सत्यमेव जयते

भारत सरकार, GOVERNMENT OF INDIA
रेल मंत्रालय, MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION FOR

Gas Chromatograph for analysis of dissolved gas in Transformer Oil

Specification No. TI/SPC/PSI/GASCHR/0250

This specification supersedes the specification no. ETI/PSI/105(07/93)

		हस्ताक्षर/Signature
अनुमोदित Approved By	प्रधान कार्यकारी निदेशक (कर्षण संस्थापन) Principal Executive Director (TI)	
अनुशंसित Recommended By	कार्यकारी निदेशक (कर्षण संस्थापन) Executive Director (TI)	

जारीकर्ता/**Issued By**
कर्षण संस्थापन निदेशालय
TRACTION INSTALLATION DIRECTORATE
अनुसंधान अभिकल्प और मानक संगठन
RESEARCH DESIGNS & STANDARDS ORGANISATION
मानक नगर, लखनऊ - 226011
MANAK NAGAR, LUCKNOW-226011.

NOTE: (i) This Specification is the property of RDSO. No re-production shall be done without the permission of DG(TI) /RDSO.
(ii) All Clauses of this Specification shall be enforced from cutoff date …….

	द्वारा तैयार/ Prepared By	द्वारा जाँचा गया/ Checked By	द्वारा जारी किया गया/ Issued By
हस्ताक्षर/ Signature			
Designation	SSE/TR	ADE/TI-III	DTI/3

DRAFT

INDEX

DRAFT

1.0 **Forward**

1.1 Gas Chromatography is a method widely used for detecting various types of dissolved gases in the insulating oil of oil-filled equipments, identifying the concentration of these gases to interpret the incipient faults and to adopt preventive measures before the transformer fails under energized conditions.

1.2 In order to facilitate initial procurement and installation of the instrument, Specification No. ETI/PSI/105(7/93) for Gas Chromatograph was issued by the Traction Installation Directorate of RDSO.

1.3 In view of more technical advancement in the field of dissolved gas analysis, this Specification No. TI/SPC/PSI/GASCHR/0250, which incorporates the latest Data on Gas Chromatograph and its requirements, supersedes the earlier specification no. ETI/PSI/105(7/93).

2.0 Scope:

2.1 It is to be noted that "The 'Make in India' Policy of the Government of India shall be applicable."

2.2 ~~This specification applies to gas chromatograph for analysis of dissolved gasses both organic and inorganic, in the transformer oil.~~ This specification applies to the constructional and technical requirements of the Gas Chromatograph, including associated detection devices and accessories.

2.3 Gas Chromatograph/Transformer Oil Gas Analyser should be suitable for performing the analysis of gases extracted from Transformer oil. The results shall be printed out.

3.0 Governing Specifications:

3.1 Assistance has been taken from the following standards, codes of practices, etc. in preparation of this specification.

SN	Standard No.	Description
i.	IS: 9434 ~~1992~~ 2019	~~Guide for sampling and analysis of free and dissolved gases in oil from oil filled electrical equipment~~ Oil Filled Electrical Equipment — Sampling of Gases and Analysis of Free and Dissolved Gases
ii.	IS: 10593, ~~1992~~ 2023	~~Method of evaluating the analysis gases in oil filled electrical equipment in service.~~ Mineral Oil-Filled Electrical Equipment in Service — Guidance on the Interpretation of Dissolved and Free Gases Analysis
iii.	~~IEC:599-1978~~ IEC: 60599 (2022-05)	~~Interpretation of analysis of gases in transformers and other oil filled electrical equipment in service~~ Mineral Oil-filled Electrical Equipment in service – Guidance on the interpretation of dissolved and free gases analysis.
~~iv.~~	ASTM D 3612-02 (Reapproved 2009)	Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography

4.0 Environmental & Operating Conditions

4.1 The instrument shall be suitable for indoor use and operate satisfactorily in coastal areas under normal polluted atmospheric conditions, subjected to normal vibrations and shocks

DRAFT

encountered in a machine testing shop. It shall operate satisfactorily up to a temperature of ~~40~~ 50^{0}C and relative humidity of 100%.

5.0 General requirements

5.1 Micro-processor-based equipment with self-diagnostic facilities shall be provided with a front panel touchscreen of at least 7 inches for DGA functionality.

5.2 The instrument should have a self-diagnostic feature available on the touchscreen of analyzer. It should provide an alarm for the same. The manual must provide comprehensive fault analysis.

5.3 The Alarms on the Touchscreen shall be provided for failure or incorrect functioning of any critical components of the equipment. The alarm can be acknowledged, but it shall remain till alarm conditions are mitigated and faults are addressed.

5.4 Data logging and storage should be possible using a laptop or desktop PC. A suitable laser-jet printer (B&W) should be provided with the DGA.

5.5 All faults shall be logged in the system and can be seen on the touchscreen.

5.6 Whenever fuses are used for protection of the instrument, they should have LED indicators to communicate their status.

6.0 ~~Constructional Features~~ Technical Requirements

6.1 The instrument shall be operated ~~off~~ by single-phase, 230V, 50Hz AC supply that may vary by +10% and -15% of rated voltage. Protection against high voltage shall be provided in the form of ~~blow off fuse,~~ appropriate MOV (Metal Oxide Varistors).

6.2 The equipment shall be a compact unit with three-column Gas Chromatography with Single Flame Ionisation Detector (FID) and two Thermal Conductivity Detectors (TCD).

6.3 The detector modules, power supply units, and all should be in a single compact unit. The unit should be designed to analyze the gases like Hydrogen (H_2), Oxygen (O_2), Nitrogen (N_2), Carbon dioxide (CO_2), Carbon monoxide (CO), Methane (CH4), Ethane (C2H6), Ethylene (C2H4), Acetylene (C2H2), Propane (C3H8) and Propylene (C3H6) at ambient temperature. The Gas Circuit should be designed to have four separate inlet connections for carrier gases and fuel gases. Only one recorder would be used by inter-charging the connecting leads with the help of a selector switch. To ensure sturdy and leak-proof operation, stainless steel gas tubing connections are preferred for the internal gas circuit.

6.4 The sensitivity of the apparatus should be able to detect the following minimum concentration of dissolved gases.

i. Hydrogen : 05 ppm
ii. Hydrocarbon : 01 ppm
iii. Carbon monoxides : 25 ppm
iv. Carbon dioxides : 25 ppm

6.5 The equipment shall consist of the following;

6.5.1 Flame Ionisation Detectors (FID):

DRAFT

~~a) Single Flame Ionisation Detector connected to 40/60 mesh silica gel column of 2m long and 3mm diameter. Stainless steel construction is preferred. It should have minimum two pressure gauges and two flow control needle valves – one each for hydrogen and carrier.~~

~~b) One Injection Port.~~

Parameters	Requirement
Operating Temperature	Ambient to 250 °C
Temp. accuracy	± 0.5 % of set value

6.5.2 Thermal Conductivity Detectors (TCD):

~~In these detectors, both the filaments arte not connected to the column. Only one filament is connected to the column and the other filament will have only gas passing through it through a flow control valve.~~

~~a) The first detector will have a stainless steel (SS) 80/100 mesh Porpak column of 2m long and 3mm diameter.~~

~~b) The second detector will have a SS column of 80/100 mesh activated charcoal, of 2 m long and 3mm diameter. A suitable column to analyse carbon monoxide also should be supplied as spare.~~

~~c) Two injection ports.~~

Parameters	Requirement
Operating Temp.	Ambient to 200 °C Minimum
Temp. accuracy	± 0.5 % of set value

6.5.3 **Column Details**

Column 1	Porapak N, 3 m length X 3mm diameter
Column 2	Molecular Sieve 5A or 13X 0.5m length X 3mm diameter

6.5.4 **Methanizer (Methannator)**

The specially designed high sensitivity methanizer is required for converting CO, C02 to Methane using Nickel Catalyst for low level CO & C02 analysis.

Parameters	Requirement
Operating Temp.	Ambient to 400 °C Minimum
Temp. accuracy	± 0.5 % of set value

6.5.5 Injection Ports

~~There are low volume injectors designed for vertical/horizontal injection. They should take 9.6mm dia and 3.2mm thickness Rubber Septa.~~

Parameters	Requirement
Inlet System Type	Packed Injector
No. of injector installed	02 installed
Temp. range	Ambient to 400 °C Minimum
Temp. read out	All temperatures should be set and displayed on the 7-inch color touch screen. The set point and process value should be visible.
Temp. accuracy	± 0.5 % of set value
Overheat protection	Should be available

DRAFT

6.5.6 ~~Column Oven~~

Parameters	Requirement
Temp. range	Ambient to 450 °C Minimum
Temp. read out	All temperatures should be set and displayed on the 7-inch color Touch screen. The set point and process value should be variable.
Temp. accuracy	± 0.5 % of set value
Overheat protection	Should be available
Auto cooling	Forced air
Heating rate	50 to 250 °C in 5min
Cooling rate	250 °C to 50 °C in 10 min

6.5.7 ~~Detector and Controls~~

~~These should be optimized for analytical performance.~~

~~a) Thermal Conductivity Detector with Power Supply Unit:~~

~~i. It should be flow through type for high sensitivity and internal volume should be less than 300 micro liters. Tungsten filament should be used. Material of Construction should be stainless steel.~~
~~ii. It should be of solid state type using integrated circuit with regulation ±0.01%.~~
~~iii. Current range: Upto 300mA. Indication by digital Display.~~
~~iv. Balance : Coarse and fine ranges.~~
~~v. Attenuator : Output in binary steps from x1 to x512 and short position.~~

~~b) Flame Ionisation Detector with electrometer amplifier:~~

~~i. It should be of parallel plate type for high collection efficiency and ease of maintenance. Material of construction should be stainless steel.~~
~~ii. Sensitivity: Amplifier sensitivity in steps of x1 and x100, the last position should give a selection x100 times more sensitive than the first. In terms of better than 10^{-3} gm of fatty acid micro liter solvent or better, to ensure high sensitivity measurements of hydrocarbons in ppm level.~~
~~iii. Linearity: Greater than $1X10^{6}$.~~
~~iv. FID module electrometer amplified should be an impedance converter and should operate in the voltage follower mode.~~
~~v. Input impedance: Greater than $10^{11}\Omega$.~~
~~vi. Attenuator: Output in Binary Steps from x1 to x512 and short (infinity).~~
~~vii. Balance: x1 and x100 should be used for the respective sensitivity positions.~~

~~Both the TCD Bridge Power Supply and FID Electrometer should be housed in single module. The switch over from one to another should be by press button switch.~~

~~Detector~~

Parameters	Requirement
Detector used	FID/TCD/Methanizer
Detectors Installed	FID/TCD/Methanizer
Temp. read out	All temperatures should be set and displayed on the 7-inch color touch screen. The set point and process value should be visible.
Temp. accuracy	± 0.5 % of set value

DRAFT

Overheat protection	Should be available

6.5.8 Mechanical Gas Flow Control Valve:

The Mechanical Mass Flow Control valves should have excellent flow repeatability & precision.

6.5.9

~~Strip Chart Recorder:~~

~~i. Sensitivity: 1mV to 10V preferred in as many ranges as possible.~~
~~ii. Response time: ½ Second full scale.~~
~~iii. Circuitry : I.C. version (solid state)~~
~~iv. Accuracy: Better than +0.3%.~~
~~v. Span : 1mV full scale and up with full complement of optical multispan attenuator.~~
~~vi. Zero: Should be able to be positioned over the entire scale. With control for instant correction of detector base line drift. Also facility to record signals from inverse detectors.~~
~~vii. Chart Drive: Positive feed and sprocketless mechanism.~~
~~viii. Speeds: Push button selection for four speeds of metric units.~~
~~ix. Pen lift: Mechanic Controls without touching the pen.~~

7.0 Data System with Associated Hardware and Software.

An MS-Windows-based program for Data collection, Data handling and generation of reports is to be provided. This provides flexibility for the option to shrink or enlarge a graph of interest and creates a quantitative report for percentage Area, & Height.

8.0 Dissolved Gas Interpretation Software

Special DG Interpretation software for the computation and interpretation of results for the analysis of dissolved gases in transformer oil shall be provided, which should be licensed from the OEM. The software shall provide the user with an option to enter all respective and relevant data related to the transformer and the method used for analysis and interpretation.

9.0 Constructional Features

A gas chromatograph should have the following features.

9.1 Colour Touchscreen (of at least 7 inches) for controlling system parameters with a 24-bit microcontroller running at the back end to provide good performance.

9.2 The mainframe should be equipped with an auto-cooling facility. The set point for the auto cooling should be user-settable from the touch screen and should be able to be disabled if required.

9.3 The control system should have extensive auto-diagnostic features & a user-friendly system with password protection for the factory setup menu.

9.4 Safety features should be provided with a few controls, like a maximum column temperature set by the user using password protection.

9.5 Dual-channel software and hardware with USB interface are required to be provided for data acquisition, data analysis and report generation.

9.6 DGA Calculation and Interpretation software for Head-Space Sampling should be provided. The Interpretation methods supported should be the Duvall triangle, IEC Cubic and IEC ratio methods.

9.7 The PC should be a minimum i5 with a 19.5-inch Monitor along with SSD and HDD. The B/W Laser printer is also to be provided.

10.0 Vial Head Space Auto Sampler with Vial Preparation Kit

DRAFT

i. Vial Preparation kit with necessary regulator, valves and needles x 1 set
ii. Vial Crimping tool x 2
iii. 20 ml Vials x 100 numbers
iv. Perforated Aluminium Cap + TFE-fluorocarbon-faced butyl septum X 400 Numbers
v. Vial Head Space Auto sampler with heating & Agitation and storage to inject samples up to 2.5 ml
vi. Fully automatic
vii. Shaker to be in-built & included.
viii. Heating zone to be in-built & included.
ix. The cleaning system should be integrated with the unit for automated and consistent purging procedures.
x. Rotating head design ensuring the injector port is always free for manual injections and maintenance.
xi. Integrity check for the Auto sampler.
xii. Automatic leakage checks.
xiii. Automatic cleaning system.
xiv. Oven temperature - 150°C

11.0 Calibration Gas Mixture (1 No)

Calibration Standard Gas Mixture (0.5 Liter Water capacity) with NABL traceability should have the composition as Methane 500 ppm, Ethane 500 ppm, Ethylene 500 ppm, Acetylene 500 ppm, Hydrogen 1000 ppm, Carbon monoxide 1000 ppm, Carbon dioxide 2500 ppm, Oxygen 1 %, Nitrogen 3%, balance Argon.

12.0 Standard Accessories for GC Installation:

12.1 The manufacturer may separately quote for the following items required for the analysis of dissolved gases in the transformer oil:

i. Two nos. Hydrogen Cylinders 47 litres. Water capacity filled at >110 bar with 2-stage SS pressure regulator.
ii. Two nos. Argon Cylinders 47 litres. Water capacity filled at >110 bar with 2-stage SS pressure regulator.
iii. Two nos. Zero Air Cylinders 47 litres. Water capacity filled at >110 bar with 2-stage SS pressure regulator.
iv. 5 KVA Voltage Stabilizers with digital display.

12.2 The following accessories will be supplied free along with the instrument.

~~i. Recorder Pen, 1No.~~
~~ii. Recorder ink bottle, 1No.~~
~~iii. Chart Roll, 1No.~~
~~iv. Signal Cable, 1No.~~
~~v. Soap bubble Manometer, 1No.~~
~~vi. Air Compressor, 1No.~~
~~vii. Gas torch with Cells, 1No.~~
~~viii. Set of fuses, 1No. (Each),~~
~~ix. Set of tools, spanners, screw drivers, 2 Nos (each).~~
~~x. Silicon rubber Septum, 25Nos.~~
~~xi. Copper Tubing with Connectors for H2, N2 and O2, 2No (each).~~
~~xii. Gas tight syringes 100ml- 05 Nos. & 1000ml- 5Nos.~~

i) Set of fuses - 1 set

DRAFT

ii) Tubing for gases - 12 meter
iii) 2 ml Syringe with side bore needle - 1 Nos.
iv) Brass nut & ferrule - 20 Nos.
v) Soap bubble flow meter -1 No.
vi) Set of Tools -1 set
vii) Manual Head Space Sampling kit in case of failure of Automated Head Space Sampler – 1 Set
viii) The PC should be supplied with a licensed OS.

12.3 ~~The tenderer manufacturer shall separately quote for and supply along with the equipment, the following items required for the analysis of dissolved gases in Transformer Oil.~~
~~i. Two Nos. Hydrogen Cylinders.~~
~~ii. Two Nos. Nitrogen Cylinders.~~
~~iii. Two nos. Cylinders of any other gas required for the operation of gas chromatograph.~~

13.0 Tests

13.1 The equipment shall be inspected and tested at the ~~firms~~ manufacturer's premises before dispatch as per the schedule mutually agreed between the supplier and purchaser. The tests shall be witnessed by the purchaser's representative(s).

13.2 The ~~tenderer~~ manufacturer shall also furnish complete technical details along with the ~~manufacturers~~ test certificates for the performance claimed.

14.0 Technical Data: Particulars and Drawings

14.1 The ~~tenderer~~ manufacturer shall furnish their compliance or otherwise against each clause/sub-clause of the technical specification. If the ~~tenderer~~ manufacturer wishes to deviate from any clause/sub-clause, they shall furnish the full details with justification for such deviation.

14.2 The ~~tenderer~~ manufacturer shall also furnish descriptive technical literature, assembly layout drawing, schematic diagrams, etc., for scrutiny to the purchaser.

15.0 Commissioning

15.1 The equipment shall be supplied and commissioned by the supplier at the purchaser's premises. The offer shall include training on the equipment for one week at the purchaser's premises, at the time of commissioning.

16.0 Operation and Maintenance Instructions

16.1 The supplier shall supply two copies of the instruction manual for the operation and maintenance of the equipment. The manual shall contain full particulars of various components, fully dimensioned drawings, circuit diagrams, etc.

17.0 ~~Spares/Special Tools~~

17.1 ~~The tenderer shall quote separately for the spares recommended to maintain the equipment for a period of two years.~~
17.2 ~~The tenderer shall also quote for supply of special tools, if any, required for trouble free operation and maintenance.~~
17.3 ~~The tenderer shall also quote for all the consumables required for the operation of the equipment.~~
17.4 ~~Spare parts/special tools, as ordered shall be delivered along with the supply of the instrument.~~

18.0 ~~Guarantee~~

DRAFT

18.1 ~~The equipment shall be guaranteed for its trouble free performance for a period of 18 months from the date of commissioning or 24 months from the date of supply whichever is earlier.~~

****

DRAFT