



# TOGA

## Transformer Oil Gas Analyser

- Fully automated Transformer Oil Gas Analyser
- According to ASTM D3612c
- Automated instrument performance verification
- High uptime due to modular injector/detector technology

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Transformer oil is a highly refined mineral oil used in electrical transformers. It has excellent insulating properties, suppresses corona and arcing, and serves as a coolant. In cases where an electrical error has taken place, the oil undergoes a break down into component gases which can identify and relate to the type and severity of the electrical fault. ASTM D3612c describes extraction and determination of gases in transformer oil based on head space sampling.

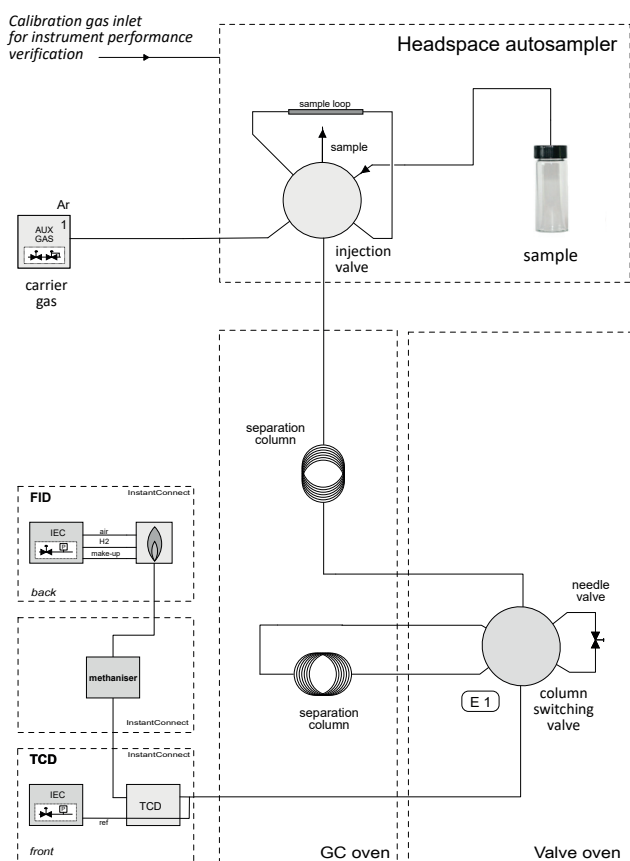


Figure 1. Schematic diagram TOGA



Figure 2. Transformer oil gas analyser with headspace sampling

## Transformer Oil Gas Analyser - Principle

An aliquot from the vapour phase above a sample of transformer oil is injected from a sealed vial using a headspace autosampler. After  $H_2$ ,  $O_2$ ,  $N_2$ ,  $CH_4$  and  $CO$  have passed the first separation column, these components are isolated on the second column by switching valve E1. Next  $CO_2$ ,  $C_2H_2$ ,  $C_2H_4$  and  $C_2H_6$  elute from the first column via the needle valve (NV) to the detectors. After valve E1 is switched back to the initial position,  $H_2$ ,  $O_2$ ,  $N_2$ ,  $CH_4$  and  $CO$  are detected.

When  $C_3$  and  $C_4$  components need to be analysed as well, a valve and separation column is added to the system.  $CO$  and  $CO_2$  are converted to  $CH_4$  using a methaniser, enabling sensitive FID detection at ppm level. (See figure 1).

Diaphragm valves and InstantConnect detector technology result in a robust and flexible instrument.

## Headspace sampling

The oil samples are automatically injected using Thermo TriPlus 500 headspace autosampler with 12, 120 or 240 sample position trays. This system uses the closed loop injection principle, so loss of components or false results from ambient gases are avoided. Each sample is individually equilibrated at  $70^\circ C$ . The required equilibration time is minimised by using the mixer function of the autosampler. The headspace sample is injected by (1) pressurisation of the vial (2) expansion to a loop (3) transferring the loop content to the separation columns (see figure 3). To guarantee the expected sample integrity at every analysis, each vial is automatically checked for possible leaks just prior to the loop filling stage.

The Chromeleon chromatography data system is seamlessly integrated with TriPlus 500 HS autosampler, offering a single point of control for optimal simplicity and convenience.

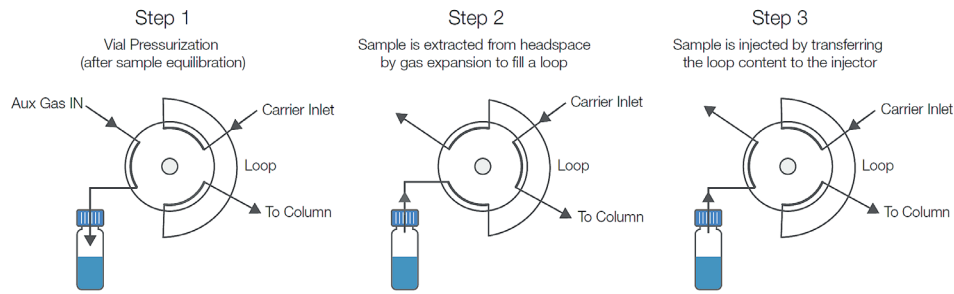


Figure 3. TriPlus 500 headspace autosampler; vial pressurising, loop filling and injection

## Results

Figure 4 and 5 show the results of 10 and 100 ppm dissolved gases in oil standards on FID and TCD. Figure 6 shows the achieved limits of detection per component and by which detector.

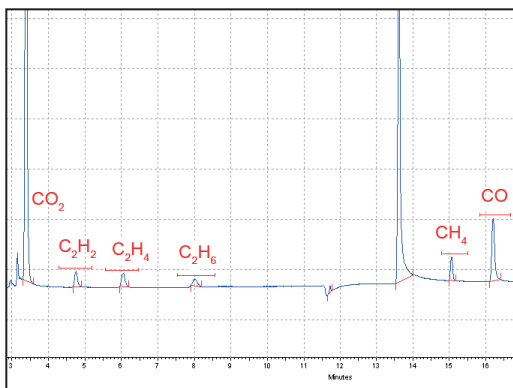


Figure 4. FID, 10 ppm Morgan Schaffer oil standard

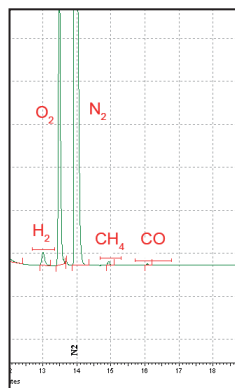


Figure 5. TCD, 100 ppm Morgan Schaffer oil standard

Component	Detection limit GAS (ppm)	Detected on
CO <sub>2</sub>	< 1	Methaniser-FID
Acetylene	< 1	FID
Ethylene	< 1	FID
Ethane	< 1	FID
Hydrogen	< 5	TCD
Oxygen	< 100	TCD
Nitrogen	< 100	TCD
Methane	< 1	FID
CO	< 1	Methaniser-FID

Figure 6. LODs TOGA analyser

## Option to verify instrument performance and kit for standard and sample preparation

A kit is available to facilitate (1) instrument performance verification and (2) preparation of standards and samples:

### (1) Instrument performance verification

A series of empty sample vials is placed in the head-space autosampler. The vials are automatically loaded with calibration gas, and subsequently analysed. This process allows for the assessment of the analytical instrument's repeatability by calculating the Relative Standard Deviation (RSD%) using the Chromeleon data system. Additionally, this method allows verification of peak shape and separation.

### (2) Preparation of calibration standards and sample loading

The kit includes all necessary components for manually preparing calibration standards using blank oil and calibration gas. This eliminates the need for third-party calibration standards and ensures correct sample loading into the sample vials.

Component	ppm	RSD%
CO <sub>2</sub>	10000	0.162
Ethylene	3000	0.146
Ethane	2000	0.155
Acetylene	1000	1.181
Methane	1000	0.176
Propane/propylene	3000	0.201
Carbon monoxide	2000	0.132
Hydrogen	500	0.732
Oxygen	250000	0.092
Nitrogen	720000	0.245

Figure 7. Instrument performance verification report, showing analyser repeatability using a calibration gas

# Technical specifications

- Standard method:** ASTM D3612 part c
- Configuration:** One channel instrument based on Thermo Trace GC1600.  
using microTCD, methaniser and FID.  
Automated injection, closed loop principle, using Thermo Triplus 500 (12, 120 or 240 vials of 10, 20 or 22 ml)  
Carrier gas: Argon
- Application:** Custom configured analyser for the analysis of dissolved gases in transformer oil.  
Components: H<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub>, CO, CO<sub>2</sub>, C<sub>2</sub>H<sub>2</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub> (C<sub>3</sub> and C<sub>4</sub> components optional).
- Sample requirements:** The oil sample must be offered to the analyser using appropriate 10 or 20/22 sample vials. Vials are purged with Argon before sampling (using the optional manual preparation kit or sample preparation device from figure 7).
- Analysis Time:** 20 minutes.
- Minimum Detectability:**
- | Component       | Detection limit<br>GAS (ppm) |
|-----------------|------------------------------|
| CO <sub>2</sub> | < 1                          |
| Acetylene       | < 1                          |
| Ethylene        | < 1                          |
| Ethane          | < 1                          |
| Hydrogen        | < 5                          |
| Oxygen          | < 100                        |
| Nitrogen        | < 100                        |
| Methane         | < 1                          |
| CO              | < 1                          |
- Dynamic Range:** 4 decades for TCD, 7 decades for FID.
- Repeatability:** Better than 5% RSD at 100ppm concentration level for all analytes specified, measured over at least 10 consecutive runs.
- Optional:** Additional column and switching valve for C<sub>3</sub>/C<sub>4</sub> analysis  
Kit for verification of instrument performance and preparation of calibration standards & samples  
DGA Revolver Table system for TOGA sample preparation (figure 7)
- Data systems:** Chromeleon CDS



Figure 7. Optional DGA Revolver Table system for TOGA sample preparation

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