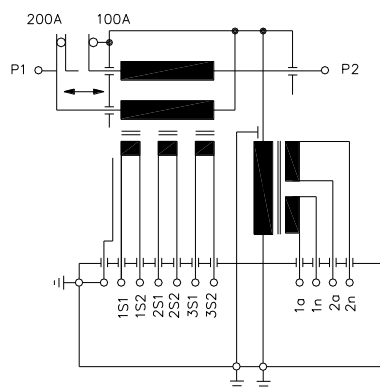


Fig. No. 1

2. Ratio
As indicated in the attachment “A”.
3. Secondary Windings
The number of secondary current and voltage windings, the purpose, the output power and the accuracy class, shall be as indicated in attachment “A” unless otherwise defined in the Inquiry.
4. Primary windings
The primary winding of the combined transformer for the current circuit, shall consist of two sections and shall be installed at the higher part of the transformer with the rating current as indicated in attachment “A”.
The primary winding of the combined transformer for the voltage circuit must be located at the lower part of the transformer and not along of the inside part of the transformer housing.
The rated voltage shall be indicated in attachment “A”.
5. Housing (enclosure) of the Combined transformer
The housing which serves as insulator shall either be of high grade porcelain of one piece, free from cracks, flows or blemishes and grazed over all exposed surfaces or of silicon rubber. The porcelain housing shall comply in all relevant respects with IEC-60233. "Test on hollow insulators for use in electrical equipment". The silicon rubber housing shall be in accordance with IEC-61462 "Composite insulators – Hollow insulators for use in outdoor and indoor electrical equipment".
6. Creepage distance of the Housing
The creepage distance of the housing shall be ≥ 4250 mm.
7. Insulating Oil
Only mineral oil shall be used and which must be non-toxic and biodegradable. The insulating oil shall be in accordance with the latest version of IEC publication 60296, for transformer oil. The use of toxic insulating agents such as PCBs or PCT's etc is prohibited.
8. Oil-expansion bellows and sealing
The combined transformer interior shall be filled with insulating oil and shall be also hermetically sealed against humidity.
Any oil volume changes due to temperature fluctuations shall be accommodate by appropriate expansion of the bellows (metallic bellows are preferred) located on the head of the combined transformer .
The sealing of the transformer shall be ensued by welding (welded type transformer), or through suitable sealing ring (O-RING) with proven long life and resistance to insulating oil, ultraviolet radiation and temperature within the limits of par. V.
The sealing strength of the transformer shall be confirmed through the appropriate test which shall be proposed by the manufacturer.
9. Primary Terminals
The primary terminals shall be of copper, cylindrical in shape with a 30 mm in diameter and with a minimum of 80 mm in length. These terminals shall be placed horizontally and diametrically opposite on the combined transformer head.

10. Secondary terminals box

For the secondary terminals box, it should be anticipated the existence of two (2) separated compartments of the terminal box, one for the secondary metering circuits and one for the secondary protection circuit so that they can be sealed separately. The compartments will be situated on the same side of the combined transformer. The terminals shall consist of threaded stubs fitted with nuts and washers. The bottom plate of the secondary terminals' box shall be furnished without holes but has to be easily drilled. Moreover the bottom plate of it shall be sufficiently large to bear three (3) cable glands suitable for a cable of $4 \times 4 \text{ mm}^2$, $\varnothing 21 \text{ mm}$. The terminals shall be easily accessible and shall be suitable to be wired with conductors of 4 mm^2 . All secondary phase leads of voltage windings shall be protected by 6 A fuses and the neutral leads by links. It shall be possible to short circuit one of these fuse elements easily in the terminal compartment. It shall be possible to connect the neutral sides of all secondary windings to the ground easily. For this purpose one grounding screw shall be available in the compartment.

The secondary winding terminals shall be located in a weatherproof hot-dip galvanized box, made either of steel or a different kind of non-corrosive metal, which will be mounted on the metallic base of the transformer. The terminal box shall have protection degree IP55.

11. Metal frame (case) parts

Apart from the primary terminals all other frame (case) metal parts shall either be of hot-dip galvanised steel or non-corrosive metal.

12. Installation

The combined transformer shall be suitable for installation on a steel structure.

13. Requirements of seismic qualification

- a. Seismic qualification of the combined transformers shall be in accordance with the IEC-61463 and IEC-60068-3-3
- b. The combined transformers shall be withstood the following seismic stresses:
 1. Horizontally (axes x and y): $0,5g$ (5 m/s^2)
 2. Vertically (axe z) : $0,25g$ ($2,5 \text{ m/s}^2$)
- c. The frequency range should be 1 Hz to 35 Hz.
- d. Acceptable methods of seismic qualification are:
 1. Qualification by vibration test or
 2. Qualification by static calculation or
 3. Qualification by dynamic analysis
- e. Bidders are obliged to submit in their offers, test reports or calculation by dynamic analysis, or static calculation.
Approval or not of all the above lies on IPTO's judgment.

15. Accessories

Each Combined transformer shall be equipped with the following:

- Oil level indicator
- Oil-filling plug
- Oil-drain plug
- Lifting lugs
- Grounding (earthing) terminal for grounding the frame (case)
- A special terminal for measuring $\tan\delta$, which shall be short-circuited during normal operation.

VIII. REQUIRED RATING CHARACTERISTICS OF THE COMBINED INSTRUMENT TRANSFORMERS

For current metering purposes

- | | |
|---|----------------------------------|
| 1. Primary rated current I_N | : As indicated in Attachment "A" |
| 2. Secondary rated current | : As indicated in Attachment "A" |
| 3. Number of secondary windings | : As indicated in Attachment "A" |
| <u>unless otherwise defined in the INQUIRY</u> | |
| 4. Rated Voltage (phase-to-phase) | : 150 kV |
| 5. Highest Voltage | : 170 kV |
| 6. Rated continuous thermal current | : $1.2 I_N$ |
| 7. Rated Output of secondary windings | : As indicated in Attachment "A" |
| <u>unless otherwise defined in the INQUIRY</u> | |
| 8. Rated short-time thermal current (I_{th}) | : 40 kA |
| 9. Rated dynamic current (I_{dyn}) | : 100 kA |

For voltage metering purposes

- | | |
|---------------------------------|------------------------------------|
| 1. Primary rated voltage | : As indicated in
Attachment A. |
| 2. Secondaries rated voltage | : As indicated in
Attachment A. |
| 3. Number of secondary windings | : As indicated in
Attachment A. |

unless otherwise defined in the INQUIRY

- | | |
|---------------------------------------|------------------------------------|
| 4. Rated output of secondary windings | : As indicated in
Attachment A. |
|---------------------------------------|------------------------------------|

unless otherwise defined in the INQUIRY

- | | |
|--------------------------|---|
| 5. Rated voltage factors | : 1.2 continuous
1.5 for 30 seconds. |
|--------------------------|---|

IX. OTHER RATING CHARACTERISTICS OF THE COMBINED INSTRUMENT TRANSFORMERS

1. Rated frequency	: 50 Hz
2. Temperature category	: -25/45 °C
3. Limits of the temperature rise of the windings	: 65 °C
4. Rated power-frequency withstand voltage of the primary winding	: 325 kV rms
5. Minimum creepage distance of the housing	: ≤4250 mm
6. Rated power-frequency withstand voltage of the secondary windings	: 3 kV rms
7. Rated lightning impulse withstand voltage of the primary winding	: 750 kV (peak)
8. Chopped lightning impulse withstand voltage of the primary winding	: 863 kV peak
9. Transmitted overvoltage limit	: ≤1.6 kV (peak) at pulse of 222 kV (peak)
10. Dielectric dissipation factor ($\tan\delta$)	: ≤0.005 at 10 kV – 98 kV
11. Partial discharge level	: ≤5 pC at 118 kV
12. Static loading withstand	: 3000 N
13. Radio interference voltage level (R.I.V)	: ≤2500 μV at 108 kV

X. TESTS

All testing shall be in accordance with IEC 61869-1, 61869-2, 61869-3, 61869-4 standards:

A Routine Tests

1. Verification of terminal markings
2. Power-frequency withstand test on primary winding
3. Partial discharge measurement
4. Power-frequency withstand test on secondary windings
5. Power-frequency withstand tests between sections of primary and secondary windings
6. Inter-turn overvoltage test
7. Determination of errors (This test shall be performed after the other six (6) tests)

B Type Tests

1. Short – time current tests
2. Temperature rise test
3. Lightning impulse test
4. Wet test for outdoor type combined transformers
5. Determination of errors
6. Short – circuit withstand capability test
7. Measurement of the radio interference Voltage (RIV)

C Special Tests (on one combined transformer of the order)

1. Chopped lightning impulse test
2. Measurement of capacitance and dielectric dissipation factor
3. Mutual influence test between current and voltage transformers
4. Measurement of transmitted overvoltage
5. Mechanical tests

6. Tightness test

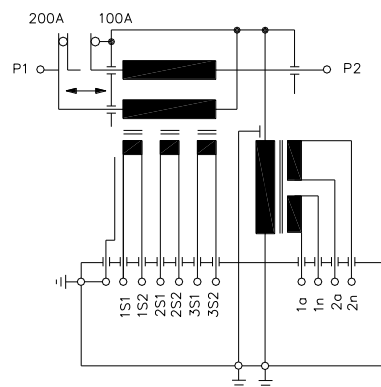
The tightness test shall be performed with a pressure of the oil at least 1 bar higher than the maximum operating pressure during normal service conditions and at a temperature of 80°C for 8 hours.

Alternatively an equivalent tightness test can be performed, subjected to IPTO's approval, provided that the test procedure will be submitted with the bid.

XI. MARKINGS

A. Terminal Markings

The terminal markings shall indicatively be as indicated below:



B. Rating Plate markings

All Combined transformers shall bear a plate of non-corrosive material with the following markings:

1. The manufacturer's name
2. Serial number and type
3. Rated primary and secondary current
4. Rated frequency
5. Rated output and corresponding accuracy class for the secondary windings
6. The highest voltage
7. The rated insulation level (impulse level)
8. The rated short-time thermal current
9. The rated dynamic current
10. Rated primary and secondary voltage
11. Rated Voltage factor

XII. DATA TO BE SUBMITTED BY BIDDERS

1. All bidders must provide all information requested in "ATTACHMENT B" of this hereby specification. Failure on 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 offered combined transformers, which will help the technical evaluation process.
3. Technical data for the oil used in the combined transformers.
4. Drawings showing the outline dimensions of the combined transformers offered and other information deemed necessary, including terminal markings.
5. Any type test certificates for the type and special tests specified in this hereby specification.

XIII. DATA TO BE SUPPLIED 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 combined transformer construction. The drawings shall include outline dimensional drawing, detail base drawing, wiring drawing and terminal marking drawing. The outline drawing shall include all necessary information, which will enable IPTO to construct the combined transformer support steel structure.

The supplier shall submit the final "as manufactured" drawings in digital format, as follows:

a) The 3D model of the complete equipment shall be submitted in Autodesk AutoCAD format (dwg file), using 3D solids modelling. Alternatively, the 3D model can be submitted in Entegra Primtech 3D format. The 2D drawings of the equipment shall be also submitted in Autodesk AutoCAD format (dwg files), but also in Adobe Acrobat format (pdf files).

b) The wiring drawings of the equipment shall be submitted in Autodesk AutoCAD format (dwg files), using attributed symbol blocks and attributed title block on every page, following IEC standards for the symbols and the design. Alternatively, the wiring drawings shall be submitted in Autodesk AutoCAD / Electrical Toolset project format, following IEC standards. The wiring drawings shall be also submitted in Adobe Acrobat format (pdf files).

All the above Autodesk AutoCAD drawings should be open for editing and preferred to be submitted with digital sign by the manufacturer.

IV. PACKING

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

Each wooden box will include one (1) transformer and all necessary assembling material (if applicable).

V. WARRANTY

The Supplier must provide a warranty for “good operation” of three (3) years beginning from the date of delivery of the transformers. In addition, a warranty of four (4) years for the bellows and the sealing of the connections between housing and metal parts must also be provided.

ATTACHMENT A
150 kV COMBINED INSTRUMENT TRANSFORMERS

(UNLESS OTHERWISE DEFINED IN THE INQUIRY)

I. Current Transformer requirements

- 1. Ratio : 100-200/1-1-1-1-1 A
- 2. Primary current : 100-200 A
- 3. Secondary current : 1 A
- 4. Number of secondary windings : 5

5. Accuracy class and rated output of the secondary windings

a) For the first winding used for metering (1S1 – 1S2)

- Rated output : 30 VA
- Accuracy class : 0.2S
- Instrument security factor : FS≤5

b) For the second winding used for metering (2S1 – 2S2)

- Rated output : 40 VA
- Accuracy class : 0.2S
- Instrument security factor : FS≤5

c) For the third winding used for metering (3S1 – 3S2)

- Rated output : 40 VA
- Accuracy class : 0.2S
- Instrument security factor : FS≤5

d) For the first winding used for protection (4S1 – 4S2)

- Rated output : 30 VA
- Accuracy class : 5P
- Accuracy limit factor : 20

e) For the second winding used for

protection (5S1 – 5S2)

- Rated output : 30 VA
- Accuracy class : 5P
- Accuracy limit factor : 20

2. Voltage Transformer requirements

1. . Ratio

$$\frac{160.000}{\sqrt{3}} V / \frac{120}{\sqrt{3}}, \frac{120}{\sqrt{3}}, \frac{120}{\sqrt{3}}, \frac{120}{\sqrt{3}} V$$

2. . Primary voltage : $\frac{160.000}{\sqrt{3}} V$

3. . Secondary voltage : $\frac{120}{\sqrt{3}} V$

4. . Number of secondary windings : 4

5. Accuracy class, rated output, percentage voltage error of the secondary windings.

1. For the first winding used for metering (1a-1n)

- Rated output : 25 VA
- Accuracy class : 0.2
- Percentage voltage error : $\pm 0.2\%$
- Phase displacement : ± 10 min

2. For the second winding used for metering (2a-2n)

- Rated output : 50 VA
- Accuracy class : 0.2
- Percentage voltage error : $\pm 0.2\%$
- Phase displacement : ± 10 min

3. For the third winding used for metering (3a-3n)

- Rated output : 25 VA
- Accuracy class : 0.2
- Percentage voltage error : $\pm 0.2\%$
- Phase displacement : ± 10 min

4. For the winding used for protection (4a-4n)

- Rated output : 10 VA
- Accuracy class : 3P
- Percentage voltage error : $\pm 3.0\%$
- Phase displacement : ± 120 minutes

“ATTACHMENT B”
150 kV COMBINED INSTRUMENTS TRANSFORMERS

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

1. Type and manufacture :
2. Current metering data
 - a. Ratio :
 - b. Primary rated currents :
 - c. Secondary rated current :
 - d. Rated continuous thermal current :
 - e. Number of secondary windings :
- 1st secondary winding used for metering
 - Rated output :
 - Accuracy class :
 - Instrument security factor :
- 2nd secondary winding used for metering
 - Rated output :
 - Accuracy class :
 - Instrument security factor :
- 3rd Secondary winding used for metering
 - Rated output :
 - Accuracy class :
 - Accuracy limit factor :
- 4th Secondary winding used for protection
 - Rated output :
 - Accuracy class :
 - Instrument security factor :
- 5th Secondary winding used for protection
 - Rated output :

– Accuracy class	:	
– Accuracy limit factor	:	
3. Voltage metering data		
a. Ratio	:	
b. Primary rated voltage	:	
c. Secondary rated voltage	:	
d. Rated voltage factors	:	
e. Number of secondary windings	:	
<u>1st Secondary winding used for metering (1a-1n)</u>		
– Rated output	:	
– Accuracy class	:	
– Percentage voltage error	:	
– Phase displacement	:	
<u>2nd Secondary winding used for metering (2a-2n)</u>		
– Rated output	:	
– Accuracy class	:	
– Percentage voltage error	:	
– Phase displacement	:	
<u>3rd Secondary winding used for metering (3a-3n)</u>		
– Rated output	:	
– Accuracy class	:	
– Percentage voltage error	:	
– Phase displacement	:	
<u>4th Secondary winding used for protection (4a-4n)</u>		
– Rated output	:	
– Accuracy class	:	
– Percentage voltage error	:	
– Phase displacement	:	
4. Rated frequency	:	
5. Temperature category	:	

6. Rated short – time thermal current (I_{th}) :
7. Rated dynamic current (I_{dyn}) :
8. Limits of the temperature rise of the windings :
9. Rated power-frequency withstand voltage
of the primary winding :
10. Rated power-frequency withstand voltage
of the secondary windings :
11. Rated lightning impulse withstand
voltage of the primary winding :
12. Chopped lightning impulse withstand
voltage of the primary winding :
13. Transmitted overvoltage :
14. Dielectric dissipation factor ($\tan\delta$) :
.....
15. Partial discharge level :
16. Static loading withstand :
17. Type of housing
(porcelain or silicon rubber) :
18. Greepage distance of the housing :
19. Type of insulating oil :
20. Type of oil-expansion bellows and sealing :
21. Is the sealing of the transformer ensured by
welding (welded type transformer)
or through “O-RING” ? :
.....
22. Description of the primary terminals in detail :
23. Description of the secondary terminal box :
24. Description of the metal frame parts :
25. Installation :
26. Is seismic test certificates or seismic study supplied? :
27. Radio interference voltage :

28. Are the phase and neutral secondary leads
protected by 6 A fuses and links respectively? :
29. Are the terminals in the box of the secondaries
of the screw-type and suitable to be wired
with 4 mm² size conductors? :
30. Total height of the combined transformer :
31. Weight of oil :
32. Total weight of the combined transformer :
33. Does the Supplier provide a warranty
according to par. V? :
34. Will the package of the transformers follow the
requirements of par. IV of this hereby specification? :