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USER GUIDE

OPT100-OPTIMUS

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M211858EN-AC

User Guide

Vaisala Optimus™ DGA Monitor for power transformers

OPT100



VAISALA

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Vaisala Oyj
Vanha Nurmijärventie 21, FI-01670 Vantaa, Finland
P.O. Box 26, FI-00421 Helsinki, Finland
+358 9 8949 1
vaisala.com
docs.vaisala.com

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1. About this document

1.1 Version information

This document provides instructions for using, maintaining, and troubleshooting the Vaisala Optimus™ DGA Monitor OPT100.

Table 1 Document versions (English)

Document code	Date	Description
M211858EN-AC	February 2026	Applicable from software version 1.25.0 onward. Updated sections: • OPT100 cable glands and connectors (page 26) and OPTPSU cable glands and connectors (page 27): Instrument power cable item code. • Interior parts (page 29): New optical measurement module in interior parts figure. • Device alerts (page 94): New alert for optical measurement module. Added sections: • Recycling instructions (page 118): New detailed recycling instructions.

Document code	Date	Description
M211858EN-AB	April 2025	Applicable from software version 1.23.0 onward. Updated sections: • Overview of OPT100 Optimus DGA monitor (page 14): Option for oxygen and nitrogen measurement added. • Basic features and options (page 14): Option for oxygen and nitrogen measurement added. • Measured parameters (page 15): Oxygen and nitrogen added to measured parameters. • OPT100 cable glands and connectors (page 26): Alternative hardware version added for Ethernet connection. • Interior parts (page 29): Figure updated to include oxygen sensor and oil filter. • Gas level alerts (page 31): Details about oxygen and nitrogen measurement added. • Autocalibration (page 35): Details about total gas pressure (TGP) and nitrogen added. • Criteria for data points in DGA diagnostics (page 48): Data point criteria limits updated. • Configuring gas level alerts (page 62): Details about oxygen and nitrogen measurement added. • Device alerts (page 94): Upper level sensor failure added. • OPT100 technical specification (page 106): Oxygen and Nitrogen measurement parameters and new spare parts added. • Measurement data registers (page 125): Oxygen and nitrogen registers added. Added sections: • Nitrogen measurement (page 17) • Criteria for calculating gas ratios (page 45)

Document code	Date	Description
M211858EN-AA	April 2024	Applicable from software version 1.22.0 onward. Updated sections: • OPT100 cable glands and connectors (page 26): Tightening torques added for cable glands and connectors and ground connection information updated. • OPTPSU cable glands and connectors (page 27): Tightening torques added for cable glands and connectors and ground connection information updated. • DGA diagnostics page (page 46): Duval triangle information updated for natural ester liquids. • Uninstalling DGA monitor (page 85): Information added about storing natural ester liquid devices. • OPT100 technical specification (page 106): Mechanical specifications added for Antivibration Wall Mount Set. Added sections: • Parts with Antivibration Wall Mounting Set (page 24): New wall mount option added for OPT100 Optimus DGA monitor. • Flushing DGA monitor (page 90): Instructions added for flushing DGA monitor that has been connected to a natural ester transformer. • Dimensions with Antivibration Wall Mounting Set (page 117): New wall mount option added for OPT100 Optimus DGA monitor.

1.2 Related manuals



For the latest versions of these documents, see docs.vaisala.com.

Table 2 Related manuals

Document code	Name
M211857EN	OPT100 Installation Guide
M212603EN	OPT100 Multilingual Quick Guide
M212595EN	Spare part instruction: Replacing MHT411 internal multigas transmitter
M212759EN	Spare part instruction: Replacing OPT100 solenoid valves

1.3 Documentation conventions



WARNING! Alerts you to a serious hazard. If you do not read and follow instructions carefully at this point, there is a risk of injury or even death.



CAUTION! Alerts you to a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.



Highlights important information on using the product.



Gives information for using the product more efficiently.



Lists tools needed to perform the task.



Indicates that you need to take some notes during the task.

1.4 Trademarks

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1.5 Patent notice

This product is protected by the following patents and patent applications and their corresponding national rights:

Table 3 Applicable patents or applications

Issuing office	Patent number
Chinese Patent Office	ZL 201480064015.2
	ZL 201580044115.3
	ZL 201880026814.9
	ZL 201780011918.8.
United States Patent and Trademark Office	US 10429371
	US 10101266
	US 11,054,406
Finnish Patent Office	125907
	127084
United Kingdom Patent Office	GB 3049806
	GB 3183572
	GB 3398669
German Patent Office	DE 3049806
	DE 60 2015 067 795.1.
	DE 3398669
	DE 60 2017 065 033.1
Swiss Patent Office	CH 3049806
	CH 3398669
	CH 3469355
Canadian Patent Office	CA 2955112
	CA 3,005,371
Irish Patent Office	IE 3469355

2. Product overview

2.1 Overview of OPT100 Optimus DGA monitor

Optimus DGA Monitor OPT100 is a device for monitoring the internal condition of an electrical transformer using dissolved gas analysis (DGA), also known as fault gas analysis. The device is intended to be installed next to the transformer, and connected to it by two oil lines. The device is suitable for outdoor or indoor use. The device draws oil from a transformer, measures the concentrations of hydrogen, moisture, and several hydrocarbons in the oil, and returns the oil back to the transformer. The device is available with optional oxygen and nitrogen measurement.

Measurement results can be transferred via communication interfaces to the substation's SCADA (Supervisory Control And Data Acquisition) system. The data is also available for viewing by human operators through the browser-based user interface.

The OPT100 Optimus DGA Monitor consists of two separate units; the DGA monitor and the power supply unit. The DGA monitor contains the entire oil monitoring system and all control systems and is powered by 24 V DC. The power supply unit houses all mains parts and delivers 24 V DC operating voltage to the DGA monitor. Power supply unit is available for AC supply voltage and DC supply voltage.

More information

‣ OPT100 technical specification (page 106)

2.2 Basic features and options

- Measurement of seven fault gases, moisture in oil, and total gas pressure
- Several calculated parameters and gas ratios available
- Ethernet and RS-485 interfaces for SCADA integration
- Modbus protocol (RTU and TCP)
- Protocol test mode for verifying SCADA integration
- Three configurable relay outputs
- Gas level alerts for measured values and rate of change (ROC)
- IP66 rated cabinet
- Hardware options:
  - Oxygen and nitrogen measurement
- Optional software features:
  - DGA diagnostics using Duval triangles
  - DNP3 (Distributed Network Protocol) over Ethernet or RS-485
  - IEC 61850 protocol over Ethernet
- Installation options:
  - Ground mounting set
  - Antivibration ground mounting set
  - Wall mounting set
  - Weather shield

- Device liquid type options:
  - Mineral oil
  - Synthetic ester liquid
  - Natural ester liquid

2.3 Measured parameters

Table 4 Measured parameters

Parameter	Output unit(s)	Description
Methane (CH_4)	ppm_v	Measured from extracted gas
Ethane (C_2H_6)	ppm_v	Measured from extracted gas
Ethylene (C_2H_4)	ppm_v	Measured from extracted gas
Acetylene (C_2H_2)	ppm_v	Measured from extracted gas
Carbon monoxide (CO)	ppm_v	Measured from extracted gas
Carbon dioxide (CO_2)	ppm_v	Measured from extracted gas
Hydrogen (H_2)	ppm_v	Measured in-oil
Moisture (H_2O)	ppm_w and %RS	Measured in-oil as relative saturation (%RS). See Calculating relative moisture saturation inside transformer (page 16).
Total gas pressure	hPa and psi	Measured from the sampled oil volume
Oxygen (O_2)	ppm_v	Measured in-oil
Nitrogen (N_2)	ppm_v	Calculated from other gas concentrations

Table 5 Calculated parameters

Property	Output unit(s)	Description
Total dissolved combustible gases (TDCG)	ppm_v	Combined total of H_2, CO, CH_4, C_2H_6, C_2H_4, and C_2H_2.

Property	Output unit(s)	Description
24 h average	ppm_v for gases ppm_w for moisture hPa and psi for total gas pressure	Available for single gases, moisture, TDCG, and total gas pressure
Rate of change (ROC)	ppm_v	Available for single gases and TDCG for 24 h, 7 d, and 30 d periods
Gas ratios for: • CH_4/H_2 • C_2H_2/C_2H_4 • C_2H_2/CH_4 • C_2H_6/C_2H_2 • C_2H_4/C_2H_6 • CO_2/CO • O_2/N_2	Ratio	Ratio is calculated from 24 h average values of the gases

2.3.1 Total gas pressure measurement

Total gas pressure (TGP) is measurement parameter introduced in software version 1.12.0. Total gas pressure is the total dissolved gas pressure of the sampled oil volume, measured by the DGA monitor as part of its normal measurement cycle. The primary use of the TGP parameter is to determine if there is an air leak into a sealed transformer. In case of a leak, majority of the dissolved gases are nitrogen and oxygen, and the proportion of fault gases in the pressure value is negligible. The pressure trend of the dissolved gasses gives reliable indication of leak, as nitrogen is the dominant component, and it is not formed or consumed in reactions inside the transformer.

From software version 1.13.0 onward TGP measurement results (current value and 24 hour average) are available through output protocols, and TGP measurement can be used for gas alerts. TGP has its own separate graph view on page **Measurements > Total gas pressure**.

2.3.2 Calculating relative moisture saturation inside transformer

CAUTION! DGA monitor measures relative oil moisture (%RS) inside its cabinet. The temperature of the moisture sensor location does not represent the temperature inside the transformer tank or inside the oil circulation pipes. Additionally, oil sampling through the steel pipes changes the oil temperature. As relative moisture saturation is strongly **temperature dependent**, the %RS measured and output by DGA monitor is not equal to %RS inside the transformer tank.

However, DGA monitor does output both the measured %RS and the temperature where it was measured. To calculate the %RS in the true temperature inside the transformer, use the following equation.

$$\%\,RS_{T2} = \%\,RS_{T1} \times 10^{\left(\frac{A(T2-T1)}{(T1+273.15)\times(T2+273.15)}\right)}$$

$\%RS_{(T1)}$	Relative moisture saturation output by DGA monitor
T1	Temperature of the in-oil measurement chamber inside DGA monitor
T2	Temperature at location where new relative moisture saturation is needed at
A	-1662.70

T1 temperature can be found in **Measurements > Latest values** or the CSV data file per measurement point (Temperature of in-oil measurement chamber (°C)).

A is a water solubility coefficient. Vaisala uses this standard value in all of its oil moisture transmitters. You can also use this equation with an oil-specific coefficient if it has been determined for your oil.

2.3.3 Nitrogen measurement

If your OPT100 Optimus DGA Monitor has an oxygen sensor, it also includes nitrogen measurement. Nitrogen concentration is not measured directly by OPT100 Optimus DGA Monitor, but is calculated from the measured concentrations of other gases and the total gas pressure (TGP).

Nitrogen measurements are visible in **Measurements > Atmospheric gases**.

More information

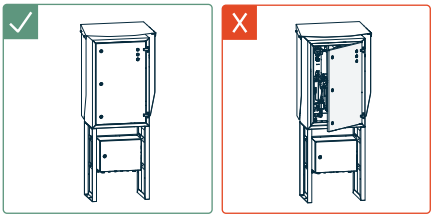
- Total gas pressure measurement (page 16)

2.4 Notes for normal operation

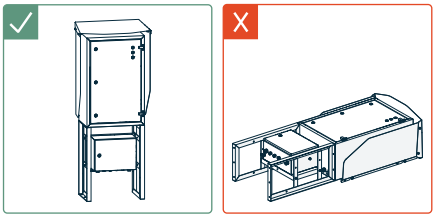
In normal operation, the DGA monitor performs measurement cycles automatically without any operator involvement. Integration with a SCADA system is recommended for convenient monitoring of measurement results and system status. Status LEDs on the cabinet door indicate system status on a general level, and detailed status is available from the browser-based user interface.

For successful operation:

- Keep the doors of the DGA monitor cabinets closed and locked during normal operation. This keeps the inside of the DGA monitor clean and the measurement environment stable. Unstable internal conditions may cause rejection of measurement points.

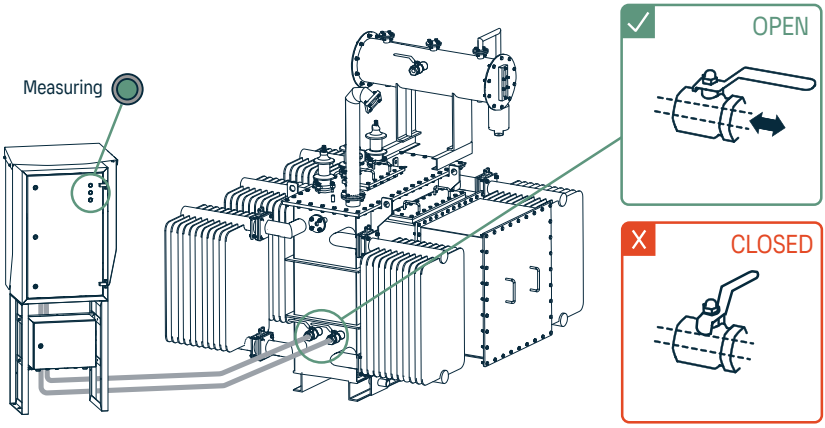


- Initialize DGA monitor only in an upward position.



- Keep the measurement running continuously to achieve the best measurement performance.
- If the DGA monitor will be unpowered for a long time (due to a transformer maintenance, for example), set the system to **Standby** by stopping measurement.
- Check that the power supply unit (OPTPSU) is on and that it is installed as instructed in OPT100 Installation Guide (M211857EN).

- Do not close the transformer intake or return valves while the DGA monitor is measuring.



More information

- Stopping measurement (page 83)

2.5 Parts with Ground Mounting Set

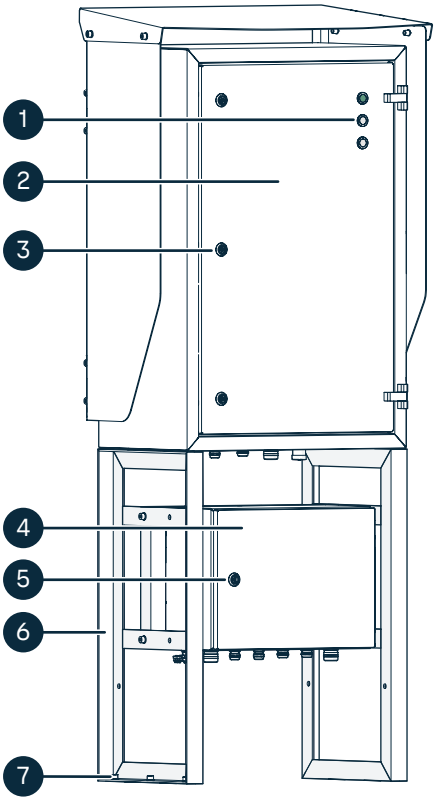


Figure 1 OPT100 front parts with Ground Mounting Set

1 Status LEDs
2 OPT100 DGA Monitor
3 Door lock (3 pcs)
4 Power supply unit (OPTPSU)
5 Door lock
6 Mounting stand
7 Wedge anchors (6 pcs)

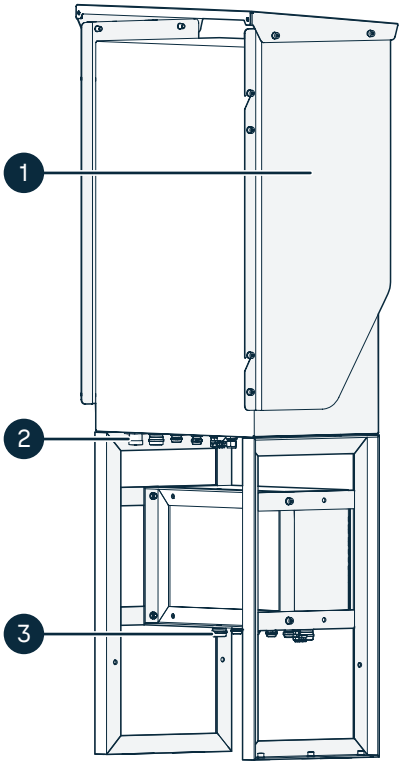


Figure 2 OPT100 rear parts with Ground Mounting Set

1 Weather shield
2 Cable glands and oil connections for DGA Monitor
3 Cable glands for power supply unit

More information

- Dimensions with Ground Mounting Set (page 114)

2.6 Parts with Wall Mounting Set

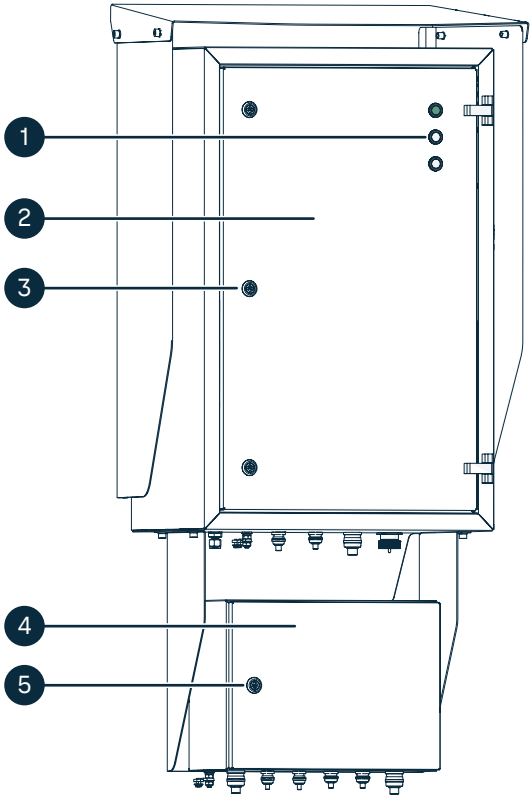


Figure 3 OPT100 front parts with Wall Mounting Set

1 Status LEDs
2 OPT100 DGA Monitor
3 Door lock (3 pcs)
4 Power supply unit
5 Door lock

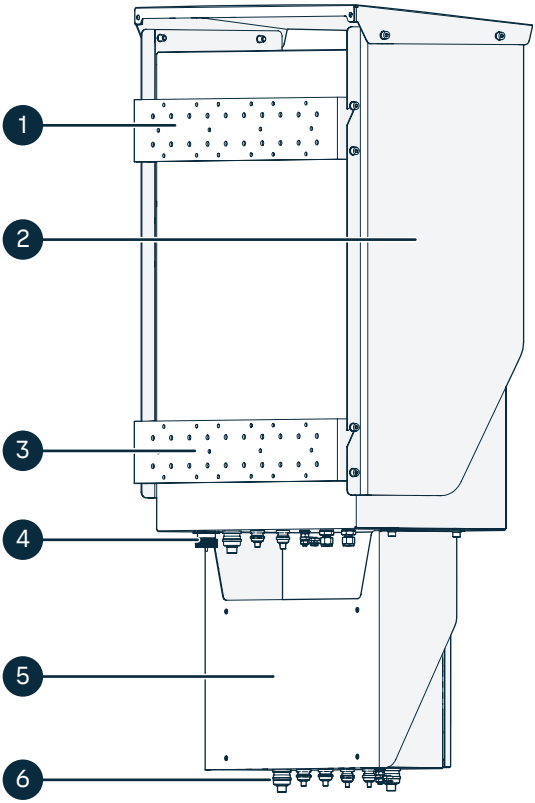


Figure 4 OPT100 rear parts with Wall Mounting Set

1 Installation beam (upper)
2 Weather shield
3 Installation beam (lower)
4 Cable glands for DGA Monitor
5 Cradle for power supply unit
6 Cable glands for power supply unit

More information

- Dimensions with Wall Mounting Set (page 115)

2.7 Parts with Antivibration Wall Mounting Set

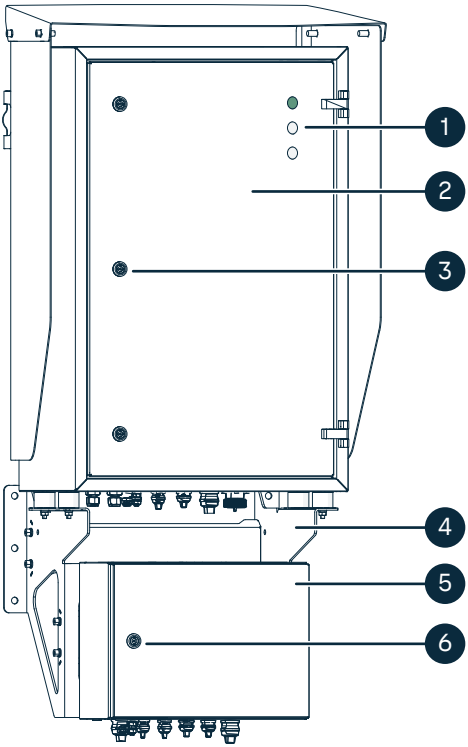


Figure 5 OPT100 front parts with Antivibration Wall Mounting Set

1 Status LEDs
2 OPT100 DGA Monitor
3 Door lock (3 pcs)
4 Wall mount
5 Power supply unit
6 Door lock

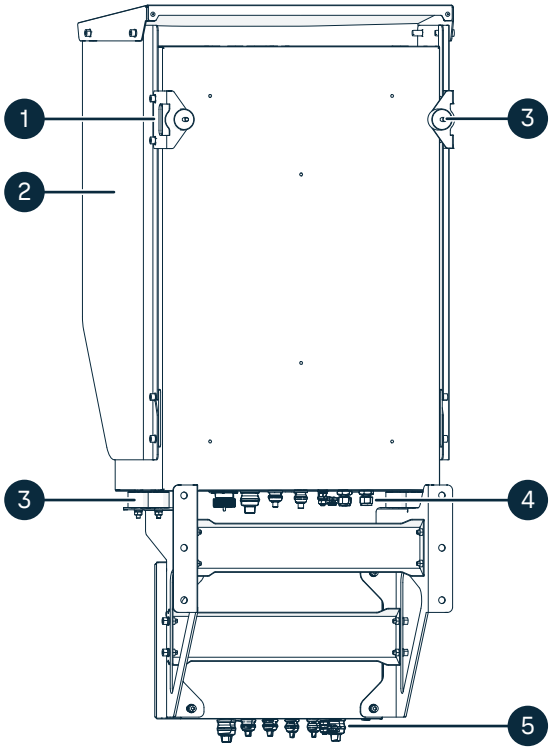


Figure 6 OPT100 rear parts with Antivibration Wall Mounting Set

1 Upper supports
2 Weather shield
3 Antivibration dampers
4 Cable glands for DGA monitor
5 Cable glands for Power supply unit

2.8 OPT100 cable glands and connectors

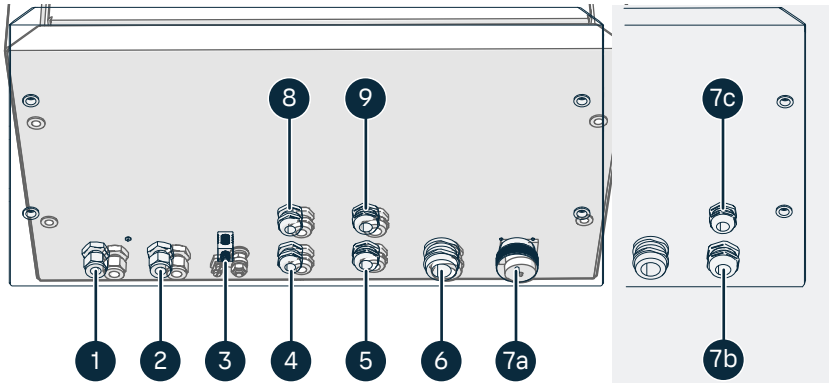


Figure 7 Cable glands and connectors on the bottom of OPT100 cabinet

#	Label	Description	Cable/pipe diameter	Tool size	Tightening torque
1	**Oil Out**	Oil return to transformer.	10 mm (0.39 in)	19 mm	-
2	**Oil In**	Oil intake from transformer.	10 mm (0.39 in)	19 mm	-
3	⏚	Additional Ground connection.	4–50 mm^2 (12–1/0 AWG) conductor	5 mm	3.5 Nm (4–10 mm^2) 10 Nm (15–50 mm^2)
4	**RS-485**	RS-485 connection.	5–10 mm (0.20–0.39 in)	20 mm	5 Nm
5	**Relay control out**	Relay control to OPTPSU. Use Vaisala cable CBL210539.	7–12 mm (0.28–0.47 in)	24 mm	10 Nm
6	**DC in**	DC input from OPTPSU. Use Vaisala cable CBL210568.	9–16 mm (0.35–0.63 in)	30 mm	12 Nm
7a [1)]	**Ethernet**	Ethernet connection. Use shielded outdoor Ethernet cable. Assemble the included protection shell on the RJ45 connector.	-	-	-

#	Label	Description	Cable/pipe diameter	Tool size	Tightening torque
7b [1)]	**Ethernet**	Alternative Ethernet connection. Use shielded outdoor Ethernet cable. Assemble the included RJ45 connector.	7–12 mm (0.28–0.47 in)	24 mm	10 Nm
7c	**Spare**	Not reserved. Option for Ethernet connection.	5–10 mm (0.20–0.39 in)	20 mm	5 Nm
8	**Spare**	Not reserved.	5–10 mm (0.20–0.39 in)	20 mm	5 Nm
9	**Spare**	Not reserved.	7–12 mm (0.28–0.47 in)	24 mm	10 Nm

1) Cable glands vary for different hardware options

2.9 OPTPSU cable glands and connectors

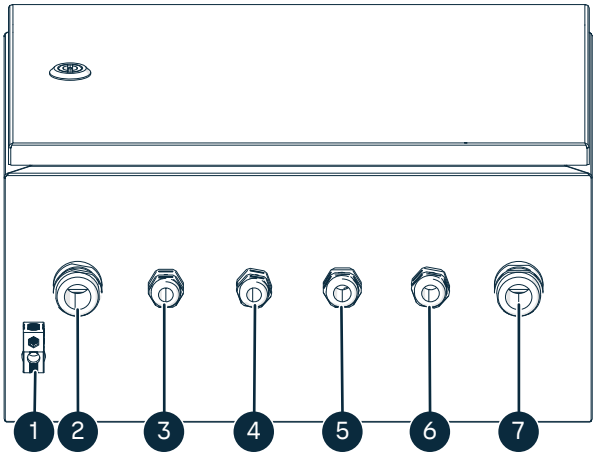


Figure 8 Cable glands and connectors on the bottom of OPTPSU power supply unit

#	Label	Description	Cable diameter	Tool size	Tightening torque
1		Additional Ground connection.	4–50 mm^2 (12–1/0 AWG) conductor	5 mm	3.5 Nm ($4–10\ mm^2$) 10 Nm ($15–50\ mm^2$)
2	**AC in** (OPTPSU1)	Mains power input. 100–240 V AC, 50–60 Hz, 10 A.	9–16 mm (0.35–0.63 in) 0.5–10mm^2 (24–6 AWG) conductor	30 mm	12 Nm
	DC in (OPTPSU2)	Mains power input. 110–220 V DC, 6.3–2.5 A.	9–16 mm (0.35–0.63 in) 0.5–10mm^2 (24–6 AWG) conductor	30 mm	12 Nm
3	**Spare**	Not reserved.	5–10 mm (0.20–0.39 in)	20 mm	5 Nm
4	**Spare**	Not reserved.	5–10 mm (0.20–0.39 in)	20 mm	5 Nm
5	**Relay out**	Relay output, max 250 V AC, 10 A.	7–12 mm (0.28–0.47 in)	24 mm	10 Nm
6	**Relay control in**	Relay control from DGA monitor. Use Vaisala cable CBL210539.	7–12 mm (0.28–0.47 in)	24 mm	10 Nm
7	**DC out**	DC output to DGA monitor, 24 V DC, 20 A. Use Vaisala cable CBL210568.	9–16 mm (0.35–0.63 in)	30 mm	12 Nm

2.10 Interior parts

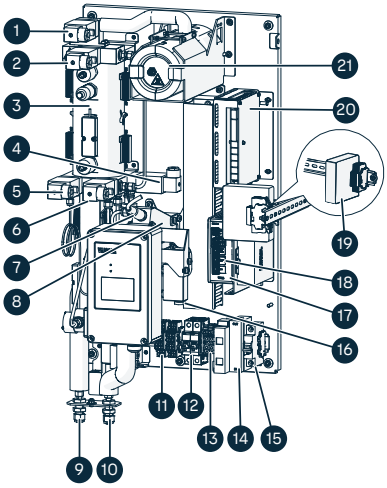


Figure 9 Inside DGA monitor cabinet

1 Valve 5 (bleed valve). Must be manually accessed during initialization and uninstallation.
2 Valve 4
3 Oil block
4 Valve 2
5 Valve 3
6 Valve 1
7 Oxygen sensor (Optional)
8 In-oil measurement of hydrogen and moisture
9 Oil out
10 Oil in
11 Terminal blocks for RS-485 output (Y1) and relay control (Y2)
12 Circuit breakers: main breaker (F2) and breaker for heating power (F1)
13 Terminal block for DC in (Y3)
14 Surge arresters
15 Circuit breaker for auxiliary device (F3) (Y4)
16 Oil filter
17 Processing unit
18 Ethernet connectors:

- ETH0 Connection for SCADA, wired to external Ethernet connector
- ETH1 Service port for temporary local use, with IP address 192.168.28.2

19 Auxiliary device and terminal blocks (Y5)
20 Control unit
21 Optical measurement module for extracted gases

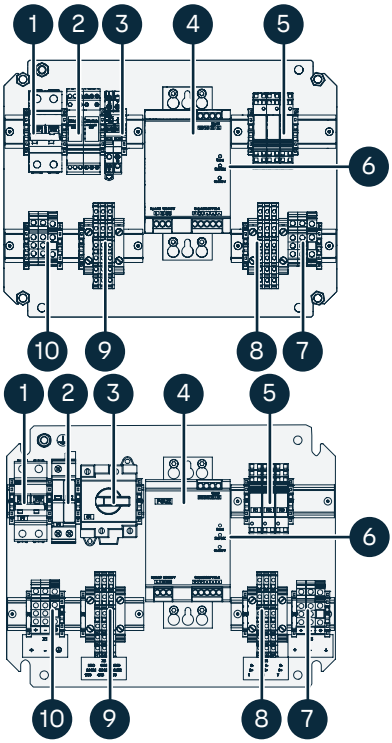


Figure 10 Inside Power Supply Unit cabinet (OPTPSU1 and OPTPSU2)

1 Circuit breaker for AC or DC power (F1)
2 Surge arresters
3 Power switch (S1)
4 Power supply
5 Relays (3 pcs). Each relay has a LED that is lit when the relay is active.
6 DC OK LED. If flashing, check DC output wiring.
7 DC out terminal block (X5)
8 Relay control terminal block (X4)
9 Relay output terminal block (X3)
10 Mains power in terminal block (X1)

2.11 Status LEDs

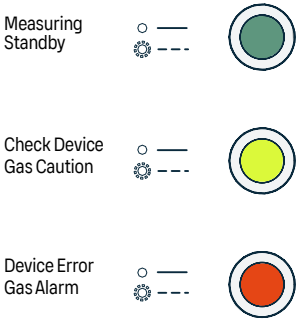


Figure 11 Status LEDs

Table 6 Status LEDs

Color	Meaning
Green	DGA monitor operates normally and performs measurement cycles.
Green (flashing)	DGA monitor is in standby mode, or running a service tool. Requires user interaction to begin measurement.
Yellow	DGA monitor requires user interaction. For example, a device warning is active, a service tool requires user input, or the DGA monitor is being initialized or uninstalled.
Yellow (flashing)	Gas level alert is active, caution limit exceeded.
Red	Device error is active. User interaction is required.
Red (flashing)	Gas level alert is active, alarm limit exceeded.

2.12 Gas level alerts

DGA monitor has a comprehensive selection of individual gas level alerts:

- 4 possible alerts for each measured gas and the total dissolved combustible gases (TDCG) parameter: latest measured value, ROC 1 day, ROC 7 days, and ROC 30 days.
- Total gas pressure (TGP), oxygen, nitrogen and moisture alerts (ppm and %RS) can be configured for the latest measured value.

Each alert has two separate limits, **caution** and **alarm**. The limits are maximum limits, and the alert is activated when the gas level is above the limit. As an exception, the TGP, and oxygen and nitrogen alert limits can also be defined as a **minimum limit**, which activates the alert when total gas pressure is below the limit value.

Active gas level alerts are seen in the user interface, status LEDs, and output protocols. They also control relay activation.

In addition to alert limits, DGA monitor implements additional rules to prevent unnecessary alerts:

- Only reliable measurement results can activate alerts. If the DGA monitor has been in the standby state, it must complete 3 measurement cycles before alarms can be activated.
- Alerts will not be activated during the initial autocalibration after installation.
- A single large jump in the measured value that exceeds the alert limit will not activate an alert. The previous measurement must be at least 75% of the latest measurement to activate an alert. If the measured value remains over the limit when the next measurement cycle is completed, the alert is activated.

Alerts are deactivated as follows:

- Alerts for gas concentration values are deactivated after 20 consecutive results have been below the alert limit.
- Alerts for rate of change (ROC) values are deactivated after the latest result is below 90% of the alert limit.

Gas level alerts can also be temporarily muted by the **Admin** user.

More information

- Muting gas level alerts (page 63)

2.13 Modbus protocol

Data measured by DGA monitor can be read using Modbus protocol. Supported Modbus variants are:

- Modbus TCP over the Ethernet interface
- Modbus RTU (serial Modbus) over the RS-485 interface

Table 7 Modbus TCP communication settings

Property	Specification
IP address of Modbus server	IP address of DGA monitor on interface ETH0
Modbus server port	502

Table 8 Default Modbus RTU communication settings

Property	Specification
Baud rate	19200
Parity	Even
Data bits	8
Stop bits	1
Modbus RTU slave address	240

More information

- Modbus registers (page 125)

2.14 DNP3 protocol

DNP3 protocol is an optional feature and requires a license. If a license is not installed on the DGA monitor, you cannot enable the protocol.

OPT100 DGA monitor provides the following functionality over DNP3 (Distributed Network Protocol):

- Latest measured values of measurement parameters and latest calculated rate of change (ROC) and gas ratio values are available as analog input points.
- Gas level alerts are available as binary input points.
- Time synchronization using DNP3 is supported. Note that time synchronization using DNP3 must be separately enabled, it is not automatically used.

DNP3 is supported over the Ethernet interface and the RS-485 interface, but DNP3 cannot be enabled for both interfaces at the same time.

You can download the DNP3 device profile in XML format from the **Settings > Network > DNP3** page of the user interface. It is needed to configure your DNP3 master system. A description of the interface is also available as a separate PDF document.

More information

‣ Setting date and time (page 58)

2.15 IEC 61850 protocol



IEC 61850 protocol is an optional feature and requires a license. If a license is not installed on the DGA monitor, you cannot enable the protocol.

Data measured by DGA monitor can be read using IEC 61850 protocol over the external Ethernet connection. IEC 61850 protocol can also be disabled if it is not needed.

The following supporting documents describe the data and functionality available through IEC 61850 protocol:

- IED Capability Description (ICD) file
- Protocol Implementation Conformance Statement (PICS)
- Model Implementation Conformance Statement (MICS)

You can download the documents from the OPT100 user interface at **Settings > Network > IEC 61850**.

2.16 Protocol test mode

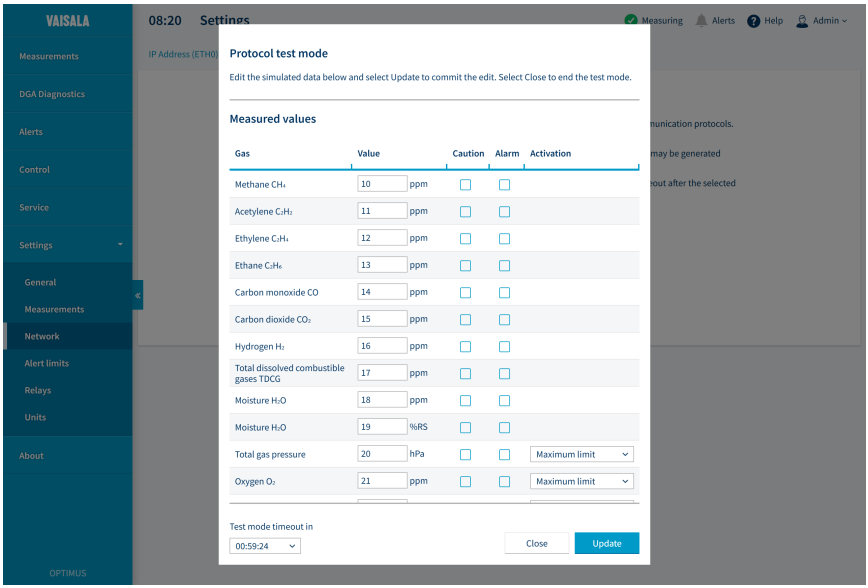


Figure 12 Protocol test mode enabled

Protocol test mode overrides the data that is available to communication protocols with arbitrary test data. The mode is useful for verifying proper handling of data and alarms when integrating the DGA monitor with a SCADA system. The recommendation is to use the protocol test mode during commissioning, after the required output protocols have been configured and enabled.

Protocol test mode can only be used by the **Admin** user. When the mode is activated, the user is presented with a page that shows default test values for each output parameter, and allows values and alert statuses to be changed as desired.

Clicking **Close** on the page ends the protocol test mode immediately. The user can also select to end the test mode after a timeout. The available timeout values are:

- 1 h
- 3 h
- 6 h
- 12 h
- 24 h
- No timeout

Be careful if you use the **No timeout** option, as DGA monitor will remain in the test mode indefinitely until it is manually closed.

When the test mode is enabled, normal measurement operation of the DGA monitor continues in the background. Only the data available through the digital output protocols is affected. When the mode ends, real measurement data and alert status are again available through the protocols.

More information

- Using protocol test mode (page 71)

2.17 Autocalibration

The autocalibration feature of the DGA monitor improves measurement performance by adapting the measurement to the individual oil conditions of the transformer. Autocalibration is implemented as special type of measurement cycles that vary the parameters of the vacuum gas extraction. The process typically completes in two days, but may take longer if ambient temperature is high. After autocalibration is completed, the measurement algorithm is adjusted according to the analysis results, and normal measurement cycles are automatically resumed.

DGA monitor makes use of autocalibration in the following ways:

Table 9 Types of autocalibration

Autocalibration type	Description	Notes
Initial autocalibration	Initial autocalibration runs automatically after a DGA monitor has been initialized and measurement started. Initial autocalibration cannot be skipped, and it must complete successfully for DGA monitor to operate normally.	Measurement results generated during the initial autocalibration may not be accurate. Gas level alerts are not indicated during initial autocalibration via any means, including relays.
Secondary initial autocalibration	Two days after the initial autocalibration, a secondary initial autocalibration runs in verification of the first one. Normal measurement performance is already achieved after finishing the first initial autocalibration.	

Autocalibration type	Description	Notes
Manually started autocalibration	One-time autocalibration that is started manually by the **Admin** user.	Recommended after: • Transformer degassing or oil change • DGA monitor software update • DGA monitor repair if components of measurement electronics have been replaced
Automatically started autocalibration	DGA monitor performs autocalibration when needed and when environmental conditions are suitable. • For devices using ester liquid, automatic autocalibration is not performed when the ambient temperature is too cold. The approximate limit is 0 °C (32 °F).	Ensures the long term accuracy of measurement results as measurement conditions change and transformer oil ages. Typical interval between autocalibrations is one month. If automatically started autocalibration is not desired, the feature can be disabled by the administrator user.

Measurement results generated during autocalibration cycles are indicated with a light blue background in measurement graphs. They are also marked in the CSV data that is exported using the **Download Data** function. Total gas pressure (TGP) and nitrogen (N_2) are not calculated during autocalibration.

More information

▸ Configuring autocalibration (page 61)

3. User interface

3.1 Overview of user interface

DGA monitor runs a web server on its processing unit. The web server provides the user interface of the DGA monitor. Access the user interface through Ethernet and a web browser; no special software is needed.

Access rights are based on 2 fixed user accounts:

- **Admin**: full access for commissioning, configuration, and maintenance tasks. Requires password to log in. Browser session expires after 3 hours of inactivity.
- **User**: limited access for viewing data and system settings. Cannot configure or control the DGA monitor. Does not require a password. Browser session expires after one year of inactivity.

The same Ethernet network that connects to the SCADA system is used to access the user interface. Additionally, local access to the interface is provided by direct access to **ETH1** port of the processing unit.

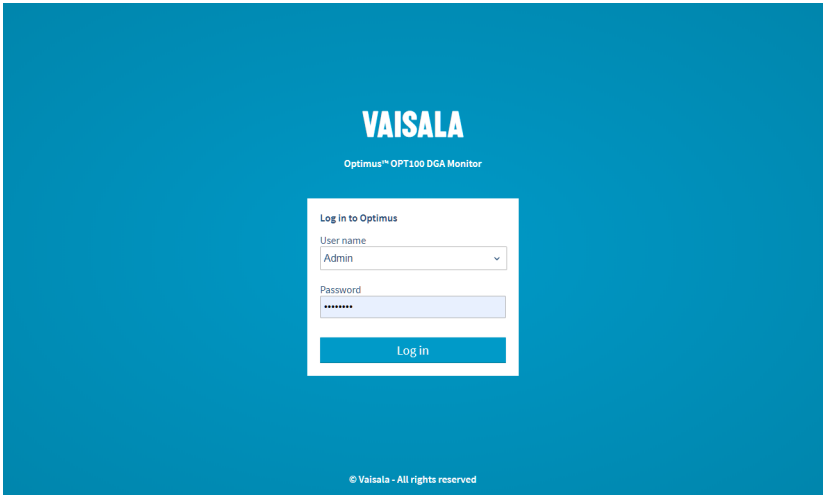
3.1.1 Connecting to user interface



- Laptop computer with:
  - RJ45 Ethernet connector
  - Web browser (Google Chrome, Microsoft Edge, or Mozilla Firefox)
- Ethernet cable with RJ45 connectors for temporary use
- Administration password for this DGA Monitor

1. Connect your computer to the same network as the DGA monitor. If you are connecting locally, connect the network cable between your computer and the port marked **ETH1** on the processing unit inside the DGA monitor.
2. Open a web browser, and enter the IP address of the DGA monitor in the address bar:
   - If you connect locally through the ETH1 port, use the following IP address: **192.168.28.2**
   - If you connect through the network meant for SCADA integration, use the IP address that has been assigned to the DGA monitor.
3. You will get a warning that your connection is not secure. This is expected and happens when connecting with a new device. The user interface of the DGA monitor is secured with a self-signed certificate by default. Continue despite the warning. HTTPS traffic is always encrypted even if the certificate is not trusted.

4. Choose the appropriate user level:
   - Select **Admin** to perform installation and maintenance tasks.
   - Select **User** to view data without making changes to the system.



5. If logging in as **Admin**, enter the password. The unique administration password of the DGA monitor is included in the delivery documentation but note that it can be changed by the **Admin** after a successful login.

   No password is required for the **User** account.
6. Select **Log in**.

3.1.2 User interface basics

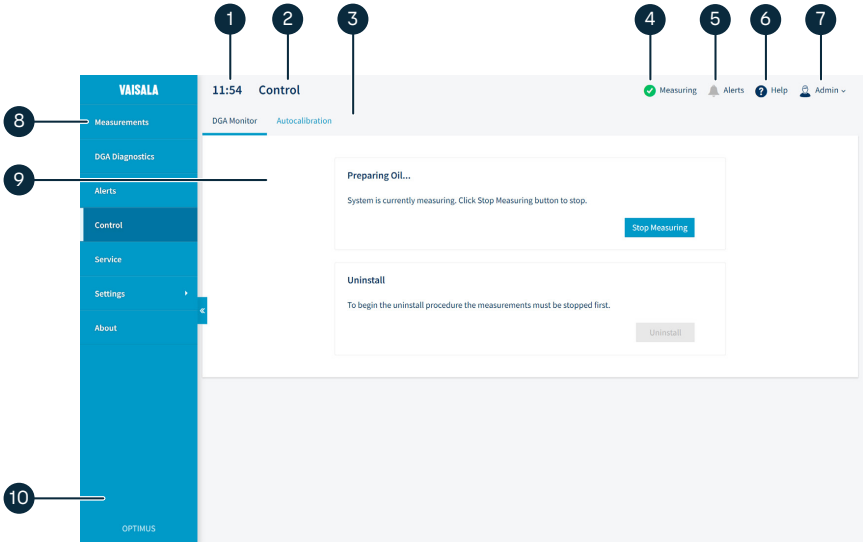


Figure 13 Elements of the DGA monitor user interface

1 Current time of the DGA monitor, adjusted to the browser's time zone. DGA monitor keeps UTC time (Coordinated Universal Time) internally.
2 Name of the currently selected user interface page
3 Navigation for subpages (if any)
4 Status indicator
5 Alert indicator
6 Access to locally stored online help system
7 Name of currently user account, and controls for password change (admin only) and logging out
8 Navigation menu
9 Content area for user interface pages
10 If device name has been set, it is shown here

3.1.2.1 Status indicator

Status indicator shows the current status of the DGA monitor. It is placed in the header at the top of the user interface.

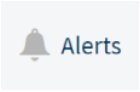
For a DGA monitor that is operating normally and performing measurement, the status is **Measuring**.

More information

- System statuses (page 93)

3.1.2.2 Alert indicator

Alert indicator shows the presence of active alerts. The colors of the indicator change according to the severity of the most severe currently active alert:



Light gray background:
no active alerts.



Orange background:
gas caution or device warning active.



Red background:
gas alarm or device error active.

Select the alert indicator to open the **Alerts** page.

3.1.2.3 Messages

User interface of the DGA monitor will display important information as messages at the top of the user interface.

- **Alert summary**: A summary of currently active alerts is shown when a user logs in to the user interface. If any alerts are active, proceed to the **Alerts** page to look up detailed information about the alert(s).
- **Changes to DGA monitor settings**: Success or failure of a settings change is indicated with a message.
- **Other notifications**: Any other messages from the DGA monitor. For example, a message will be shown when a new measurement cycle has been completed.

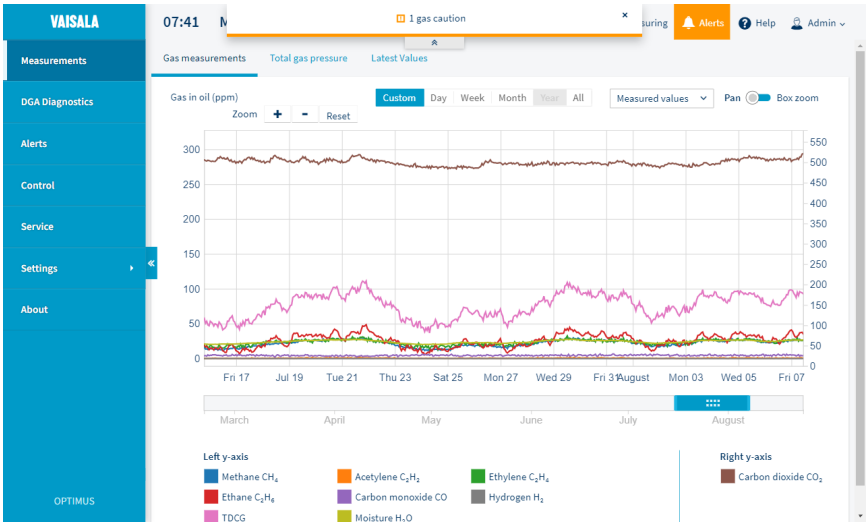


Figure 14 Alert summary message being shown

3.1.3 Measurements page

Measurements page provides views into the measurement data in graphical and tabular formats. If you have oxygen and nitrogen measurement, **Measurements** pages differ from the user interface presented here.

Gas measurements tab shows the primary graph view.

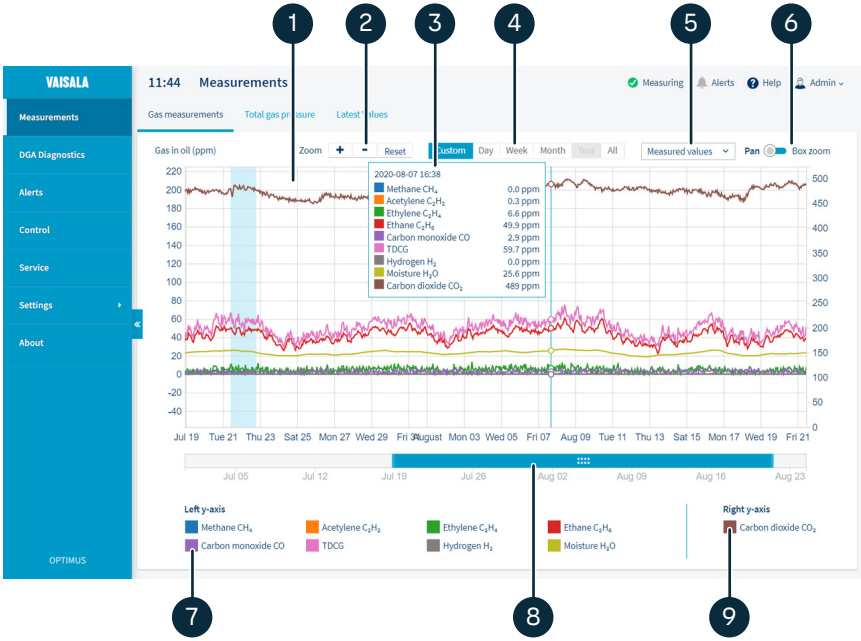


Figure 15 Measurement graph

1 Graph area. Measurement data created during autocalibration is marked with a light blue background.
2 Zoom factor controls for y-axes. You can also use the mouse wheel to adjust the zoom level.
3 Pop-up that shows the values at the point below the cursor.
4 Quick selection buttons for preset time windows.
5 Drop-down menu for selecting the parameter set that is shown.
6 Control for selecting the behavior of the graph when you click and drag over the graph area. **Pan** moves the graph while keeping the same zoom level, **Box zoom** zooms in to the highlighted area when you release the mouse button.
7 Parameters that are shown on the left y-axis. Select the color tab to show or hide a parameter.
8 Time slider for selecting the time window shown in the graph area. To adjust the size of the time window, drag the edges of the slider. To move the time window, drag the slider.
9 Measurement parameters on the right y-axis. Drag individual parameters to this area to show them on the right y-axis. This is useful when one of the parameters has a different range of values than the rest.

Graph lines show empty gaps if data is missing from 2 consecutive measurement cycles or for more than 3 hours. Data may be missing for several reasons. For example, DGA monitor may have been turned off, in standby mode, or measurement cycles have not produced reliable results for some or all measurement parameters.

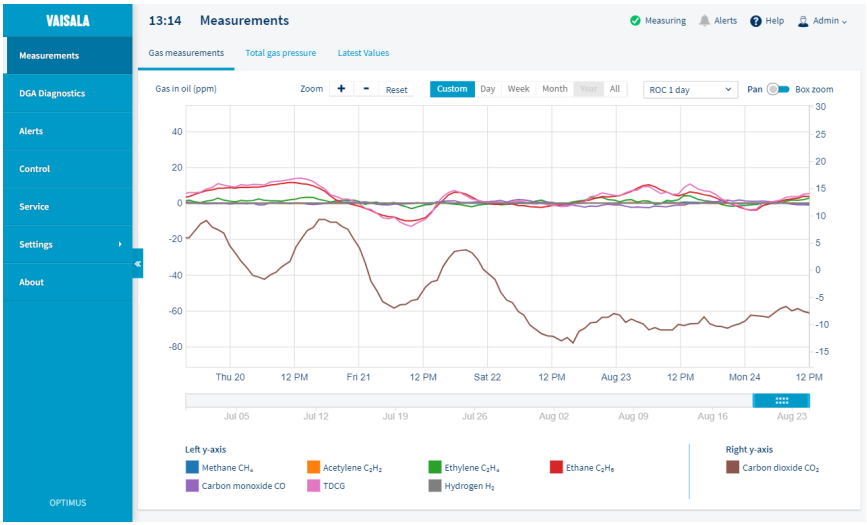


Figure 16 Measurement graph for 1 day rate of change values

Total gas pressure or **Atmospheric gases** tab shows the total gas pressure measurement graph. Pressure measurement data is not provided during autocalibration cycles.

You can change the pressure unit that is used to display the graph on page **Settings > Units**.

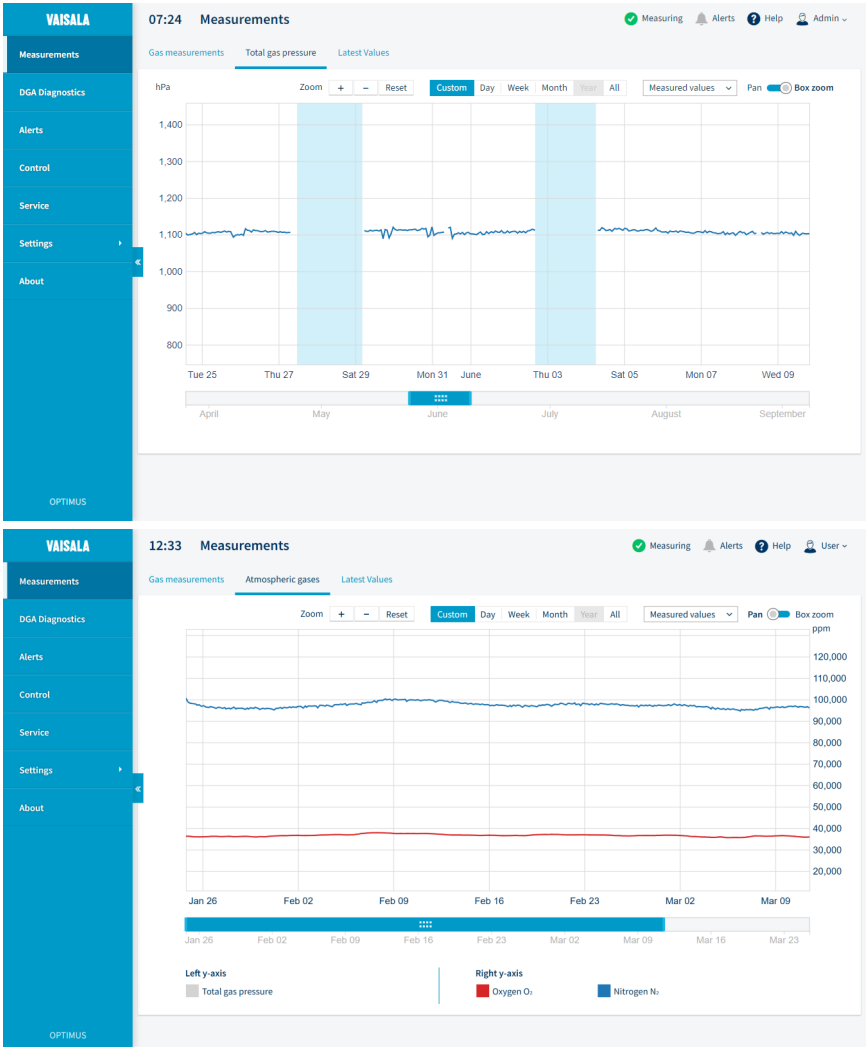


Figure 17 Total gas pressure / Atmospheric gases graph

Atmospheric gases tab is visible when you have oxygen measurement included in your device.

Latest values tab shows the latest measured and calculated values as a single table. To download all of the measured data into a file, select **Download Data** at the bottom of the page. The format of the file is CSV (comma separated value), and you can easily import it into common spreadsheet programs.

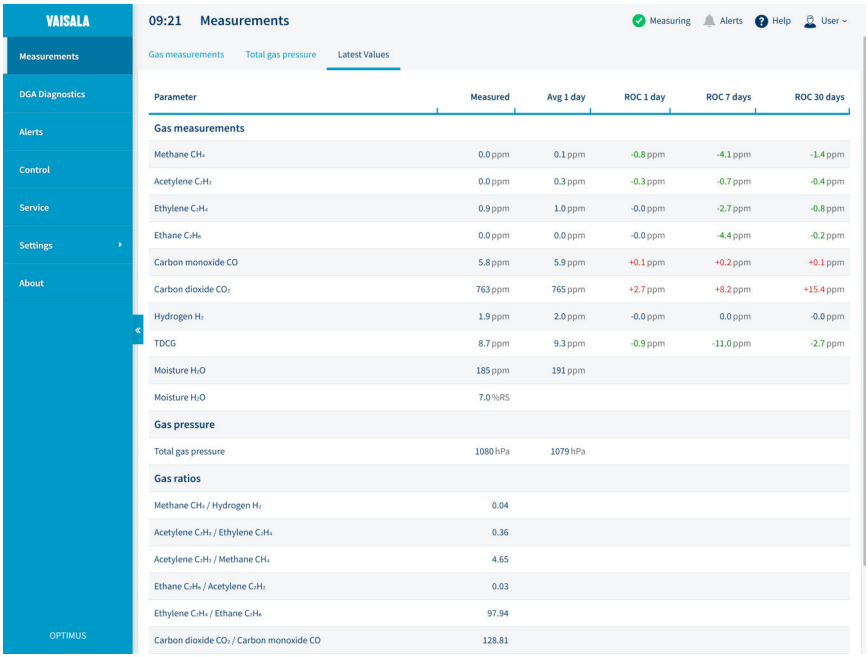


Figure 18 Table of latest values

3.1.3.1 Criteria for calculating gas ratios

Gas ratios are calculated from 24 h average values of the gases. See the gas ratios used in Table 5 (page 15). In the user interface, gas ratios are visible in **Measurements > Latest values**.

Gas ratios must meet the following criteria to be calculated:

- At least 5 reliable measurement points must exist in the previous 24 hours. Reliability criteria are the same as for gas alert functionality.
- Concentration of both gases in the ratio must be higher than the limits based on OPT100 field performance.

Table 10 Data point selection criteria

Gas	Limits based on OPT100 field performance (ppm)
Acetylene (C_2H_2)	2

Gas	Limits based on OPT100 field performance (ppm)
Methane (CH_4)	10
Ethane (C_2H_6)	10
Ethylene (C_2H_4)	10
Carbon monoxide (CO)	10
Carbon dioxide (CO_2)	10
Oxygen (O_2)	200
Nitrogen (N_2)	5000
Hydrogen (H_2)	15

3.1.4 DGA diagnostics page

CAUTION! This software utilizes publicly available and commonly used dissolved gas analysis (DGA) method for transformer fault diagnostics purposes, Duval Triangles (IEC 60599, Annex B).
Customer acknowledges and agrees that Vaisala shall not assume any risk or liability in connection with the use or application of the diagnostics data by the Customer or any other user of such data. The use and/or application of any such data shall be at the sole risk and liability of the Customer or the user.

DGA Diagnostics is an optional feature and requires a license.



Figure 19 Duval triangles on the DGA diagnostics page

DGA Diagnostics page shows the progression of selected data points from the past year overlaid on top of Duval triangles:

- **Triangle 1**: Classic Duval triangle for DGA in oil-filled transformers using methane, ethylene, and acetylene
- **Triangle 3 for synthetic ester liquids**: Duval triangle for DGA in synthetic ester filled transformers using methane, ethylene, and acetylene [1)]
- **Triangle 3 for natural ester liquids**: Duval triangle for DGA in natural ester filled transformers using methane, ethylene, and acetylene [2)]
- **Triangle 4**: Diagnosis of low-temperature faults in oil-filled transformers using hydrogen, methane, and ethane
- **Triangle 5**: Diagnosis of low-temperature faults in oil-filled transformers using methane, ethylene, and ethane

Only Triangle 3 is visible in DGA monitors with ester liquid.

1) *Triangle 3 for synthetic ester liquids applies primarily to Midel 7131. It should apply to Cargill Environtemp 260/300 as well, but it is not verified.*
2) *Triangle 3 for natural ester liquids applies primarily to FR3. It should apply to other soy bean natural esters as well, but it is not verified.*

DGA monitor automatically selects the data points according to criteria described in section Criteria for data points in DGA diagnostics (page 48). The data points are listed in a table below the triangles. Clicking a table row highlights the data point in the overlay and displays the gas ratios as percentages.

3.1.4.1 Criteria for data points in DGA diagnostics

DGA Diagnostics view shows up to 26 data points from the past year. A data point that meets selection criteria is automatically selected at roughly two week intervals. If less than one year of data is available, all of the data is used.

The data points are 24 hour average values for the included gases and must meet the following criteria for each point:

- At least 5 reliable measurement points must exist in the previous 24 hours. Reliability criteria are the same as for gas alert functionality.
- At least one of the following conditions is true:
  - Concentration of all triangle 1 gases is higher than limits based on OPT100 field performance, as listed in Table 11 (page 48)
  - At least one of the triangle 1 gases is above the limit based on IEC 60599 as listed in Table 11 (page 48)

Table 11 Data point selection criteria

Gas	Limits based on OPT100 field performance (ppm)	Limits based on IEC 60599
Acetylene (C_2H_2)	2	4
Methane (CH_4)	10	30
Ethane (C_2H_6)	10	30
Ethylene (C_2H_4)	10	30
Hydrogen (H_2)	15	50

NOTICE! Data points are original measurements, not offset values.

3.1.5 Alerts page

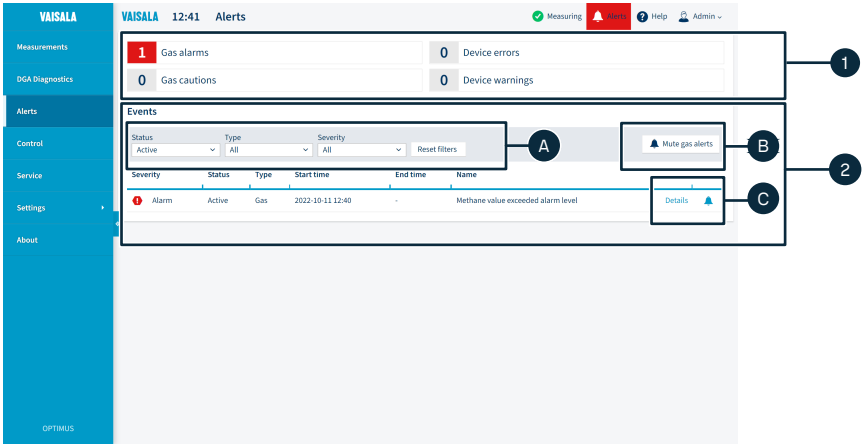


Figure 20 Alerts page with active gas caution alert

Alerts page shows the current alert status of the DGA monitor.

1. View number of currently active gas level alerts and device alerts by severity.
2. See **Events** section for more information on the individual alerts. By default, only active alerts are listed.
   a. To control what is shown, select the desired options for **Status**, **Type**, and **Severity**.
   b. To temporarily suppress gas level alerts, press **Mute gas alerts**.
   c. To view detailed information on a listed event, select **Details**. Details depend on the type of alert being viewed. Details for device alerts include information on resolving the alert.

You can also configure custom gas level alerts.

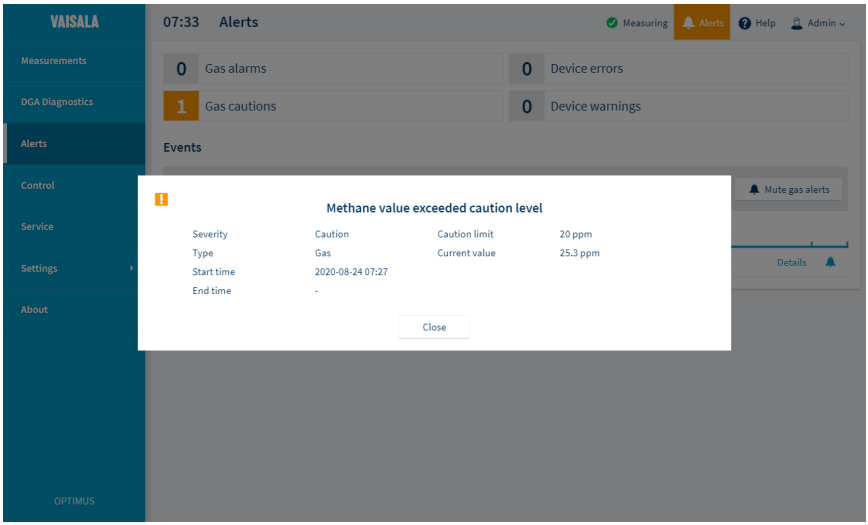


Figure 21 Event details for a gas caution alert

More information

- Configuring gas level alerts (page 62)
- Muting gas level alerts (page 63)

3.1.6 Control pages

DGA Monitor page shows current status of the DGA monitor and contains the controls for initialization, starting and stopping the measurement, and uninstalling the DGA monitor. Only relevant controls are shown, and they can only be used by the **Admin** user.

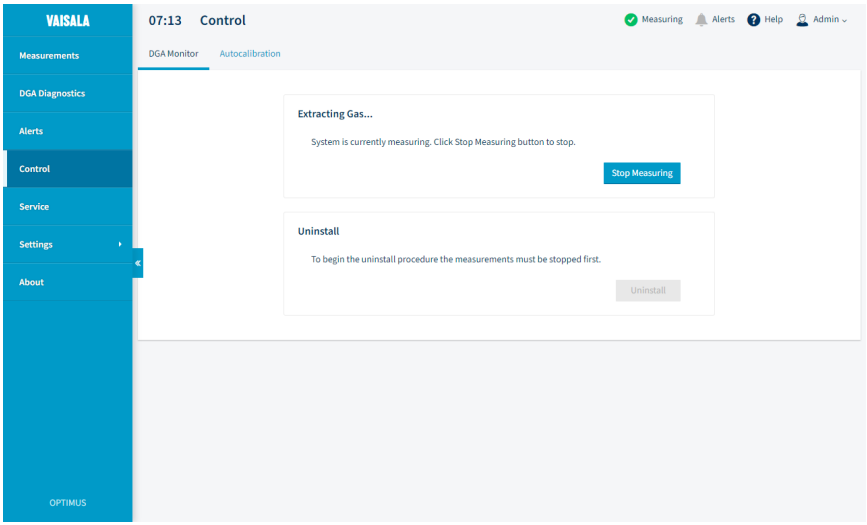


Figure 22 DGA monitor Control page

Autocalibration page shows current status of autocalibration and a history of autocalibration events. **Admin** user can configure the automatically started autocalibration on this page and also start a manual autocalibration cycle.

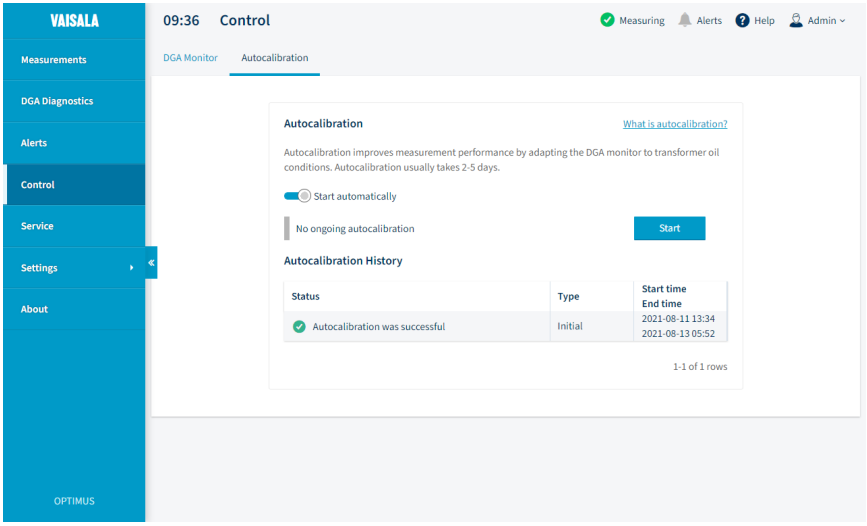


Figure 23 Autocalibration page

3.1.7 Service pages

Service pages provide tools for servicing the DGA monitor, troubleshooting problems, and recovering from error states:

- **Diagnostics package** tool generates a diagnostic file package for use by Vaisala. The package can be used by Vaisala support to diagnose any issues you may have with the DGA monitor.
- **Bleeding** tool is used to bleed excess gas out of the DGA monitor. Running this tool is only necessary if a device alert indicates the presence of excess gas in the system.
- **Pressure tightness** tool is used to test the pressure tightness of the oil block and measurement module after replacing DGA monitor components.
- **Configuration package** tool is used for installing a customized configuration package that has been sent by Vaisala.
- **Software update** tool is on its own tab. To update the software version of the DGA monitor, contact Vaisala technical support to get the software update file.

- **Service log** tool is on its own tab. Use the tool to view recent service actions.

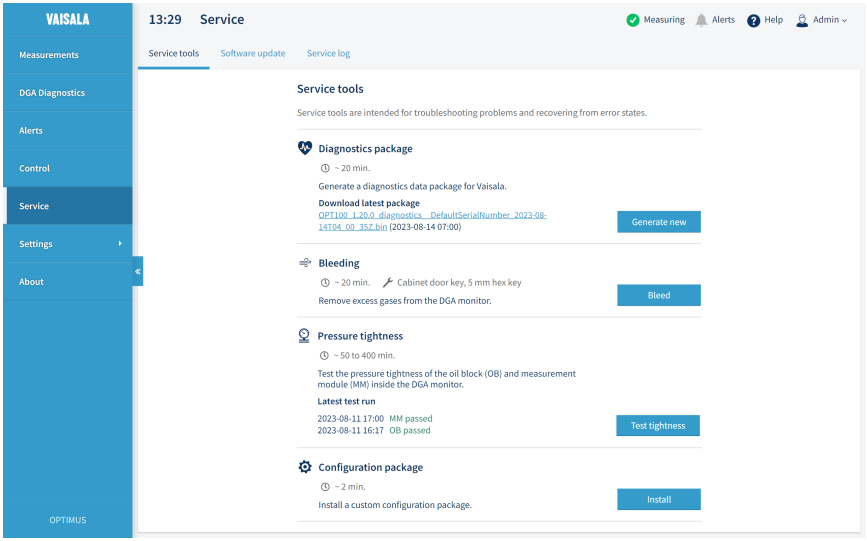


Figure 24 Service tools page

3.1.8 Settings pages

Settings pages provide access to the configuration options of the DGA monitor. Settings can only be changed by the **Admin** user.

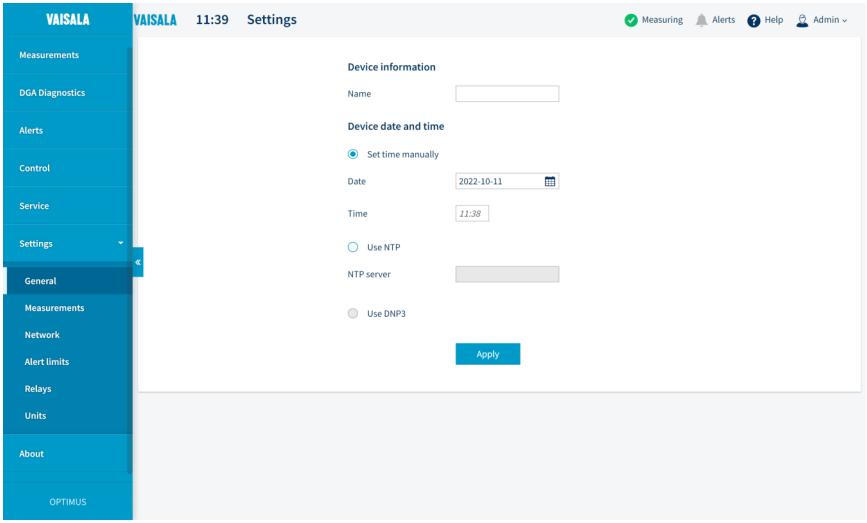


Figure 25 Settings page

3.1.9 About page

About page shows the serial number, software version, and insulation liquid type of the DGA monitor.

If you are logged in as **Admin** you can Select **View** to see the software license texts of the open source components used in the DGA monitor software.

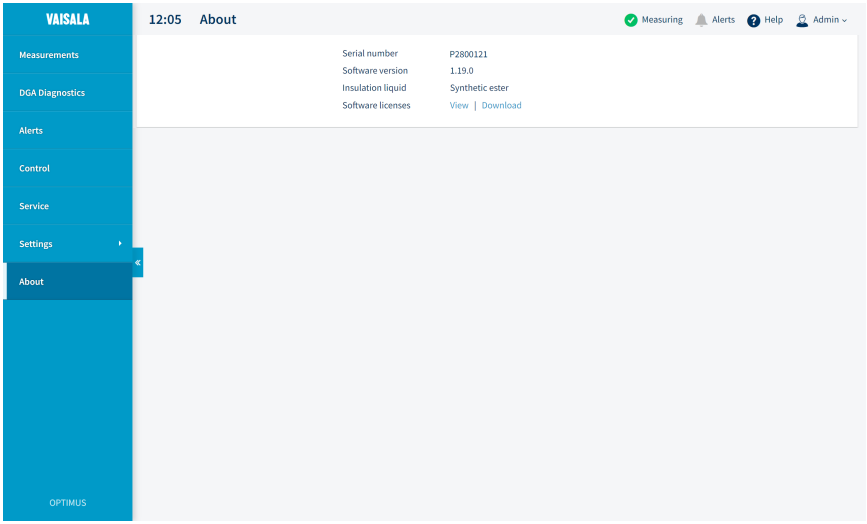


Figure 26 About page

3.2 Changing administrator password

CAUTION! If you forget your administrator password, contact Vaisala Support to reset it for you.

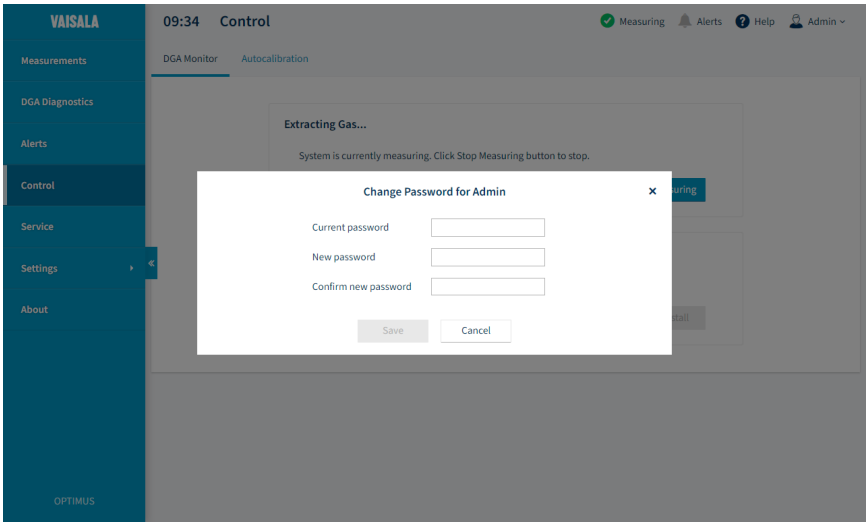
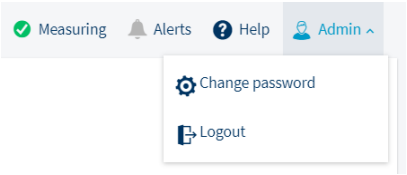


Figure 27 Changing administrator password

1. Connect to the user interface as the **Admin** user.
2. In the top right corner, select **Admin > Change password**.



3. Enter the current password in **Current password**.
4. Enter the new password in **New password** and **Confirm new password**.

   The new password must be at least 8 characters long.
5. Select **Save**.

More information

- Connecting to user interface (page 37)

3.3 Starting measurement

In normal operation DGA monitor repeats the measurement cycle continuously. You can only start the measurement if DGA monitor is currently in standby.

1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Start measurement from **Control > Start Measuring**.

DGA monitor warms up during the first three measurement cycles. Measurements made during the warm-up cycles are not guaranteed to be within the accuracy specification.

3.4 Setting device name

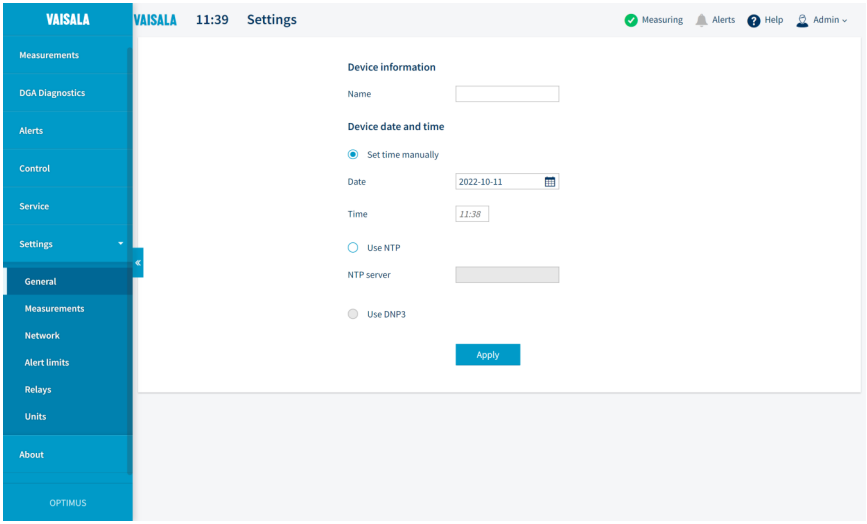


Figure 28 General settings page

You can give a name to the DGA monitor to help identify it. If the name is set, it is shown in:

- Login page
- Above the Optimus text in the navigation menu
- Names of files downloaded from the user interface

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > General**.
3. Enter a name for the device into **Name**. Maximum length is 64 characters. You can use alphanumerical characters, space, hyphen "-", and underscore "_".

4. Select **Apply** to save the name.

More information

- Connecting to user interface (page 37)

3.5 Setting date and time

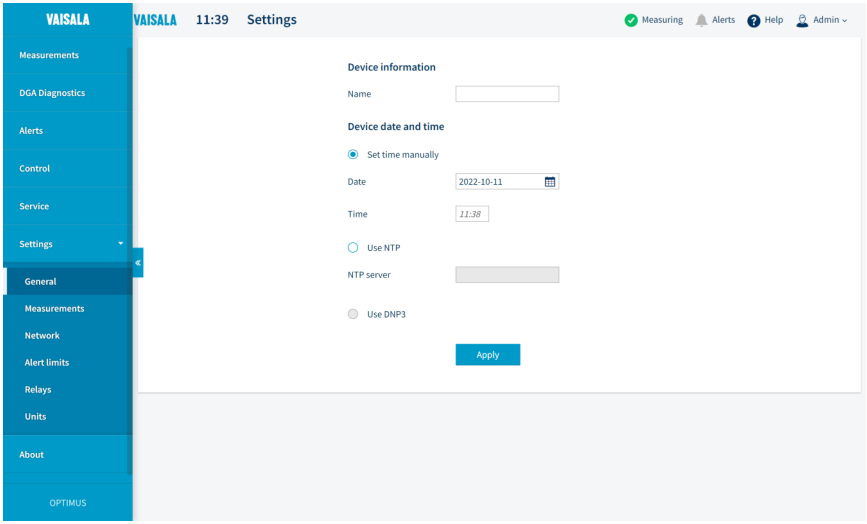


Figure 29 Date and time settings page

DGA monitor uses UTC (Coordinated Universal Time) internally. Time and time stamps in the user interface are shown according to the time zone of the connecting web browser.

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > General**.
3. To set date and time manually:
   a. Select **Set time manually**.
   b. Select or enter the current date into **Date**. The format is yyyy-mm-dd.
   c. Enter the current time into **Time**. The field is in 24-hour clock notation in format hh:mm.
   d. Select **Apply** to save the set time.

4. To set up time synchronization with a Network Time Protocol (NTP) server:

   > NTP synchronization requires that the network connection is configured and the IP address of the NTP server is reachable.

   a. Select **Use NTP**.
   b. Enter the IP address of the NTP server into **NTP server**.
   c. Select **Apply** to start time synchronization.

      Status of time synchronization is shown below the **NTP server** field. If the status shows **Connecting...** and does not progress to **Synchronizing time...** even after waiting for a minute, verify that the network connection is working and configured, and the IP address of the NTP server is correctly entered.
   d. Wait for the message **Time successfully synchronized** to appear.
5. To set up time synchronization using DNP3 protocol:
   a. Enable and configure the DN3 protocol.
   b. Select **Use DNP3**.
   c. Select **Apply** to start time synchronization.

More information

- Connecting to user interface (page 37)
- Configuring DNP3 protocol (page 68)

3.6 Configuring unit settings

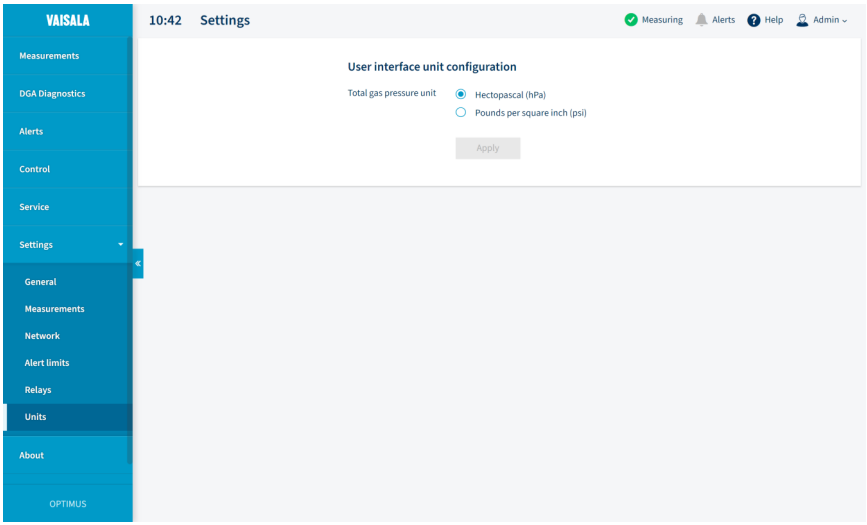


Figure 30 Unit settings page

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Units**.
3. Select the preferred unit to use for total gas pressure (hPa or psi). This selection only affects the viewing of the user interface and the downloading of data from the **Latest values** page.
4. Select **Apply** to save the selection.

More information

- Connecting to user interface (page 37)

3.7 Configuring autocalibration

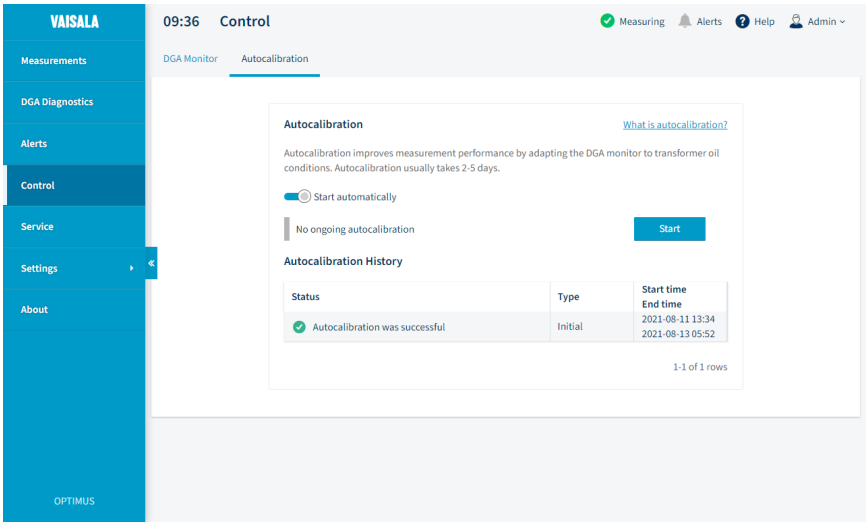


Figure 31 Autocalibration page

Starting with software version 1.11.0, the DGA monitor performs autocalibration when needed and when environmental conditions are suitable. Vaisala recommends leaving this feature enabled, but **Admin** user can disable it from the **Autocalibration** page.

Even if the automatically started autocalibration is disabled, the initial autocalibration will still run after the DGA monitor has been initialized. Autocalibration can also be manually started.

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Control > Autocalibration**.
3. Configure the setting with the switch:
   - Disable automatically started autocalibration by moving the switch to the left.
   - Enable automatically started autocalibration by setting the switch to position **Start automatically**.

More information

- Autocalibration (page 35)
- Connecting to user interface (page 37)

3.8 Configuring gas level alerts

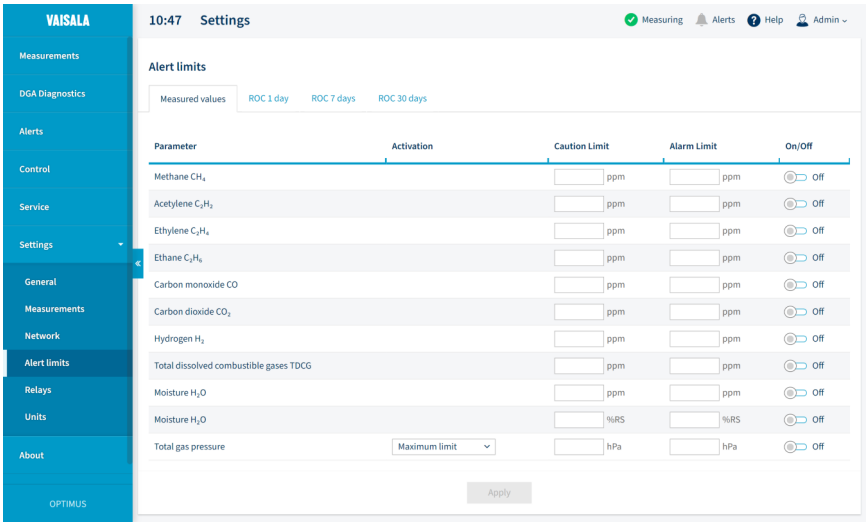


Figure 32 Alert limits settings page

Configure gas level alerts on the **Alert limits** settings page. There are separate rows for each individual gas level alert. Alerts for rate of change (ROC) values are on their own tabs. By default, all gas level alerts are off.

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Alert limits**.
3. For each alert you want to configure:
   a. Change to the tab that shows the alert you want to configure.
   b. Enter the **Caution Limit** in ppm. This is the limit that triggers a gas alert with caution severity.
   c. Enter the **Alarm Limit**. Alarm limit should be higher than the caution limit, except when configuring a minimum limit alert for total gas pressure (TGP).
   d. If the alert is for the total gas pressure (TGP), oxygen or nitrogen value, select if you want the limit value to be a **maximum limit** (alert active when value is above the limit) or a **minimum limit** (alert active when value is below the limit).
   e. Set the alert to **On** to enable it.

   It is possible to have only caution or alarm severity active. If you leave a limit value empty or enter a zero, the corresponding severity will not be active for that gas level alert.

4. Select **Apply** to take the new alert limit settings into use.

> Changing gas alert settings will not immediately activate any new alerts. Gas alert status is updated only when the next measurement cycle results set is ready.

More information

- Connecting to user interface (page 37)

3.9 Muting gas level alerts

Muting gas level alerts temporarily disables any indications that any gas level alerts are active:

- Alert indicator in the user interface is set to non-alerting state (unless any device alerts are active)
- If one or more relays have been activated by gas level alerts, they are inactivated
- Status LEDs do not indicate that a gas level alert is active
- Output protocols do not communicate any gas level alerts as active (but will set appropriate status bits/flags to signal that gas level alarms are muted)

Admin user can mute gas level alerts by selecting **Mute gas alerts** on the **Alerts** page.

> Muting of gas level alerts continues until any one of the following occurs:
> - Severity of any muted gas level alert rises from caution to alarm
> - Any new gas level alert is activated
> - **Admin** user selects **Unmute gas alerts** on the **Alerts** page

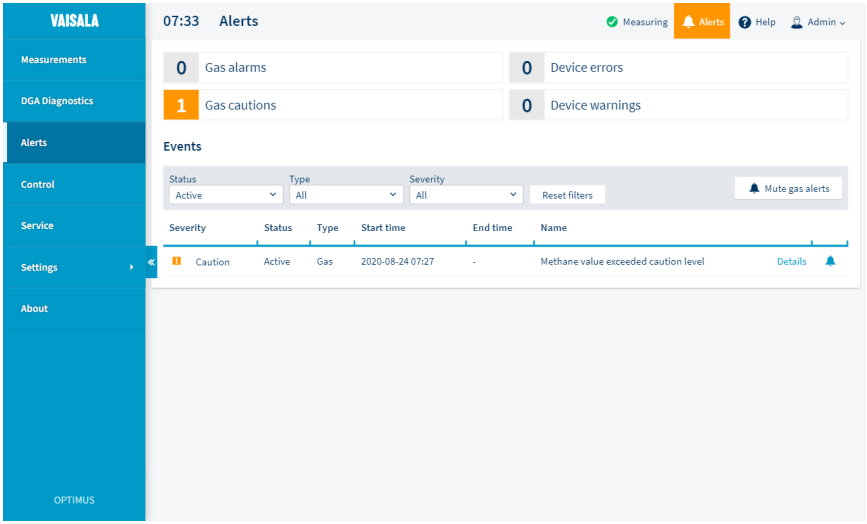


Figure 33 Alert page with methane caution alert visible

3.10 Configuring network connection

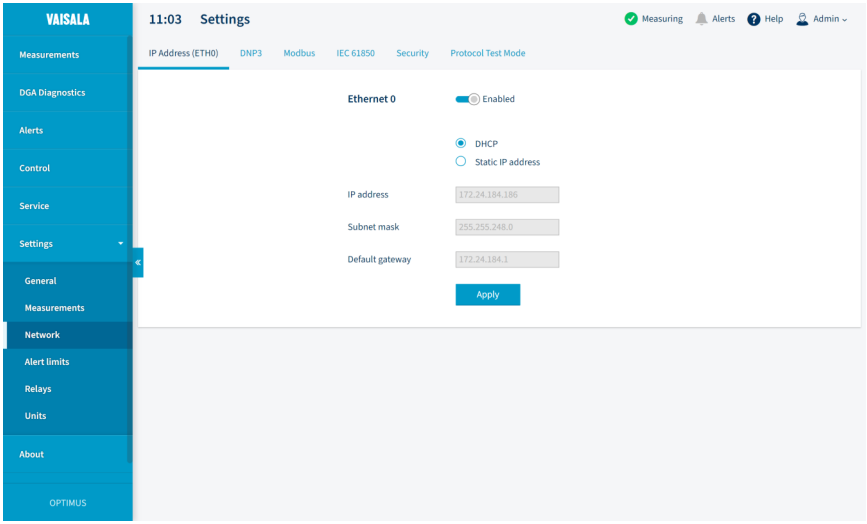


Figure 34 IP address settings page

Configure the network settings of the external Ethernet connection (ETH0).

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Network > IP address**.
3. Select if the external Ethernet connection should be **Enabled** or **Disabled**.
4. If you enabled the external Ethernet connection, select how its IP address is assigned: **DHCP** for automatic assignment, or **Static IP address** to enter the values manually.
5. If you selected **Static IP address**, enter the following values:
   - **IP address**
   - **Subnet mask**
   - **Default gateway**

   IP addresses in 192.168.28.0/24 cannot be used for the external network connection (ETH0) since they are reserved for the service port (ETH1).

6. Select **Apply** to save your changes.

More information

- Connecting to user interface (page 37)

3.11 Configuring user interface security

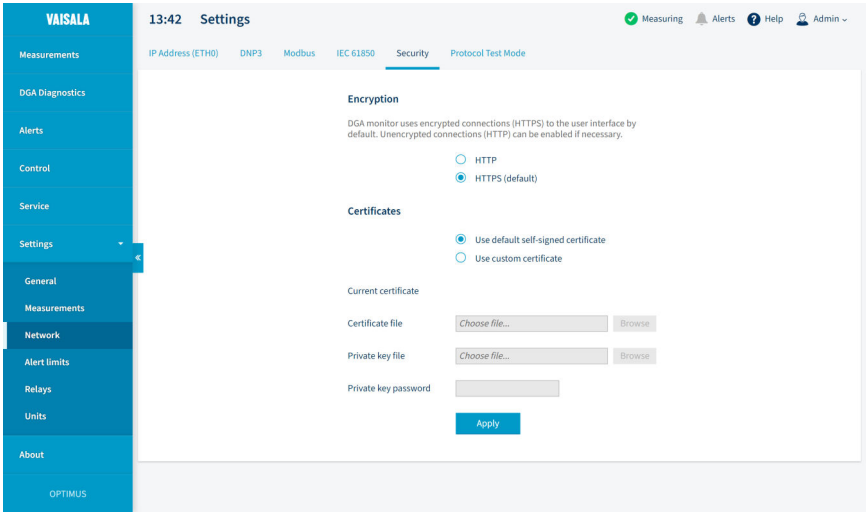


Figure 35 Network security settings page

Configure HTTPS encryption for the user interface connection. By default, DGA monitor only allows encrypted connections to the user interface (HTTPS) using a self-signed certificate. Any connections that request unencrypted communication (HTTP) are redirected to the encrypted interface (HTTPS).

The default self-signed certificate is not trusted by connecting web browsers and will give a warning that the connection is not secure. To remove the notification, install a trusted TLS certificate (TLS 1.1 or 1.2) on the DGA monitor. However, note that HTTPS traffic is always encrypted even if the certificate is not trusted. Vaisala recommends using encrypted connections (HTTPS).

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Network > Security**.
3. Select **HTTP** to use unencrypted user interface connections, or **HTTPS (default)** to secure the interface using encryption.
4. To use your own certificate with HTTPS connections:
   a. Select **Upload certificate**.
   b. Select **Certificate file > Browse** and locate the certificate file.
   c. Select **Private key file > Browse** and locate the private key file.
   d. Enter the **Private key password** if your private key requires it.
5. Select **Apply** to save your changes.

   If you change the security settings, the user interface will restart and you have to log in again.

More information

- Connecting to user interface (page 37)

3.12 Configuring Modbus protocol

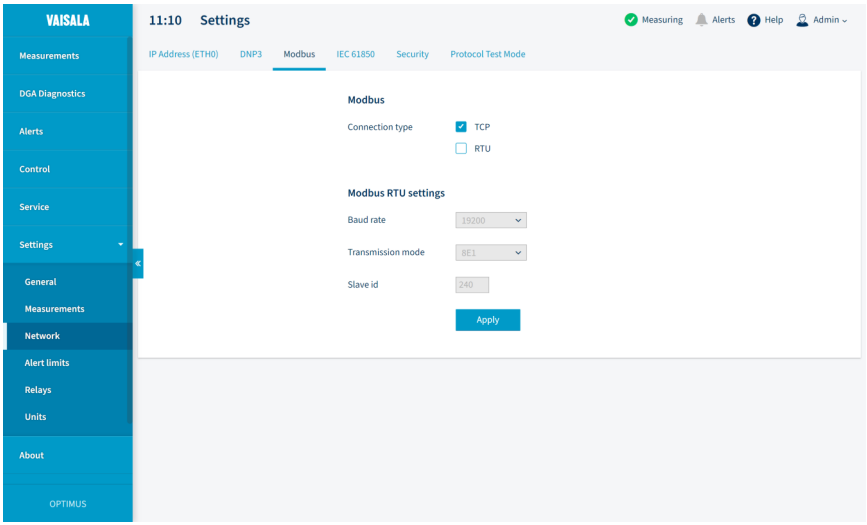


Figure 36 Modbus settings page

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Network > Modbus**.
3. Select the connection type(s) for which Modbus protocol should be enabled. Select **TCP** (Ethernet), **RTU** (serial line), or both.
4. If you enabled Modbus RTU, configure the serial connection:
   a. Select **Baud rate** for the connection. Available options are:
      - 4800
      - 9600
      - 19200
      - 38400
      - 57600
      - 115200
   b. Select **Transmission mode**, 8E1 or 8N2.
   c. Enter the Modbus **Slave ID** for the DGA monitor. Range 1–247.
5. Click **Apply** to save your changes.

More information

- Connecting to user interface (page 37)

3.13 Configuring DNP3 protocol

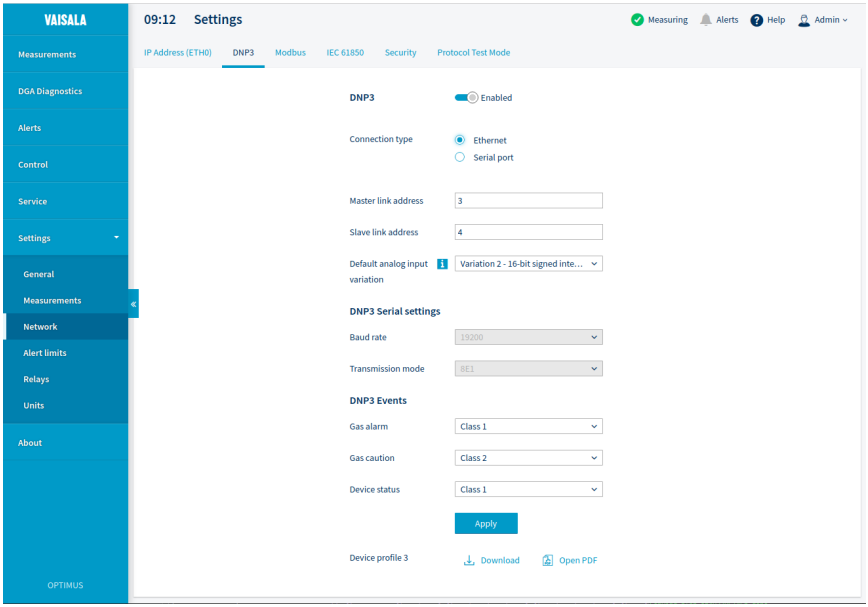


Figure 37 DNP3 settings page

DNP3 protocol is an optional feature and requires a license. If a license is not installed on the DGA monitor, you cannot enable the protocol.

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Network > DNP3**.
3. Select if the DNP3 protocol should be **Enabled** or **Disabled**.
4. If you enabled the DNP3 protocol, configure the following settings:

   Connection type
   Interface where DNP3 protocol will be available.

   Slave link address
   Address of this DGA monitor.

   Master link address
   Address of the DNP3 master.

   Default analog input variation
   Data format variation for analog input values. Variations 1–6 are available.

5. If you selected **Serial port** as the connection type, configure the following settings:

   Baud rate
   Baud rate of the serial connection. Available options are 4800, 9600, 19200, 38400, 57600, and 115200.

   Transmission mode
   Number of data bits, parity, and number of stop bits used in serial communication. Available options are 8E1 and 8N2.

6. Set the classes used for the **Gas alarm**, **Gas caution**, and **Device status** events.
7. Select **Apply** to save your changes.



Select **Download** to download the DGA monitor device profile in XML format. It is needed to configure your DNP3 master system.

More information

- Connecting to user interface (page 37)

3.14 Configuring IEC 61850 protocol

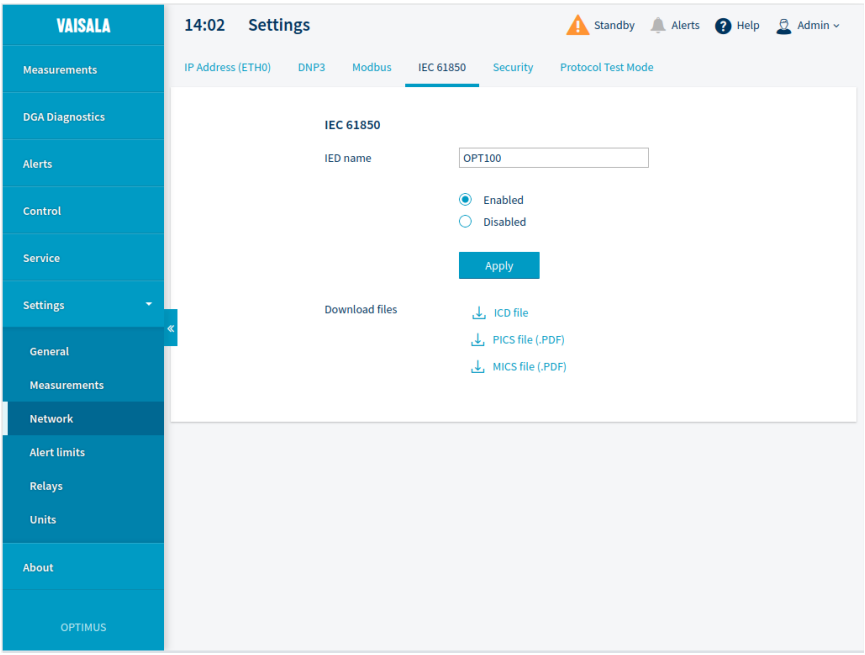


Figure 38 IEC 61850 settings page

IEC 61850 protocol is an optional feature and requires a license. If a license is not installed on the DGA monitor, you cannot enable the protocol.

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Network > IEC 61850**.
3. Select if the IEC 61850 protocol should be **Enabled** or **Disabled**.
4. Select **Apply** to save your changes.

Download the following supporting documents from this page:
- IED Capability Description (ICD) file
- Protocol Implementation Conformance Statement (PICS)
- Model Implementation Conformance Statement (MICS)

More information

- Connecting to user interface (page 37)

3.15 Using protocol test mode

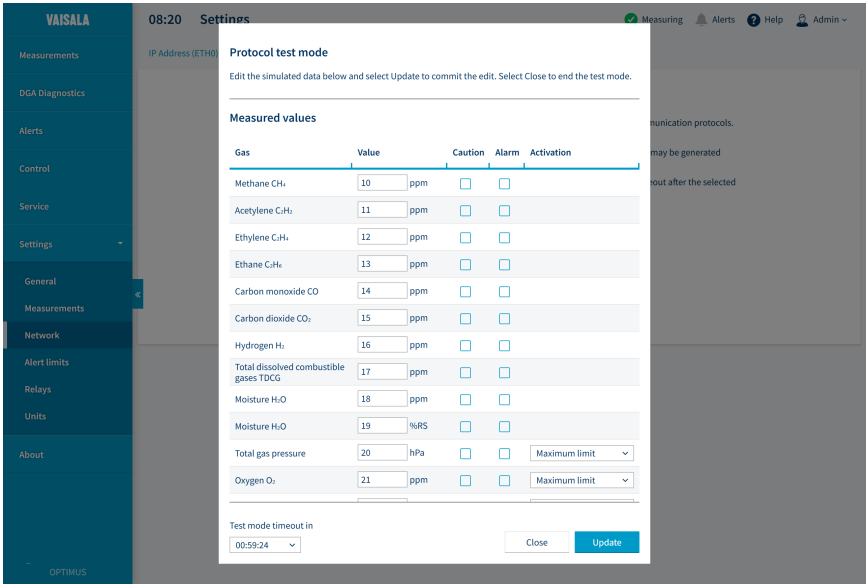


Figure 39 Protocol test mode enabled

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Network > Protocol Test Mode**.
3. Check the status of the protocols listed under **Protocols**. Make sure the protocols you want are enabled. If they are not, you must enable and configure them first before continuing this procedure.

4. Select **Start** to enable the protocol test mode and open the protocol test mode page.

   The page is preconfigured with arbitrary default values for measurement parameters. The values are all different to make it easy to verify on the SCADA side that the correct parameter is being read and displayed. Scroll the page to reveal all of the fields.

5. To set your own test data:
   a. Edit the values as required.
   b. Check the checkboxes to enable the desired caution and warning level alerts.
   c. Select **Update** at the bottom of the page to take the new test data into use.
6. The test mode will end automatically after one hour. You can select a longer timeout from the drop-down menu marked **Test mode timeout in**. Select **Update** to take the new timeout into use.
7. Start testing by reading information from the DGA monitor from the SCADA system side.
8. When you are done testing, select **Close** to end the test mode immediately or wait until the end of the timeout.

More information

- Protocol test mode (page 34)
- Connecting to user interface (page 37)

3.16 Configuring relays

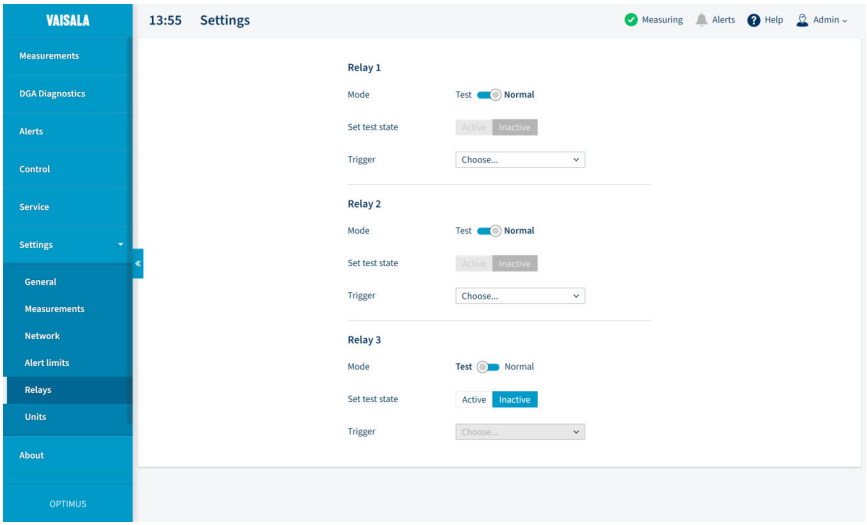


Figure 40 Relay settings page

1. Connect to the user interface as the **Admin** user.
2. In the user interface, select **Settings > Relays**.
3. Each of the three relays is configured individually. For each relay:
   a. Select relay **Mode**:
      - In **Normal** mode, the relay is activated by the selected **Trigger**.
      - In **Test** mode, the relay activation is controlled manually from the **Set test state** buttons.

      If the relay is not used, select the **Test** mode. You can also use it to test that wiring has been connected correctly.
   b. Select relay **Trigger**:
      - **Gas Caution** activates the relay if any gas level alert of **caution** severity is active.
      - **Gas Alarm** activates the relay if any gas level alert of **alarm** severity is active.
      - **Device Error** activates the relay if a device error is active.

   Settings are applied immediately.

More information

- Connecting to user interface (page 37)

3.17 Configuring offsets

Adjust reported values with offsets. Offsets are applied to the measured values as increments or decrements.

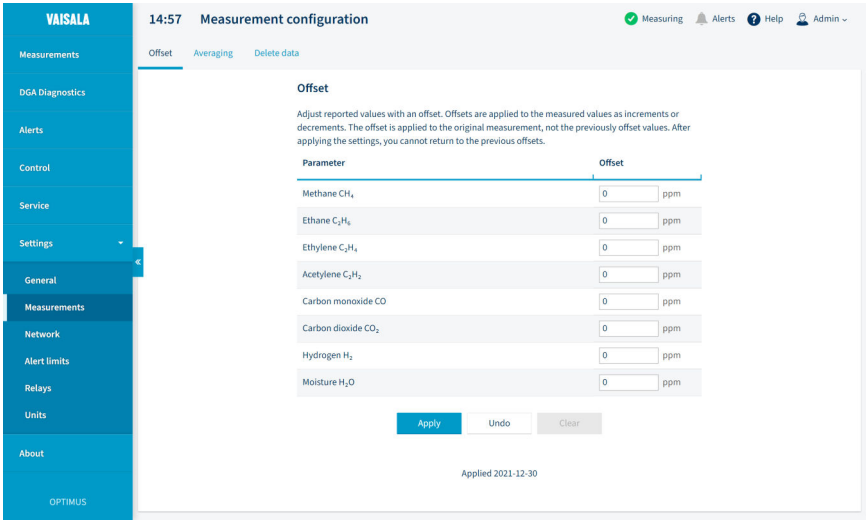


Figure 41 Configuring offsets in measurement settings

- **Apply** saves changes.
- **Undo** returns to previously applied offsets.
- **Clear** removes configured offsets.

1. Go to **Settings > Measurements > Offset**.
2. Calculate offsets. Offsets can be increments or decrements.

> **NOTICE!** New offset is applied to the original measured values, not previously offset values.

3. Fill values into all **Offset** fields.

4. Select **Apply** to save changes.

NOTICE! After applying the settings, you cannot return to the previous offsets. The previous offsets can be viewed in the data file.

To download history data, go to **Measurements > Latest values > Download Data**.

View offset values in **Measurements** page. **Offset** flag in the graphs shows when the newest offset has been applied. Offsets are added to measured values, 1 day averages, gas ratios and custom averages. Offset values are also shown in **DGA Diagnostics**.

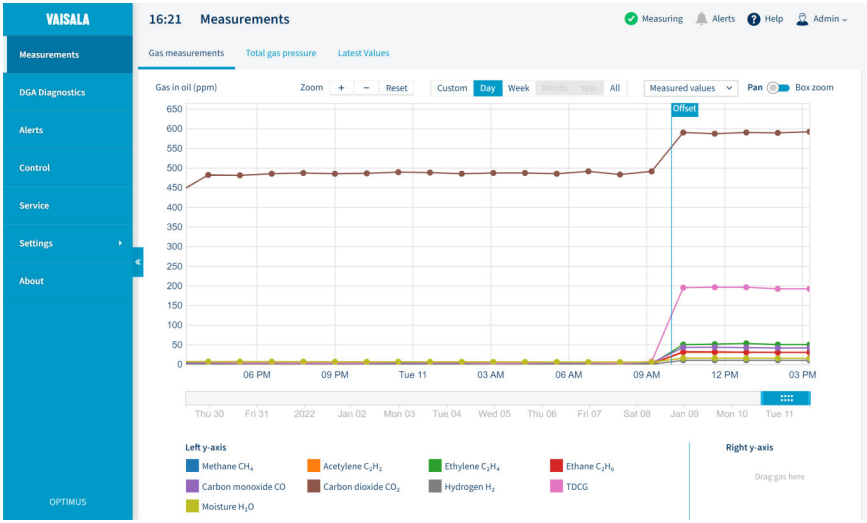


Figure 42 Offsets in Measurements

NOTICE! If you have set gas level alerts, offsets may cause additional alarms.

More information

- Configuring gas level alerts (page 62)

3.18 Configuring custom averages

Configure custom calculation of averages based on measurement points or time intervals. The values will be calculated to the new dataset separately from the default 24 h averages.

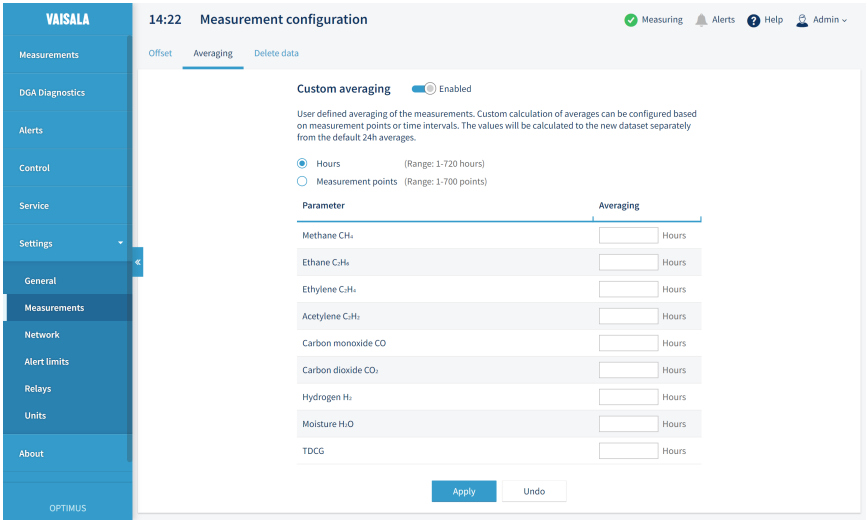


Figure 43 Configuring custom averages in measurement settings

1. Go to **Settings > Measurements > Averaging**.
2. Enable custom averaging.
3. Select **Hours** or **Measurement points**.
4. Add values into **Averaging** fields as needed.

   If a field is left empty, custom average for the particular gas is not calculated.
5. Select **Apply**.

View custom averages in **Measurements** page:

A. Go to **Gas measurements** tab and select **Custom averages** in the dropdown menu. **Avg** flag in the graph shows when the custom average has been set.

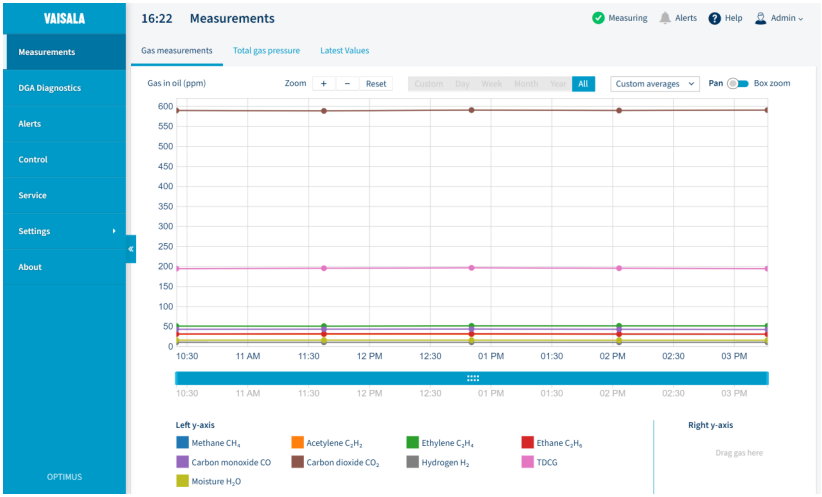


Figure 44 Custom averages in Measurements

B. In **Latest values** tab, you can see custom average values in a separate column.

To download history data, go to **Measurements > Latest values > Download Data**.

3.19 Deleting data

Delete all measurement data up to a selected date and time.

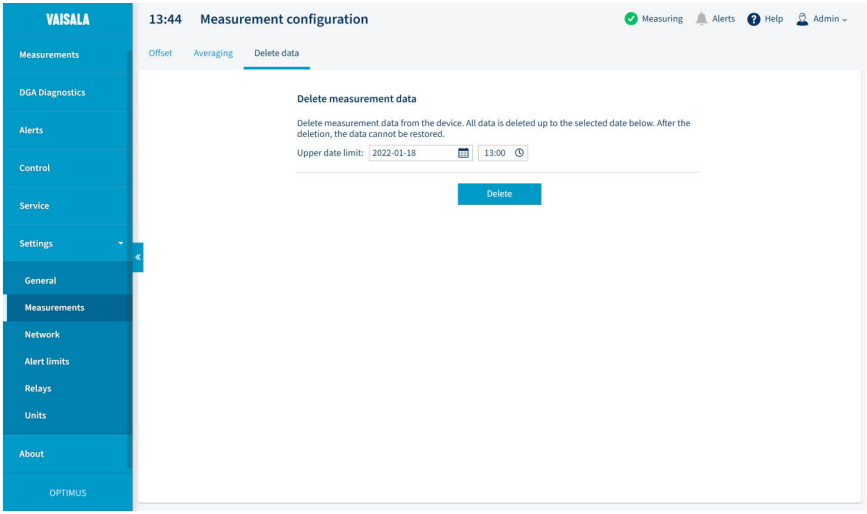


Figure 45 Deleting measurement data in settings

1. Go to **Settings > Measurements > Delete data**.
2. Select the date and time up to which you want to delete measurement data.
3. Press **Delete**.

NOTICE! After pressing **Delete**, data cannot be restored.

4. Maintenance

4.1 Maintenance

OPT100 DGA Monitor does not require visits to the installation site for preventive or periodical maintenance. There are no consumables or components that must be replaced according to a fixed schedule.

You can check the status of the DGA monitor and update its configuration remotely through the browser-based user interface. Indications of the DGA monitor's status are also available to your SCADA system through the communication interfaces (for example, Modbus).

4.2 Maintenance safety

WARNING! Keep away from live circuits. Operating personnel must observe safety regulations at all times.

WARNING! Ground the DGA monitor cabinets as instructed in the wiring instructions. Verify the grounding before and after performing maintenance on the unit.

CAUTION! Do not modify the DGA monitor or use it in ways not described in the documentation. Modifications may lead to safety hazards, equipment damage, failure to perform according to specification, or decreased equipment lifetime.

CAUTION! Surfaces inside DGA monitor that are marked with the symbol below heat up during normal operation. Avoid touching hot surfaces and wear protective gloves when working inside the cabinet. Whenever possible, allow the DGA monitor to cool down before starting the work.





Wear protective eyewear and gloves.

4.3 Cleaning DGA monitor

OPT100 DGA monitor does not need to be cleaned to maintain its normal operation. The enclosures are IP66 rated and measurement system is hermetically sealed. If a significant amount of contamination is present inside the enclosures, verify that:

- All cable glands fit tightly around cables, or are plugged if unused.
- Doors of the enclosures close properly.
- There are no oil leaks inside the DGA monitor.

4.4 Updating DGA monitor software

- Software update file for DGA monitor

CAUTION! Software update may change the settings of your DGA monitor. This is necessary as new features are added and settings of previously existing features are updated. After a successful software update, go through the pages in the **Settings** menu. For example, verify that the necessary communication protocols are enabled and their settings are correct.

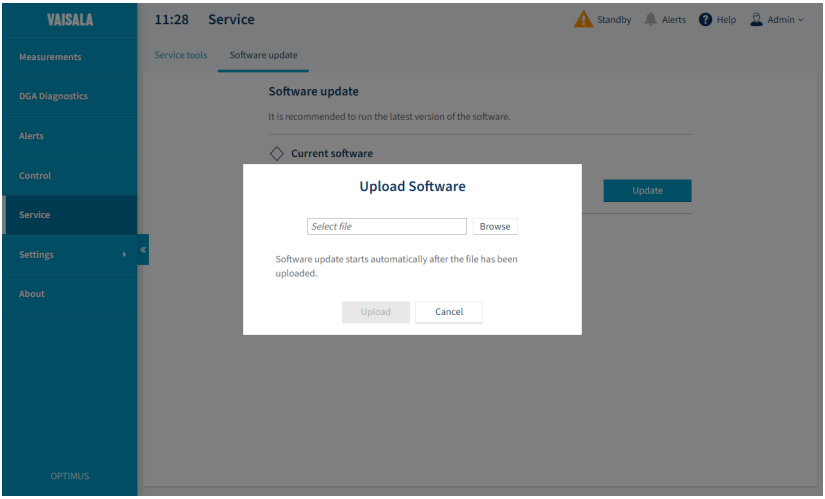
Updated software may include improvements to the measurement algorithm. These updates are only applied to new measurement cycles after the update, which may cause some discontinuity in the measured gas levels even if the concentration of gases in the measured oil has not changed. Vaisala recommends starting autocalibration manually after a software update.

Software update does not delete the measurement data stored on the DGA monitor.

Follow these instructions to update DGA monitor software. The DGA monitor software can be updated remotely.

1. Connect to the user interface as the **Admin** user.
2. Switch the DGA monitor to **Standby** mode by stopping measurement.
3. Verify that date and time on the DGA monitor are set correctly.
4. Wait for DGA monitor to stop and enter the **Standby** mode. Depending on the stage in the measurement cycle, stopping may take up to 60 min.
5. Select **Service > Software update > Update > Browse** and locate the firmware update file.

6. Select **Upload** to send the file to the DGA monitor.



7. DGA monitor verifies that the file was received successfully, and starts the update. The update may take up to 30 min. When the process is complete, a user interface message will show the result of the update.

CAUTION! Do not power off the DGA monitor during the update. Do not attempt to reconfigure the DGA monitor, generate a diagnostic data package, or use any other functions of the user interface until the update is ready.

While waiting for the update to complete you may lose connection to the user interface, or receive a message indicating that the update has failed. This may happen because your browsing session expires or due to a network connectivity problem, and does not necessarily mean that the upgrade has actually failed. To continue from this situation, close the browser window, and reconnect to the user interface as the **Admin** user.

8. Verify that the new software version is displayed as the current software version on the **Software update** page. This means the software update has been successful.
9. Verify the current **Settings** of the DGA monitor. The software update may have added new settings or changed existing ones.
10. Switch the DGA monitor back to **Measuring** mode to continue normal measurement by starting measurement.

11. Optional: Start autocalibration manually to make sure any updates to the autocalibration mechanism are applied right away.

> Autocalibration takes from 2 to 5 days depending on conditions.

More information

- Connecting to user interface (page 37)
- Starting measurement (page 57)
- Setting date and time (page 58)
- Starting autocalibration manually (page 82)
- Stopping measurement (page 83)

4.5 Starting autocalibration manually

Autocalibration improves measurement performance by adapting the DGA monitor to transformer oil conditions. Autocalibration takes from 2 to 5 days depending on conditions.

It is not normally necessary to start autocalibration manually, and autocalibration always runs automatically after a DGA monitor is initialized. However, it is recommended to start autocalibration in some specific cases, for example after the software of the DGA monitor has been updated.

> **CAUTION!** Manual autocalibration is not recommended for devices using ester liquid if the ambient temperature is -10 °C (+14 °F) or below. The autocalibration accuracy is compromised in cold temperatures.

1. Connect to the user interface as the **Admin** user.
2. Select **Control** and verify that the system is currently measuring. You can only start autocalibration when DGA monitor is in **Measuring** state.
3. Select **Autocalibration** and verify the current autocalibration status. Do not attempt to start autocalibration if it is already ongoing.
4. Select **Start**. DGA monitor will perform autocalibration and continue with normal measurement cycles after it is completed.

More information

- Connecting to user interface (page 37)

4.6 Repair

If your OPT100 DGA monitor needs repair, note the following:

- Make sure you have the latest product documentation before taking any actions. Check the OPT100 product page http://www.vaisala.com/opt100 for updates.
- If a repair procedure you need is not available in the documentation, contact Vaisala for assistance.
- Some repairs can only be performed by a Vaisala representative.
- If OPT100 DGA Monitor is sent to Vaisala for repairs, use sufficient packing material to ensure safe shipping. Pay special attention to the connections at the bottom of the main cabinet. If both DGA monitor and OPTPSU power supply unit are sent, pack them in separate boxes. Label "fragile".
- For any components included inside the OPT100 DGA Monitor or the OPTPSU power supply unit, use only spare parts supplied by Vaisala.

4.6.1 Stopping measurement

1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Stop the measurement mode by selecting **Control > Stop Measuring**.
3. Wait for DGA monitor to enter **Standby** mode. Depending on the stage in the measurement cycle, stopping may take up to 60 min.

4.6.2 Turning off DGA monitor for maintenance

1. Switch the DGA monitor to standby mode.
2. Turn off OPTPSU power to the DGA monitor:
   a. Turn off OPTPSU power from the external disconnection device.
   b. Lock the disconnection device in the off position, if possible.
   c. Attach a warning label to the disconnection device that clearly states why the power is turned off.
3. Turn off power inside the power supply unit:
   a. Open the power supply unit cabinet.
   b. Turn off switch **S1**.
   c. Turn off circuit breaker **F1**.

4.6.3 Verifying safety after repair

Go through the following verification steps after performing repairs on the DGA monitor.

1. If you have replaced or altered any mechanical parts of the DGA monitor cabinet or mounting accessories, verify that:
   - Cabinet can be opened and closed normally.
   - Cabinet tightness is maintained.
   - All attachment points are intact.
2. If you have replaced any electrical components or wiring, verify that:
   - All components that are secured to a DIN rail are firmly in place.
   - There are no disconnected cables or loose wires.
   - All grounding wires are attached.
   - Wiring is done according to the wiring instructions in the *OPT100 Installation Guide (M211857EN)*, unless intentionally altered by the repair procedure.
3. If you have replaced any of the oil handling components (pipes, valves, pump, oil block, etc.) or opened any of the oil connections, verify that:
   - There are no open oil connections.
   - All oil handling components are securely attached.
   - All oil leaks have been cleaned and wiped clean. No oil is visible on the parts or oil connections.

4.6.4 Turning on DGA monitor after maintenance



CAUTION! If the circuit breakers will not stay in the ON position, turn off Mains power to the DGA monitor immediately and inspect the Mains and OPTPSU power wiring. The circuit breakers may be tripping because of a loose wire or incorrect connection.

1. Verify that the circuit breakers **Main** and **Heat** inside the DGA monitor are turned on.
2. Turn on power inside the power supply unit:
   a. Open the power supply unit cabinet.
   b. Turn on circuit breaker **F1**.
   c. Turn on switch **S1**.
3. Turn on OPTPSU power to the DGA monitor:
   a. Check if there are any warning labels attached to the disconnection device. If there are, make sure it is safe to turn on the OPTPSU power. Remove any labels that are now unnecessary.
   b. If the external disconnection device is locked in the off position, unlock it.
   c. Turn on OPTPSU power from the external disconnection device.

4.6.5 Starting measurement

In normal operation DGA monitor repeats the measurement cycle continuously. You can only start the measurement if DGA monitor is currently in standby.

1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Start measurement from **Control > Start Measuring**.

DGA monitor warms up during the first three measurement cycles. Measurements made during the warm-up cycles are not guaranteed to be within the accuracy specification.

4.7 Uninstalling DGA monitor

- Adjustable wrench
- Screwdriver with 3-mm-wide (0.12-in) flat head
- 5-mm Allen key
- Swagelok® plugs for oil connector fittings (2 pcs, Swagelok part no. SS-10M0-P (316 Stainless Steel Plug for 10-mm Swagelok Tube Fitting))
- Container for waste insulation liquid with at least 5 liter (1.3 gallon) capacity
- Insulation liquid absorption material for controlling possible leaks
- Rags for wiping off insulation liquid



Wear protective eyewear and gloves.

Follow this procedure to uninstall the DGA monitor. Uninstallation empties the DGA monitor of oil and allows it to be safely stored and transported.

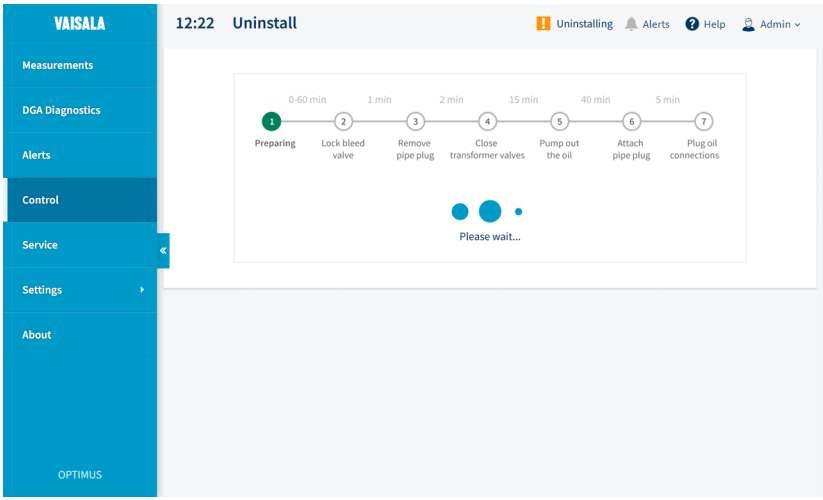
The procedure assumes that the DGA monitor is completely installed and currently measuring when the uninstallation is started. The complete procedure may take up to 3 hours. If the DGA monitor is already in **Standby** mode, you can skip step 4 and step 5.

CAUTION! Do not transport the DGA monitor without uninstalling it properly:
- If the oil connections are not properly plugged, oil will drain out from the DGA monitor during transport.
- Oil may contaminate the optical measurement module during transport unless you complete the uninstallation procedure successfully and **lock the bleed valve manually**.

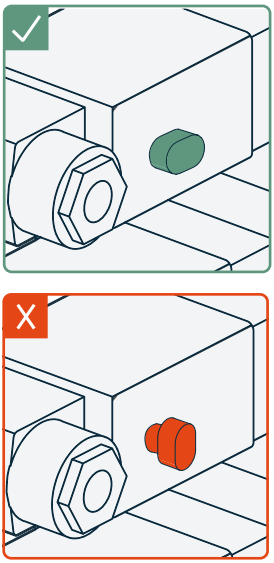
CAUTION! Do not store a DGA monitor that has been installed to a natural ester filled transformer for long periods of time. The maximum recommended storage time is 1 month. If you need to store a **used** natural ester liquid DGA monitor for a longer period, flush it first by temporarily operating it connected to a container filled with synthetic ester liquid or mineral oil.

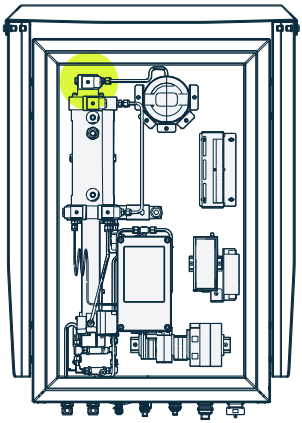
1. Check that the oil lines between DGA monitor and transformer are intact.
2. Check that the oil intake and return valves on the transformer side are open.
3. Connect to the DGA monitor user interface and log in as an **Admin** user.
4. Stop the measurement mode by selecting **Control > Stop Measuring**.
5. Wait for DGA monitor to enter **Standby** mode. Depending on the stage in the measurement cycle, stopping may take up to 60 min.
6. Select **Control > Uninstall > OK**.

The user interface shows the uninstallation stages and approximate times between the stages. The time required for the preparation stage varies, and it may take up to 60 min before you are prompted to perform the next step.

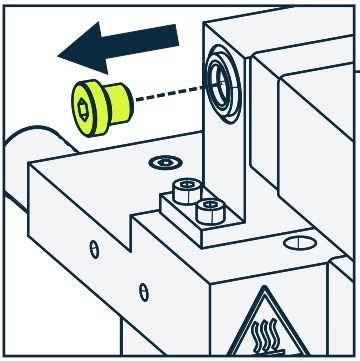


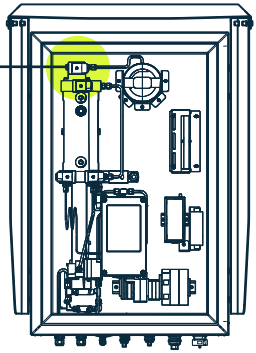
7. When instructed to do so, push in the gray knob on the side of the bleed valve, and turn it 90° clockwise to lock the valve manually. Select **Continue** from the user interface when done.





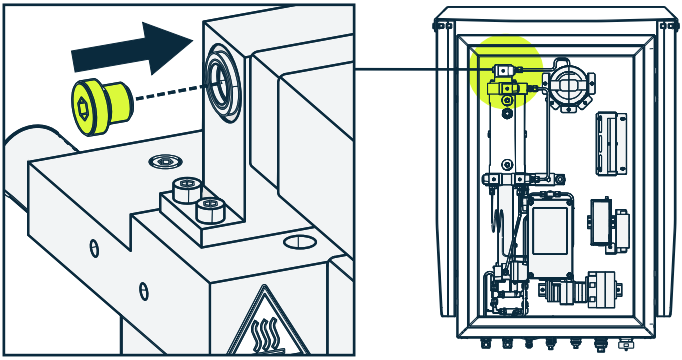
8. When instructed to do so, remove the bleed plug from the bleed valve. Select **Continue** when done.





9. When instructed to do so, close the oil intake and return valves on the transformer.

10. When instructed to do so, disconnect oil pipes from the **Oil In** and **Oil Out** connections on the outside of the DGA monitor. Place the ends of the pipes in the waste oil container to collect the oil that drains out.
11. Check the checkbox to acknowledge that the oil pipes are now disconnected, and select **Continue**.
12. When instructed to do so, reattach the bleed plug to the bleed valve.



13. Plug the **Oil In** and **Oil Out** connectors of the DGA monitor to prevent the small amount of oil remaining in the system (less than one deciliter, 3.4 fl. oz.) from draining out during transport.
14. Plug the intake and return oil lines.
15. Select **Finish** to end the uninstallation sequence.
16. Turn off OPTPSU power to the DGA monitor:
    a. Turn off OPTPSU power from the external disconnection device.
    b. Lock the disconnection device in the off position, if possible.
    c. Attach a warning label to the disconnection device that clearly states why the power is turned off.
17. Disconnect the cables between the power supply unit and the DGA monitor.
18. Plug and tighten the cable glands to maintain cabinet tightness during storage.
19. Uninstall the equipment in reverse order of installation.

    See OPT100 Installation Guide (M211857EN) for details.

20. Place the equipment door side up in the original packaging, if available. Safe lifting and carrying of the DGA monitor requires two people.

    If original packaging is not available:
    - Use double wall cardboard boxes. If both OPT100 DGA Monitor and OPTPSU power supply unit are packaged, pack them in separate boxes.
    - Protect the main cabinet fittings at the bottom. Fill the box with enough protective material that the equipment cannot move around in the box.
    - Close the box with plastic tape and add bands around the box.

21. If devices are sent for service, use "fragile" markings.

4.7.1 Forcing uninstallation

CAUTION! Use forced uninstallation only if normal uninstallation cannot be completed, the device is faulty or the oil pipes have already been disconnected.

CAUTION! If forced uninstallation is not completed correctly, it may cause damage to the transformer.

CAUTION! Do not transport the DGA monitor without uninstalling it properly:
- If the oil connections are not properly plugged, oil will drain out from the DGA monitor during transport.
- Oil may contaminate the optical measurement module during transport unless you complete the uninstallation procedure successfully and **lock the bleed valve manually**.

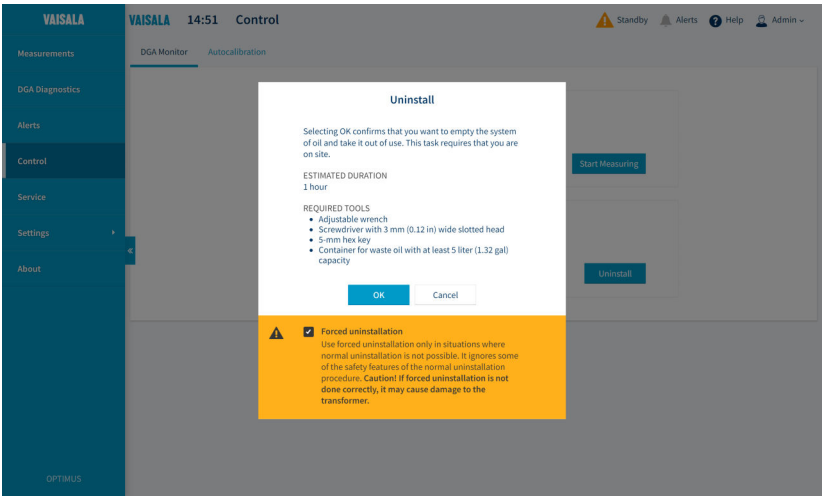
You need to be on site to complete this task.



Wear protective eyewear and gloves.

1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Stop the measurement mode by selecting **Control > Stop Measuring**.
3. Wait for DGA monitor to enter **Standby** mode. Depending on the stage in the measurement cycle, stopping may take up to 60 min.
4. Select **Control > Uninstall**.

5. Select **Forced uninstallation > OK**.



6. Select **Confirm**.
7. Follow the instructions in the user interface.
8. After completing the forced uninstallation sequence, follow the normal uninstallation instructions from step 16 until the end of the procedure to safely disconnect and transport the device.

4.7.2 Flushing DGA monitor

- Container for mineral oil or synthetic ester liquid

Follow these instructions to flush a DGA monitor that has been installed to a natural ester filled transformer if you need to store the device for a longer period of time. The maximum recommended storage time is 1 month.

Natural ester liquid is prone to oxidation and polymerization. To avoid hardened natural ester liquid sticking inside the monitor during storing time, flush the monitor with mineral oil or synthetic ester liquid.

1. Before flushing, uninstall the DGA monitor. See Uninstalling DGA monitor (page 85).
2. Insert the DGA monitor oil pipes or hoses into a container filled with mineral oil or synthetic ester liquid.
3. Install and perform initializing according to OPT100 Installation Guide (M211857EN).

4. Let the monitor operate normally for approximately 4 to 5 h. This removes residuals of natural ester liquid from the monitor.
5. Stop the measurement.
6. Run the forced uninstall procedure. See Forcing uninstallation (page 89).

5. Troubleshooting

5.1 Problem situations

Table 12 Troubleshooting table

Problem	Possible cause	Solution
Green status LED is flashing.	DGA monitor is in standby mode.	Start the measurement mode. See Starting measurement (page 57).
Yellow status LED is lit.	A device warning is active.	Log in to the user interface. Check system status and active alerts. See sections System statuses (page 93) and Device alerts (page 94).
	DGA monitor has been installed but not initialized.	Perform commissioning and initialization according to the *OPT100 Installation Guide (M211857EN)*.
	DGA monitor has been uninstalled.	Confirm the cause from the user interface.
Yellow status LED is flashing.	Gas level alert is active, caution limit exceeded.	Log in to the user interface. Check gas levels and active alerts.
Red status LED is lit.	A device error is active.	Log in to the user interface. Check system status and active alerts. See sections System statuses (page 93) and Device alerts (page 94).
Red status LED is flashing.	Gas level alert is active, alarm limit exceeded.	Log in to the user interface. Check gas levels and active alerts.
Data missing in measurement view (gaps in graphs)	Measurement cycles have not produced reliable results for some or all measurement parameters.	Can be caused by rapid temperature changes. Make sure the DGA monitor doors are closed and locked. See Notes for normal operation (page 17).
	DGA monitor has been in standby mode or turned off.	Keep the DGA monitor powered on and in measurement mode.

Problem	Possible cause	Solution
My web browser warns me that the connection is not secure when connecting to the user interface.	User interface is secured using a self-signed certificate that is not trusted by your web browser, because the certificate is not publicly distributed.	To get rid of the warning permanently, create a trusted certificate and key and configure the user interface security to use them (recommended) or disable HTTPS security (not recommended). See Configuring user interface security (page 65). Alternatively, you can ignore the warning and proceed to the user interface. HTTPS traffic is always encrypted even if the certificate is not trusted.
I am unable to log in to the user interface as **Admin** user.	Forgotten password.	Contact Vaisala. See Technical support (page 145).
DGA monitor LED lights are off.	Issue with the power supply.	Check power input from the power supply unit (switches **F1** and **S1**).
Oil is leaking from inside the DGA monitor or the connecting pipes.	Loose connection or faulty piping.	Tighten any loose connections. If there is still leakage, stop measurement and complete uninstallation procedure before maintenance. If maintenance work cannot be started immediately, close transformer valves to prevent more oil leaking into the system.
There is water inside the DGA monitor.	Faulty cabinet or cabinet door left open.	Dry with rags or if necessary, drain the liquid out by opening a connector at the bottom of the DGA monitor (**Spare**, item 8; see OPT100 cable glands and connectors (page 26)). Remove the cables or black plug to drain the liquid out. Reinstall cables or plug after draining.

5.2 System statuses

System status is shown in the header at the top of the user interface. Note that the presence of alerts (gas level alerts or device alerts) is indicated by a separate alert indicator.

Table 13 System statuses

Symbol and text	Meaning
Autocalibrating	DGA monitor is performing autocalibration cycles. Autocalibration improves measurement performance by adapting the DGA monitor to transformer oil conditions. Autocalibration takes from 2 to 5 days depending on the conditions. After autocalibration has been completed successfully, DGA monitor automatically starts normal measurement operation.
Connecting	System state is being determined. This state is shown after a software update has been performed.
Measuring	Normal operation; DGA monitor is performing measurement cycles.
Not initialized	DGA monitor has not been initialized. Initialization is part of the installation and requires physical access inside the DGA monitor cabinet.
Initializing	DGA monitor is being initialized.
In service	DGA monitor is performing a service action, for example, running a service tool.
Standby	DGA monitor is idle and waiting for commands from the administrator. Measurement cycles are not being performed.
Stopping	Normal measurement is being stopped. When complete, the DGA monitor will remain in the standby state.
Stopped	DGA monitor has stopped measurement due to an error.
System error	System status of the DGA monitor could not be determined.
Uninstalling	DGA monitor is being uninstalled. Uninstallation empties the DGA monitor of oil and prepares the measurement system for transportation.
Updating	Software update is in progress.

More information

- Status indicator (page 39)

5.3 Device alerts

Device alerts are warnings and errors that communicate potential problems with the DGA monitor device. Device alert status is shown in the header at the top of the user interface. A message that describes the alert is also shown.

Device alerts come in two severities:

- **Warnings** are less serious and may not require any action to be taken.
- **Errors** typically prevent normal measurement and require user intervention to recover from.

Contact Vaisala for support if you are unable to resolve a device alert yourself. From the **Service** page of the user interface you can create a diagnostic data file that can help Vaisala diagnose the device alert. It is recommended that you do this if your DGA monitor stops due to an error, regardless of if the error was successfully resolved.

Table 14 Device alerts

Code	Alert text	Severity	Description
1098	Measurement cycle started after an error	Warning	The measurement cycle has been started after an error. It is yet unclear if the error has been resolved and the measurement cycle can be completed successfully. Please wait. This warning is inactivated once the measurement cycle has been completed successfully.
1401	Unable to measure due to unstable temperature	Warning	Results of the latest measurement cycle have been rejected due to unstable temperature. This is typically caused by the cabinet door being left open. 1. Close the cabinet door of the DGA monitor. 2. Wait for the next measurement cycle to complete to see if the problem has been solved. 3. Contact Vaisala support if the problem remains.
1402	Unable to measure due to unstable light intensity level	Warning	Results of the latest measurement cycle have been rejected due to unstable intensity level of the optical measurement module. Contact Vaisala support if this warning repeats for many measurement cycles.

Code	Alert text	Severity	Description
1403	O_2 results not available	Warning	If the DGA monitor has just started measurement, wait a few measurement cycles to see if the results become available. Otherwise make sure that the O_2 sensor cable is properly connected to Control Unit connector **X09** and DMU connector **COM5**. If the problem remains, contact Vaisala support.
1404	N_2 results not available	Warning	If the DGA monitor has just started measurement, wait a few measurement cycles to see if the results become available. If the problem remains, contact Vaisala support.
1405	H_2 results not available	Warning	If the DGA monitor has just started measurement, wait a few measurement cycles to see if the results become available. Otherwise make sure that the MHT411 sensor cable is properly connected to Control Unit connector **X16**. If the problem remains, contact Vaisala support.
1406	H_2O results not available	Warning	If the DGA monitor has just started measurement, wait a few measurement cycles to see if the results become available. Otherwise make sure that the MHT411 sensor cable is properly connected to Control Unit connector **X16**. If the problem remains, contact Vaisala support.
1501	Hardware clock time lost	Warning	Hardware clock of the DGA monitor has incorrect time. Set new time or enable time sync in the **Settings > General** page. If this error reoccurs, consider changing the backup battery of the real-time clock. Contact Vaisala support for help with changing the backup battery.

Code	Alert text	Severity	Description
1502	Unable to read measurement module calibration file	Warning	The system is unable to read the calibration file of the optical measurement module. DGA monitor continues measuring without the optical measurements. Contact Vaisala support.
1503	Incompatible DGA monitor software version	Warning	DGA monitor software is unable to operate with the optical measurement module. The DGA monitor continues measuring without the optical measurements. To resolve this, update the DGA monitor to the newest software version.
2099	Measurement cycle fault	Error	If the DGA monitor has a serious hardware problem or cannot measure due to some external cause, it will automatically stop trying to run the measurement cycles. See Resolving measurement cycle fault (page 99)
2102	Oil inside cabinet	Error	The float sensor inside DGA monitor cabinet is activated, indicating a possible oil leak. It is recommended to check the device right away. Inspect inside the DGA monitor and oil lines to determine the cause of the error, and remove it if possible. If necessary, drain the liquid out by opening a connector at the bottom of the DGA monitor (**Spare**, item 8, see OPT100 cable glands and connectors (page 26)). Remove the cables or black plug to drain the liquid out. Reinstall cables or plug after draining. This error may appear if the measurement has not been started with DGA monitor in an upright position. Install the DGA monitor in an upright position and perform the initialization to clear the error.

Code	Alert text	Severity	Description
2200	Valve 2 failure	Error	1. Open the DGA monitor cabinet and locate valve 2. See Interior parts (page 29). 2. Check the position of the manual lock on valve 2. If the grey knob is pushed down, the valve is locked and that is causing the error. 3. Turn the knob counter-clockwise 90 degrees to open the lock and resolve the error. If the lock is open, the valve must be replaced to resolve the error. Contact Vaisala support.
2201	Lower level sensor failure	Error	DGA monitor is unable to continue initialization due to a lower level sensor failure. The lower level sensor may be disconnected, malfunctioning, or broken. Make sure the sensor is properly connected. The LED at the end of the sensor should be on and unblinking. If the sensor needs to be replaced, contact Vaisala support.
2202	Upper level sensor failure	Error	DGA monitor is unable to continue operating due to an upper level sensor failure. The upper level sensor may be disconnected, malfunctioning, or broken. Make sure the sensor is properly connected. The LED at the end of the sensor should be on and unblinking. If the sensor needs to be replaced, contact Vaisala support.
2300	Excess gas in the system	Error	There is excess gas in the measurement system, and the DGA monitor is unable to safely dissolve the gases back into the oil. You must bleed the excess gas from the system to resume normal operation. See Bleeding DGA monitor (page 101).

Code	Alert text	Severity	Description
2400	Hydrogen and moisture module communication error	Error	Communication to hydrogen and moisture module MHT411 is not working properly. Download diagnostics package from **Service** page and send it to Vaisala support.

More information

- Generating diagnostics package (page 101)

5.4 Resolving measurement cycle fault

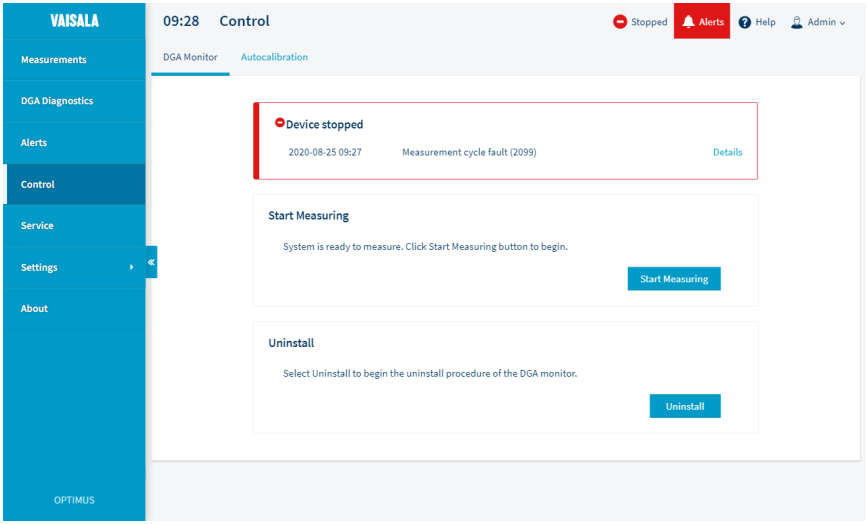


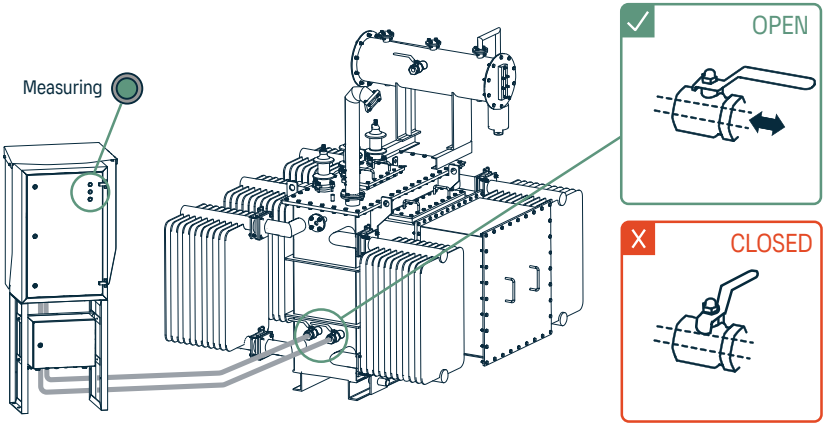
Figure 46 Measurement cycle fault active

Measurement cycle fault (code 2099) device alert is activated when DGA monitor has detected a problem that prevents measurement, and has automatically stopped running measurement cycles. Possible causes include hardware failure and problems with the oil connection. For example, someone may have closed the oil valve(s) on the transformer and prevented the DGA monitor from pumping oil.

To resolve the problem:

1. Connect to the user interface as the **Admin** user.
2. Read any active messages in the user interface.

3. Check currently active alerts on the **Alerts** page.
4. Check status of DGA monitor on the **Control** page.
5. Inspect the DGA monitor and oil lines to determine the cause of the error, and remove it if possible. For example, open the oil valves on the transformer if they are closed.



Make sure the trace heating is working. The insulation liquid temperature must be over 0 °C for ester liquids and well above pour point for mineral oil.

6. If you have resolved the likely problem or there does not seem to be an apparent cause, select **Control > Start Measuring** to restart measurement.
7. Wait to see if the DGA monitor is able to complete a measurement cycle and keep running normally.

   The device alert will change to **Measurement cycle started after an error** (code 1098), which will be inactivated when the first cycle after the restart is successfully completed.
8. If the DGA monitor stops measuring again and the measurement cycle fault returns, try to restart measurement once more.
9. If the problem is not resolved after a couple of attempts:
   a. Perform the uninstallation procedure according to instructions but stop uninstalling at step 15. Do not disconnect any cabling.
   b. Reconnect the oil lines.
   c. Perform the initialization procedure according to *OPT100 Installation Guide (M211857EN)*.
   d. After a successful initialization, select **Control > Start Measuring** to restart measurement.

10. If uninstalling and re-initialization did not remove the problem:
    a. Generate a new diagnostic data file from the DGA monitor.
    b. Contact Vaisala support and provide the diagnostic data file to help diagnose the error.

More information

- Connecting to user interface (page 37)
- Uninstalling DGA monitor (page 85)
- Generating diagnostics package (page 101)

5.5 Generating diagnostics package

The diagnostic package can be used by Vaisala support to diagnose any issues you may have with the DGA monitor. The diagnostic data in the file is intended for use only by Vaisala.

1. Connect to the user interface as the **Admin** user.
2. Select **Service** to open the **Service tools** page, and locate the **Diagnostics package** tool.



3. If a data package has been previously generated, a file name and the generation date are shown. Select the file name to download the package.
4. To generate a new package, select **Generate new**. Any existing package will be overwritten. Generating the package may take up to 20 min.
5. Send diagnostics package to Vaisala support through MyVaisala, if possible.

More information

- Connecting to user interface (page 37)

5.6 Bleeding DGA monitor

- Cabinet key
- 5-mm Allen key

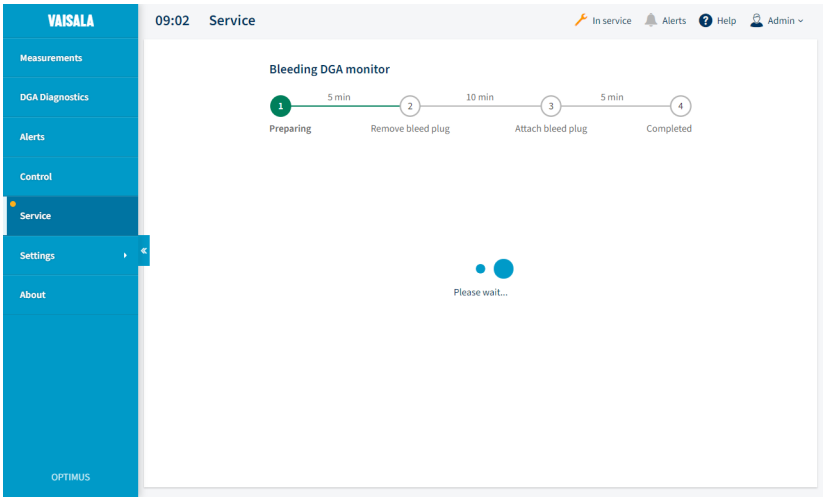
The DGA monitor can accumulate excess gases in the measurement system. This can happen, for example, because of an air leak in the oil lines. The DGA monitor detects excess gases and enables device alert code 2300, **Excess gas in the system**.

To restore normal operation, perform the procedure below to bleed the excess gas, and restart measurement after successfully bleeding the system. You must be on site with access to the DGA monitor cabinet, as you have to remove and reattach the bleed plug as instructed.

CAUTION! Do not use this procedure for bleeding oil lines. This procedure only works for excess gas inside the DGA monitor. Using this procedure for oil lines may push the air into the transformer and damage it. If the oil lines need bleeding, use forced uninstallation and then perform installation as instructed in OPT100 Installation Guide (M211857EN).

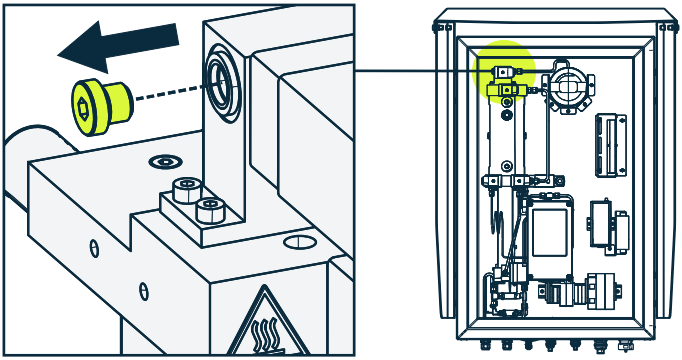
1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Select **Service** to open the **Service tools** page, and locate the **Bleeding** tool.
3. Select **Bleed > Start** to start the bleeding sequence.

   The user interface will change to show the bleeding stages and approximate times between the stages.

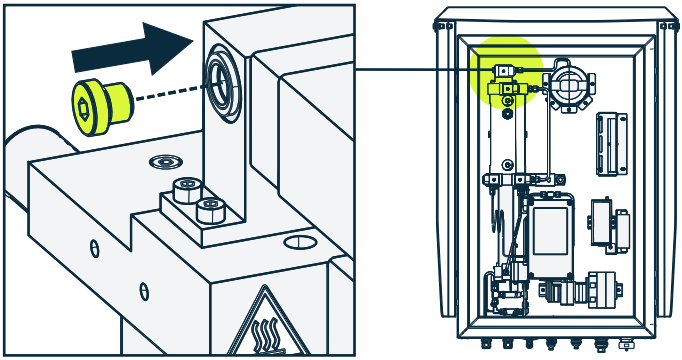


4. Follow the progress and instructions on screen. While waiting, open the door of the DGA monitor cabinet and locate the bleed plug.

5. When instructed to do so, remove the bleed plug from the bleed valve. Select **Continue** when done.



6. When instructed to do so, reattach the bleed plug to the bleed valve. Select **Continue** when done.



7. When the bleeding sequence is completed, select **Continue** to exit the tool.
8. Close and lock the door of the DGA monitor cabinet.

Even if the bleeding tool does not complete successfully, you must reattach the bleed plug in any case before closing the door of the cabinet.

More information

- Connecting to user interface (page 37)

5.7 Testing pressure tightness

NOTICE! Each test procedure can last from 50 min to 7 h depending on the result.

Complete pressure tightness test for oil block or measurement module if there has been a leak or you have replaced components during repair or maintenance work.

1. If the device is measuring, stop the measurement.
2. Make sure the DGA monitor cabinet door is closed. Use a free cable gland to connect to the user interface or use the **ETH1** connector for a temporary connection.

   CAUTION! An open cabinet door may cause invalid test results.

3. Connect to the DGA monitor user interface and log in as an **Admin** user.
4. Go to **Service > Pressure tightness**.
5. Select **Test tightness**.
6. Follow the instructions in the user interface.
7. You will see the test results in the user interface.

   Contact Vaisala technical support if the problem remains after you have completed all the suggested repair actions.

5.8 Installing configuration package

- Configuration package file from Vaisala

Installing the configuration package is not possible when the device is measuring.

Installing the configuration package is only needed if requested by Vaisala.

1. If the device is measuring, stop measurement.
2. In the user interface go to **Service > Configuration package**.
3. Select **Install**.

4. Select **Browse** and locate the configuration package file that you received from Vaisala.
5. Select **Upload**.

The user interface informs you when the installation is completed.

If the installation fails, contact Vaisala helpdesk. You can download the diagnostics package and send it with your help request.

6. Technical specification

6.1 OPT100 technical specification

Table 15 OPT100 measurement specification

Parameter [1]	Range	Accuracy [2] [3]	Repeatability [3]
Methane (CH_4)	0–10 000 ppm_v	±4 ppm or ±5 % of reading	10 ppm or 5 % of reading
Ethane (C_2H_6)	0–10 000 ppm_v	±10 ppm or ±5 % of reading	10 ppm or 5 % of reading [4]
Ethylene (C_2H_4)	0–10 000 ppm_v	±4 ppm or ±5 % of reading	10 ppm or 5 % of reading
Acetylene (C_2H_2)	0–5000 ppm_v	±0.5 ppm or ±5 % of reading	1 ppm or 5 % of reading
Carbon monoxide (CO)	0–10 000 ppm_v	±4 ppm or ±5 % of reading	10 ppm or 5 % of reading
Carbon dioxide (CO_2)	0–10 000 ppm_v	±4 ppm or ±5 % of reading	10 ppm or 5 % of reading
Hydrogen (H_2)	0–5000 ppm_v	±15 ppm or ±10 % of reading	15 ppm or 10 % of reading
Moisture [5] (H_2O)	0–100 ppm_w [6]	±2 ppm [7] or ±10 % of reading	Included in accuracy
Oxygen (O_2) [8]	0–50 000 ppm_v	±200 ppm or ±10 % of reading	Included in accuracy
Nitrogen (N_2) [8]	0–150 000 ppm_v	±5000 ppm or ±15 % of reading	Included in accuracy
Total gas pressure	0–2000 hPa	±10 hPa or ±2 % of reading	10 hPa or 5 % of reading

1) *ppm values are defined as µl/l according to IEC 60567 standard conditions.*
2) *Accuracy specified is the accuracy of the sensors during calibration gas measurements.*
3) *Whichever is greater.*
4) *Repeatability of ethane measurement is specified with averaging of five measurements.*
5) *Measured as relative saturation (%RS).*
6) *Upper range limited to saturation.*
7) *Calculated ppm value is based on average solubility of mineral oils.*
8) *Optional parameter.*

Table 16 OPT100 measurement operation

Property	Description/Value
Measurement cycle duration	1–1.5 h (typical)
Response time for fault gases (T63)	One measurement cycle [1)]
Warm-up time until first measurement data available	Two measurement cycles
Initialization time to full accuracy	Two days
Data storage	At least 10 years [2)]
Expected operating life	> 15 years

1) *Three cycles for ethane and hydrogen.*
2) *Data storage may run out of space after 20 years of measurements. To keep the old data, it is recommended to download it every 10 years.*

Table 17 OPT100 field performance

Parameter	Typical variance to laboratory DGA[1) 2)]
Acetylene (C_2H_2)	±1 ppm or ±10 % of reading
Hydrogen (H_2)	±15 ppm or ±15 % of reading
Other gases (CH_4, C_2H_6, C_2H_4, CO, CO_2)	±10 ppm or ±10 % of reading
Moisture (H_2O)	±2 ppm or ±10 % of reading

1) *Compared with gas chromatography result from an oil sample considering also laboratory uncertainty. Performance of the gas-in-oil measurement may also be affected by oil properties and other chemical compounds dissolved in oil.*
2) *ppm values are defined as µl/l according to IEC 60567 standard conditions.*

Table 18 OPT100 calculated parameters

Property	Description/Value
Total dissolved combustible gases (TDCG)	Combined total of H_2, CO, CH_4, C_2H_6, C_2H_4, and C_2H_2
24 h average	Available for single gases, moisture, TDCG, and total gas pressure
Rate of change (ROC)	Available for single gases and TDCG for 24 h, 7 d, and 30 d periods

Property	Description/Value
Gas ratios [1]	Available ratios: • CH_4/H_2 • C_2H_2/C_2H_4 • C_2H_2/CH_4 • C_2H_6/C_2H_2 • C_2H_4/C_2H_6 • CO_2/CO • O_2/N_2

1) Calculated from 24 h average values. See standard IEC 60599.

Table 19 OPT100 operating environment

Property	Description/Value
Transformer liquid type [1]	Mineral oil or ester liquids
Required minimum fire point of insulation liquid [2]	+125 °C (+257 °F)
Transformer oil pressure at oil inlet	Max. 2 bar (absolute) continuous Burst pressure 20 bar (absolute)
Transformer insulation liquid temperature at oil inlet	Max. +100 °C (+212 °F) Min. +0 °C (+32 °F) for ester liquids Min. temperature for mineral oil depends on the pour point of the mineral oil.
Ambient humidity range	0–100 %RH, condensing
Ambient temperature range in operation	−40 ... +55 °C (−40 ... +131 °F)
Storage temperature range	−40 ... +60 °C (−40 ... +140 °F)
IP rating	IP66: Dust-tight. Protected from powerful water jets from any direction.

1) Selected when ordering the device.
2) "The fire point [of transformer oil] is normally approximately 10 °C [18 °F] higher than the closed flash point." Heathcote, Martin J. The J & P Transformer Book. 13th ed. Elsevier, 2007.

Table 20 OPT100 power supply

Property	Description/Value
Operating voltage	OPTPSU1: 100–240 V AC, 50–60 Hz, ±10 % OPTPSU2: 110–220 V DC, ±10 %

Property	Description/Value
Overvoltage category	III
Maximum power consumption	500 W
Typical power consumption at +25 °C (+77 °F)	100 W
Connector	Screw terminals (inside power supply unit) Wire size 2.5–4 mm^2 (14–12 AWG)

Table 21 OPT100 outputs

Property	Description/Value
RS-485 interface	
Connector	Screw terminals (inside OPT100 housing) Wire size 0.5–4 mm^2 (20–12 AWG)
Supported protocols	Modbus RTU, DNP3 (optional feature)
Galvanic isolation	2 kV RMS, 1 min
Ethernet interface	
Connector	Industrial RJ45 connector with protective plug (outside OPT100 housing)
Supported protocols	Modbus TCP, HTTP, HTTPS, DNP3 (optional feature), IEC 61850 (optional feature)
Standard	IEEE 802.3
Physical layer	Base-T
Data rate	10/100 Mbps
Galvanic isolation	4 kV AC (50 Hz, 1 min)
Insulation voltage	250 V_{rms}
Relay outputs	
Number of relays	3 pcs, normally open (NO) or normally closed (NC), user-selectable
Trigger type	Gas alert with user-selectable limits
Connector	Screw terminals (inside power supply unit housing) Wire size 0.5–4 mm^2 (20–12 AWG)
Max. switching current	6 A (at 250 V AC) 2 A (at 24 V DC) 0.2 A (at 250 V DC)

Property	Description/Value
Min. switching voltage	12 V DC (at 10 mA)
Min. switching current	10 mA (at 12 V)
Contact type	1 PDT
Auxiliary device interface	
Maximum power	48 W
Voltage output	24 V DC
User interface	
Interface type	Web-based user interface, can be operated with standard web browsers
Connector for service use	RJ45 connector, inside OPT100 housing (temporary local use only)

Table 22 OPT100 mechanical specifications

Property	Description/Value
Oil fitting	Stainless steel Swagelok® fitting for 10 mm (0.39 in) outer diameter tubing. See list of available accessories for adapters.
Max. length of oil pipe to transformer for mineral oil	Max. 10 m (33 ft) with 7 mm (0.28 in) inner diameter tubing [1)] Max. 5 m (16 ft) with 4 mm (0.15 in) inner diameter tubing
Max. length of pipe to transformer for ester liquid	Max. 10 m (33 ft) with 8 mm (0.31 in) inner diameter tubing
Recommended oil pipe properties	10 mm (0.39 in) outer diameter 1–1.5 mm wall thickness (mineral oil devices) 1 mm wall thickness (ester liquid devices) Material stainless steel
Dimensions (H × W × D)	
Installed with ground mounting set and weather shield	1630 × 675 × 453 mm (64 × 27 × 18 in)
Installed with wall mounting set and weather shield	1390 × 675 × 467 mm (55 × 27 × 18 in)
Installed with antivibration wall mounting set and weather shield	1395 × 683 × 541 mm (55 × 27 × 21 in)
Weight	
OPT100 DGA Monitor	37 kg (82 lb)

Property	Description/Value
OPTPSU Power Supply Unit	12 kg (27 lb)
OPTMSET1 Wall Mounting Set	8 kg (18 lb)
OPTMSET2 Ground Mounting Set	16 kg (35 lb)
OPTMSET3 Antivibration Wall Mounting Set	9 kg (20 lb)
OPTSHLD1 Weather shield	6 kg (13 lb)
Materials	
OPT100 DGA Monitor housing	Marine aluminum (EN AW-5754), stainless steel AISI 316
OPTPSU Power Supply Unit housing	Stainless steel
OPTMSET1 Wall Mounting Set	Stainless steel AISI 316
OPTMSET2 Ground Mounting Set	Stainless steel
OPTMSET3 Antivibration Wall Mounting Set	Stainless steel
OPTSHLD1 Weather Shield	Marine aluminum (EN AW-5754)
Materials in contact with oil	
Oil pipes, chambers, and valves	Aluminum (EN AW 6026), stainless steel AISI 316, brass
Gaskets and seals	NBR, FKM, FVMQ
Pump gears and bushing	PEEK/PTFE

1) *Bigger pipe volume will increase response time.*

Table 23 OPT100 compliance

Property	Description/Value
EU directives and regulations	EMC Directive (2014/30/EU) Low Voltage Directive (2014/35/EU)
	OPT100 is specifically designed to be installed as part of another type of equipment that is excluded from the RoHS directive (2011/65/EU) scope.
EMC immunity	EN 61326-1, industrial environment IEC 61000-6-5, class 4
EMC emissions	FCC 47 CFR 15, section 15.107, class A ISED ICES-003, section 5(a)(i), class A
Safety	IEC/EN/UL/CSA-C22.2 61010-1

Property	Description/Value
Environmental	IEC 60068-2-1 IEC 60068-2-2 ISO 6270-1:2017, constant humidity condensation atmosphere, C5 ISO 9227:2017, salt fog, C5 IEC 61010-1:2010/AMD1:2016, pollution degree 4 (outdoor), 3 (industrial area), 2 (device internal)
Compliance marks	CE, China RoHS, EAC, RCM

6.2 OPT100 accessories and spare parts

Table 24 OPT100 accessories

Description	Part number
Wall Mounting Set	OPTMSET1
Ground Mounting Set	OPTMSET2
Antivibration Wall Mounting Set	OPTMSET3
Weather Shield	OPTSHLD1
Tubing adapter, 10 mm to 3/8″ (2 pcs)	ASM213275SP
Tubing adapter, 10 mm to 1/4″ (2 pcs)	ASM213274SP
Flex hose kit, 10 m (2 pcs)	ASM214666SP
1/2″ NPT adapter kit	ASM214667SP
1″ NPT adapter kit	ASM214668SP
2″ NPT adapter kit	ASM214669SP
Pipeline valve kit	ASM214670SP

Table 25 OPT100 spare parts

Description	Part number
Internal Multigas Transmitter (MHT411)	MHT411SP
Solenoid valves	OPTVALVEKITSP
Temperature sensor spare part kit	DRW258265SP
AC Power Supply Unit	OPTPSU1SP
DC Power Supply Unit	OPTPSU2SP

Description	Part number
Insulation liquid filter	ASM284073SP
Oxygen sensor	283450SP

6.3 Dimensions with Ground Mounting Set

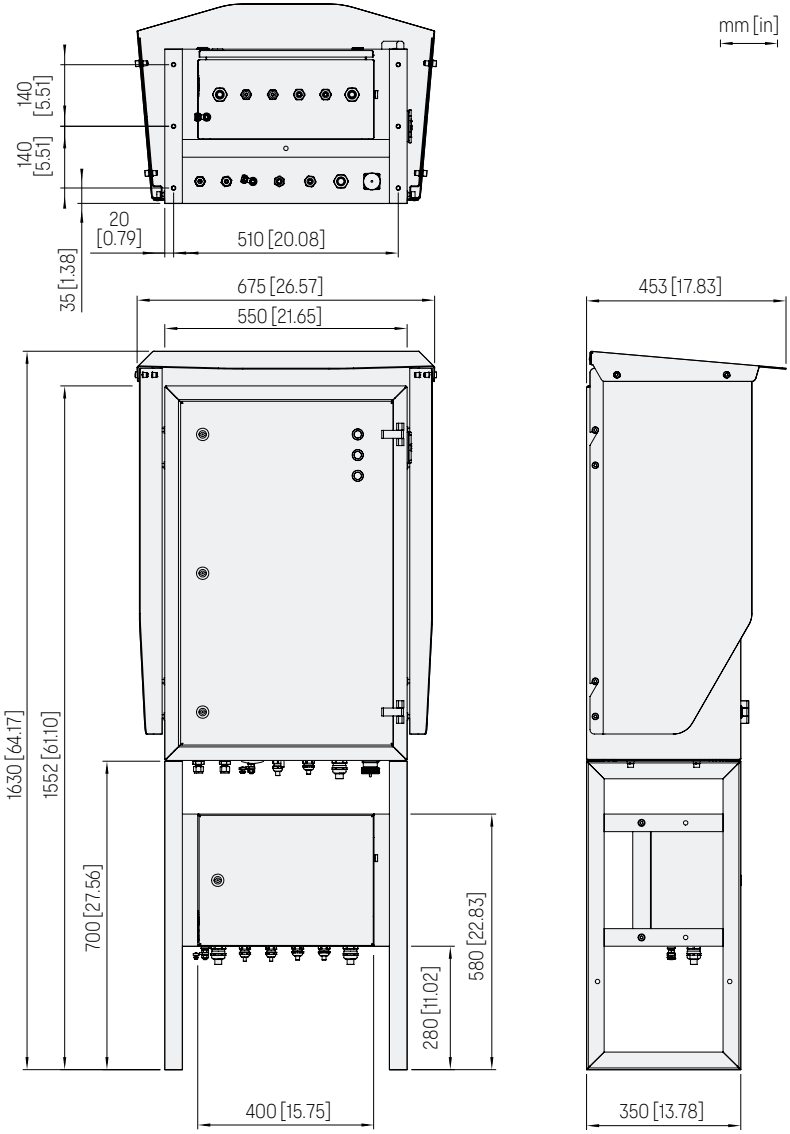


Figure 47 OPT100 dimensions with Ground Mounting Set

6.4 Dimensions with Wall Mounting Set

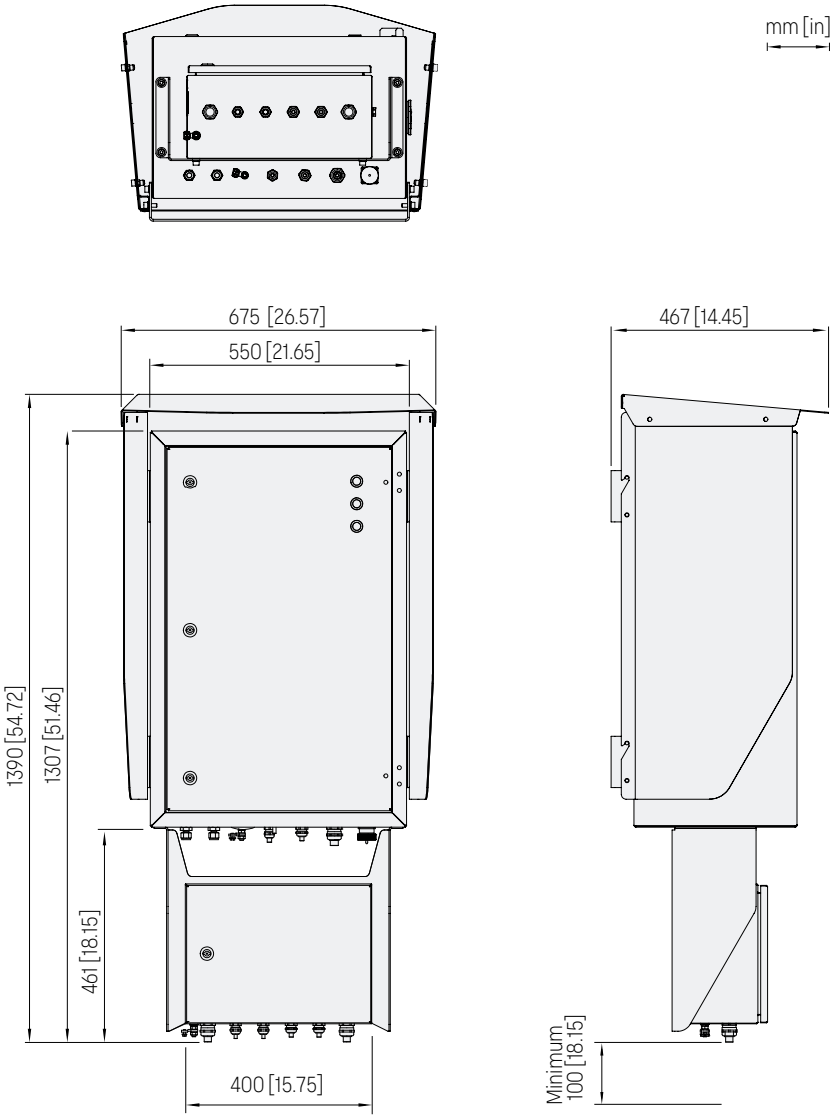


Figure 48 OPT100 dimensions with Wall Mounting Set

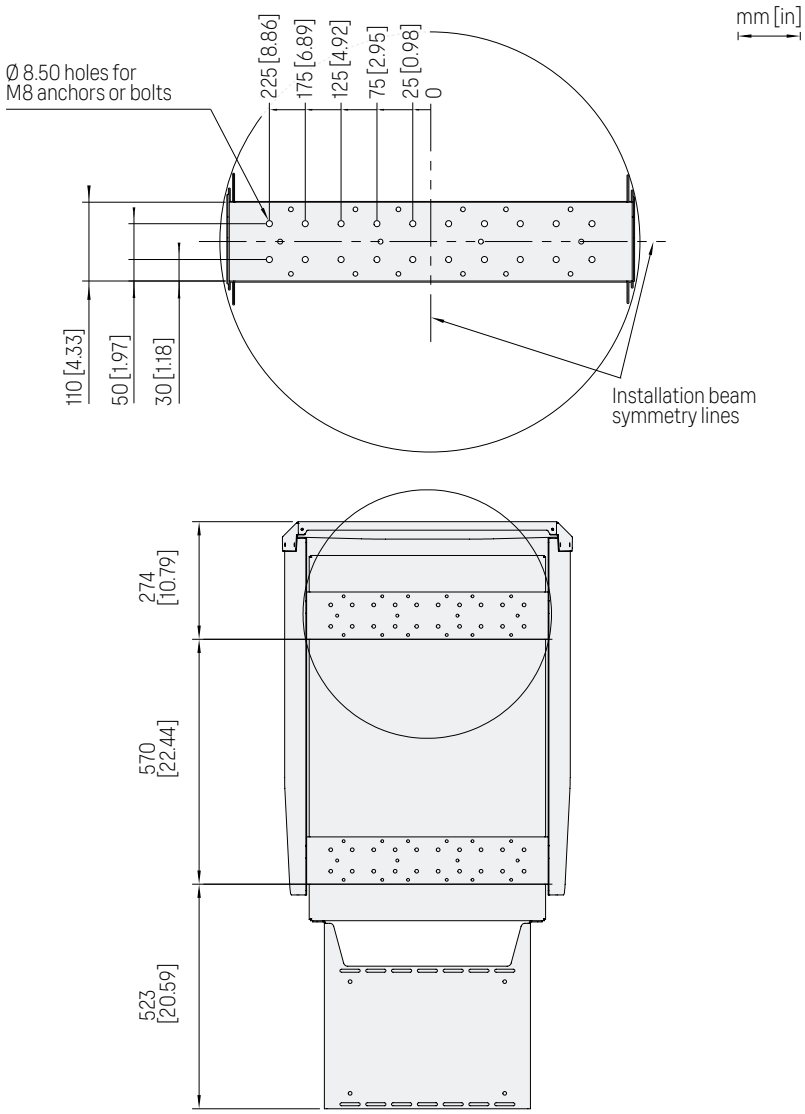


Figure 49 Mounting dimensions of installation beams

6.5 Dimensions with Antivibration Wall Mounting Set

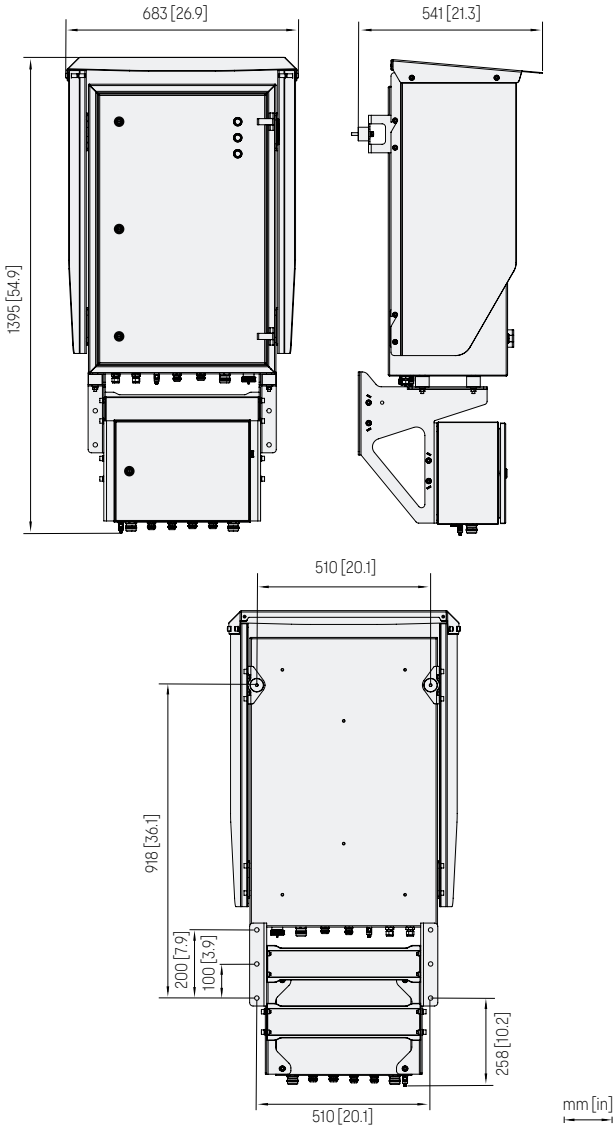


Figure 50 OPT100 dimensions with Antivibration Wall Mounting Set

6.6 Recycling instructions

These recycling instructions guide you on the end-of-life treatment of this Vaisala product. As waste regulations and infrastructure vary in each country, these instructions only indicate the different components to be separated and common ways to handle them. Always follow local requirements when disposing of the product. Vaisala encourages to use the best available recycling practices to minimize related environmental impacts.



Vaisala is committed to meeting the requirements of the EU Waste Electrical and Electronic Equipment (WEEE) Directive. This directive aims to minimize the impact of electrical and electronic goods on the environment, by increasing reuse and recycling, and reducing the amount of WEEE going to landfill. This symbol indicates that the product should be collected separately from other waste streams and treated appropriately.



Recycle all wires and cables to Electrical and electronic waste.



Recycle installation material that is not provided by Vaisala, such as pipes, fittings, and thermal insulation according to the manufacturers' instructions. Recycle parts to hazardous waste if they have insulation liquid contamination.

OPT100 cabinets and mounting materials

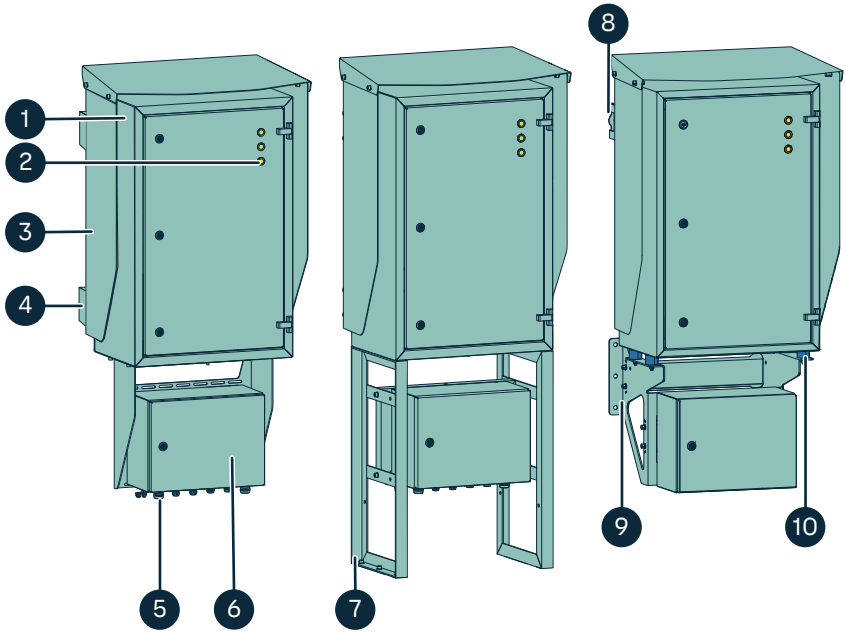


Table 26 OPT100 cabinet and mounting materials for recycling

Recycling	Part	Material	Notes
Electrical and electronic waste	2	Various	
Metal waste	5	Nickel-plated brass	Includes DGA monitor and OPTPSU cable glands.
	1, 3	Aluminum	
	4, 6, 7, 8, 9	Stainless steel	
Mixed waste	10	Rubber (EPDM)	

Recycling DGA monitor interior parts

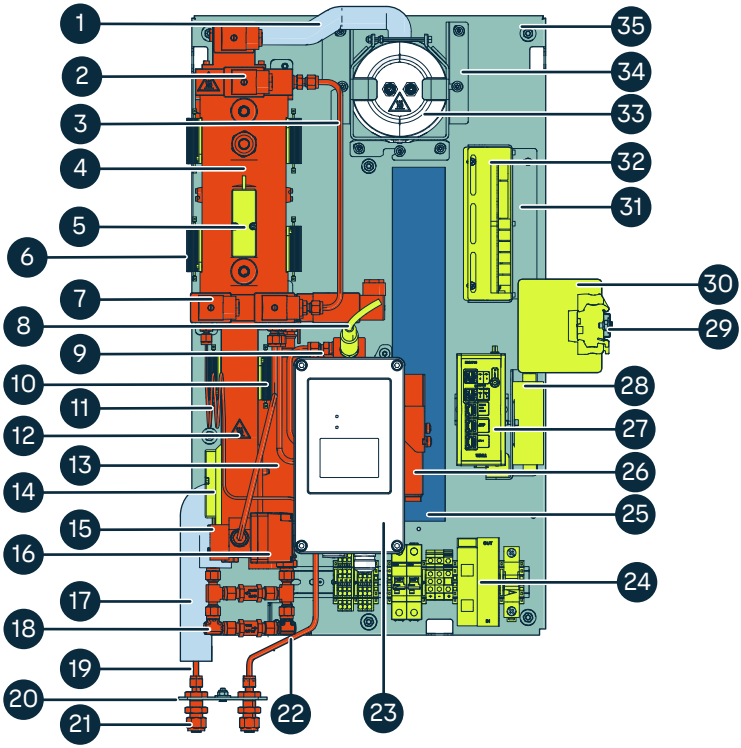


Table 27 DGA monitor materials for recycling

Recycling	Part	Material	Notes
Hazardous waste	2, 3, 7, 9, 11, 13, 15, 16, 18, 19, 21, 22, 26	Various materials with insulation liquid contamination (oil or ester liquids)	
	4, 12	Aluminum (with insulation liquid)	The parts can be recycled if insulation liquid is thoroughly cleaned from them.

Recycling	Part	Material	Notes
Electrical and electronic waste	5, 6, 8, 10, 14, 24, 27, 28, 30, 32	Various	
Metal waste	20	Stainless steel	
	29	Steel	
	31, 34, 35	Aluminum	
Plastic waste	25	Polycarbonate (PC/ABS)	
Mixed waste	1, 17	Rubber (EPDM)	
Other	23	Various	See MHT410 User Guide (M211737EN), available at docs.vaisala.com.
	33	Various	See Recycling measurement module parts, Table 28 (page 122).

Recycling measurement module parts

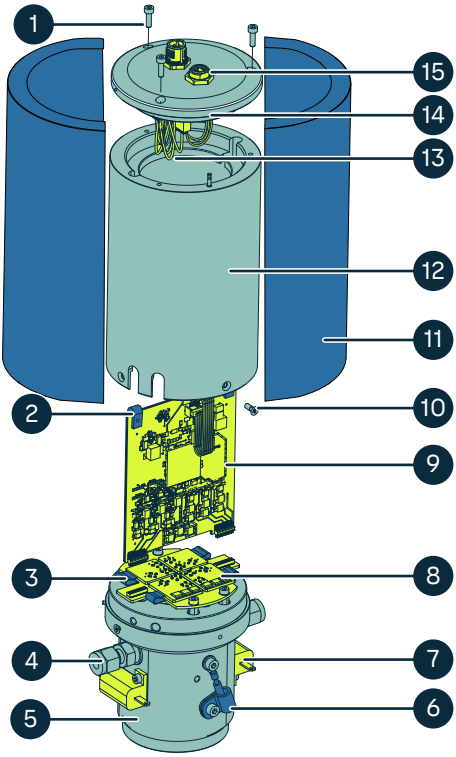


Table 28 Measurement module materials for recycling

Recycling	Part	Material
Electrical and electronic waste	7, 8, 9, 13, 15	Various
Metal waste	1, 4, 10	Stainless steel
	5, 12, 14	Aluminum
Plastic waste	2, 3	Elastomer (TPE)
	6	Polyamide
	11	Polypropylene (PP)

Recycling OPTPSU interior parts

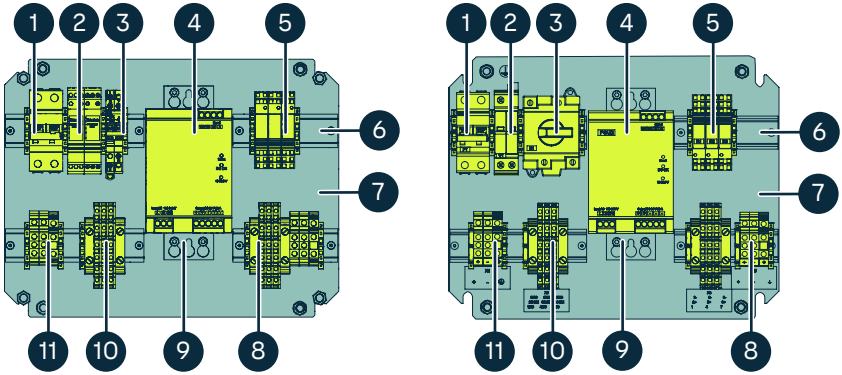


Table 29 OPTPSU materials for recycling

Recycling	Part	Material
Electrical and electronic waste	1, 2, 3, 4, 5, 8, 10, 11	Various
Metal waste	6, 7, 9	Steel

Appendix A. Modbus reference

A.1 Default Modbus communication settings

Table 30 Modbus TCP communication settings

Property	Specification
IP address of Modbus server	IP address of DGA monitor on interface ETH0
Modbus server port	502

Table 31 Default Modbus RTU communication settings

Property	Specification
Baud rate	19200
Parity	Even
Data bits	8
Stop bits	1
Modbus RTU slave address	240

A.2 Function codes

Table 32 Supported function codes

Function code (decimal)	Function code (hexadecimal)	Name
03	0x03	Read Holding Registers

A.3 32-bit floating point or 32-bit integer format

Registers using **32-bit float** data format are encoded using the **binary32** encoding defined in IEEE 754. The format is also known as "single-precision floating point format".

The least significant 16 bits of a floating point number are placed at the Modbus register listed in the table, while the most significant 16 bits are placed in the register with number/address + 1, as specified in Open Modbus TCP Specification, Release 1.0. This is also known as "little-endian" or "Modicon" word order.

Despite the specification, some Modbus masters may expect a "big-endian" word order (most significant word first). In such case, you must select "word-swapped" floating point format in your Modbus master for the Modbus registers of the device.

A complete 32-bit floating point or 32-bit integer value should be read and written in a single Modbus transaction.

CAUTION! Reading the measurement data registers with incorrect floating point format setting may occasionally result in correct-looking, but nevertheless incorrect values.

It is highly recommended to verify that you have configured the floating point format correctly on your Modbus host system by reading a floating point value from a test value register.

A.4 Modbus registers

Registers are numbered in decimal, starting from 1. Register addresses in actual Modbus messages (Modbus Protocol Data Unit (PDU)) are in hexadecimal and start from zero. Register number 1 corresponds to address 0x0 in the actual Modbus message.

CAUTION! Reading the wrong register(s) may result in correct-looking values. Check the reference documentation of your Modbus host (PLC) to verify which notation it uses for Modbus register addresses.

A.4.1 Measurement data registers

Table 33 Measurement data registers (read-only)

Register number	Address	Register description	Data format	Unit and notes
Present values				
21	0x0014	Methane	32-bit float	ppm_v
	0x0015			
23	0x0016	Acetylene	32-bit float	ppm_v
	0x0017			
25	0x0018	Ethylene	32-bit float	ppm_v
	0x0019			

Register number	Address	Register description	Data format	Unit and notes
27	0x001A	Ethane	32-bit float	ppm_v
	0x001B			
29	0x001C	Carbon monoxide	32-bit float	ppm_v
	0x001D			
31	0x001E	Carbon dioxide	32-bit float	ppm_v
	0x001F			
33	0x0020	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v
	0x0021			
35	0x0022	Hydrogen	32-bit float	ppm_v
	0x0023			
37	0x0024	Moisture in oil	32-bit float	ppm_w
	0x0025			
39	0x0026	Temperature of in-oil measurement chamber	32-bit float	°C
	0x0027			
41	0x0028	Relative moisture in oil See Calculating relative moisture saturation inside transformer (page 16)	32-bit float	%RS
	0x0029			
43	0x002A	Total gas pressure (TGP)	32-bit float	hPa
	0x002B			
45	0x002C	Oxygen	32-bit float	ppm_v
	0x002D			
47	0x002E	Nitrogen	32-bit float	ppm_v
	0x002F			
24 hour average values				
51	0x0032	Methane	32-bit float	ppm_v
	0x0033			

Register number	Address	Register description	Data format	Unit and notes
53	0x0034	Acetylene	32-bit float	ppm_v
	0x0035			
55	0x0036	Ethylene	32-bit float	ppm_v
	0x0037			
57	0x0038	Ethane	32-bit float	ppm_v
	0x0039			
59	0x003A	Carbon monoxide	32-bit float	ppm_v
	0x003B			
61	0x003C	Carbon dioxide	32-bit float	ppm_v
	0x003D			
63	0x003E	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v
	0x003F			
65	0x0040	Hydrogen	32-bit float	ppm_v
	0x0041			
67	0x0042	Moisture in oil	32-bit float	ppm_w
	0x0043			
69	0x0044	Total gas pressure (TGP)	32-bit float	hPa
	0x0045			
71	0x0046	Oxygen	32-bit float	ppm_v
	0x0047			
73	0x0048	Nitrogen	32-bit float	ppm_v
	0x0049			
Rate of change (ROC), 24 hour				
81	0x0050	Methane	32-bit float	ppm_v/d
	0x0051			
83	0x0052	Acetylene	32-bit float	ppm_v/d
	0x0053			
85	0x0054	Ethylene	32-bit float	ppm_v/d
	0x0055			

Register number	Address	Register description	Data format	Unit and notes
87	0x0056	Ethane	32-bit float	ppm_v/d
	0x0057			
89	0x0058	Carbon monoxide	32-bit float	ppm_v/d
	0x0059			
91	0x005A	Carbon dioxide	32-bit float	ppm_v/d
	0x005B			
93	0x005C	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v/d
	0x005D			
95	0x005E	Hydrogen	32-bit float	ppm_v/d
	0x005F			
241	0x00F0	Oxygen	32-bit float	ppm_v/d
	0x00F1			
243	0x00F2	Nitrogen	32-bit float	ppm_v/d
	0x00F3			
Rate of change (ROC), 7 days				
101	0x0064	Methane	32-bit float	ppm_v/w
	0x0065			
103	0x0066	Acetylene	32-bit float	ppm_v/w
	0x0067			
105	0x0068	Ethylene	32-bit float	ppm_v/w
	0x0069			
107	0x006A	Ethane	32-bit float	ppm_v/w
	0x006B			
109	0x006C	Carbon monoxide	32-bit float	ppm_v/w
	0x006D			
111	0x006E	Carbon dioxide	32-bit float	ppm_v/w
	0x006F			
113	0x0070	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v/w
	0x0071			

Register number	Address	Register description	Data format	Unit and notes
115	0x0072	Hydrogen	32-bit float	ppm_v/w
	0x0073			
261	0x0104	Oxygen	32-bit float	ppm_v/w
	0x0105			
263	0x0106	Nitrogen	32-bit float	ppm_v/w
	0x0107			
Rate of change (ROC), 30 days				
121	0x0078	Methane	32-bit float	ppm_v/m
	0x0079			
123	0x007A	Acetylene	32-bit float	ppm_v/m
	0x007B			
125	0x007C	Ethylene	32-bit float	ppm_v/m
	0x007D			
127	0x007E	Ethane	32-bit float	ppm_v/m
	0x007F			
129	0x0080	Carbon monoxide	32-bit float	ppm_v/m
	0x0081			
131	0x0082	Carbon dioxide	32-bit float	ppm_v/m
	0x0083			
133	0x0084	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v/m
	0x0085			
135	0x0086	Hydrogen	32-bit float	ppm_v/m
	0x0087			
281	0x0118	Oxygen	32-bit float	ppm_v/m
	0x0119			
283	0x011A	Nitrogen	32-bit float	ppm_v/m
	0x011B			
Gas ratios (24 hour average values)				
141	0x008C	CH_4/H_2	32-bit float	-
	0x008D			

Register number	Address	Register description	Data format	Unit and notes
143	0x008E	C_2H_2/C_2H_4	32-bit float	-
	0x008F			
145	0x0090	C_2H_2/CH_4	32-bit float	-
	0x0091			
147	0x0092	C_2H_6/C_2H_2	32-bit float	-
	0x0093			
149	0x0094	C_2H_4/C_2H_6	32-bit float	-
	0x0095			
151	0x0096	CO_2/CO	32-bit float	-
	0x0097			
153	0x0098	O_2/N_2	32-bit float	-
	0x0099			
Other				
161	0x00A0	Time stamp of measurement result set, in seconds since start of Unix epoch	64-bit float (double)	s
	0x00A1			
	0x00A2			
	0x00A3			
165	0x00A4	Index of measurement result set	32-bit integer	-
	0x00A5			
Custom averages				
171	0x00AA	Methane	32-bit float	ppm_v
	0x00AB			
173	0x00AC	Acetylene	32-bit float	ppm_v
	0x00AD			
175	0x00AE	Ethylene	32-bit float	ppm_v
	0x00AF			
177	0x00B0	Ethane	32-bit float	ppm_v
	0x00B1			
179	0x00B2	Carbon monoxide	32-bit float	ppm_v
	0x00B3			

Register number	Address	Register description	Data format	Unit and notes
181	0x00B4	Carbon dioxide	32-bit float	ppm_v
	0x00B5			
183	0x00B6	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v
	0x00B7			
185	0x00B8	Hydrogen	32-bit float	ppm_v
	0x00B9			
187	0x00BA	Moisture in oil	32-bit float	ppm_w
	0x00BB			
191	0x00BE	Oxygen	32-bit float	ppm_v
	0x00BF			
193	0x00C0	Nitrogen	32-bit float	ppm_v
	0x00C1			
Present values as 16-bit signed integer				
221	0x00DC	Methane	16-bit signed integer	ppm_v
222	0x00DD	Acetylene	16-bit signed integer	ppm_v
223	0x00DE	Ethylene	16-bit signed integer	ppm_v
224	0x00DF	Ethane	16-bit signed integer	ppm_v
225	0x00E0	Carbon monoxide	16-bit signed integer	ppm_v
226	0x00E1	Carbon dioxide	16-bit signed integer	ppm_v
227	0x00E2	Total dissolved combustible gases (TDCG)	16-bit signed integer	ppm_v
228	0x00E3	Hydrogen	16-bit signed integer	ppm_v
229	0x00E4	Moisture in oil	16-bit signed integer	ppm_w*10

Register number	Address	Register description	Data format	Unit and notes
230	0x00E5	Temperature of in-oil measurement chamber	16-bit signed integer	°C*10
231	0x00E6	Relative moisture in oil	16-bit signed integer	%RS*10
232	0x00E7	Total gas pressure (TGP)	16-bit signed integer	hPa
233	0x00E8	Oxygen	16-bit signed integer	ppm_V*0.1
234	0x00E9	Nitrogen	16-bit signed integer	ppm_V*0.1

A.4.2 Alert registers

Gas level alert registers are 16-bit fields. Each register communicates the status of alerts of specific severity for a particular timeframe (for example, gas level caution alerts for present values).

If an alert is active, the corresponding bit is set to 1. The bit is set to 0 when the alert is deactivated, turned off, or gas level alerts are muted. For more information, see Gas level alerts (page 31).

Table 34 Alert registers (read-only)

Register number	Address	Register description	Data format	Bit order
11	0x000A	Gas level caution alerts for present values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 8 = Moisture in oil 9 = Relative moisture in oil 11 = TGP above maximum limit 12 = TGP below minimum limit 15 = Any caution alert active in this register
301	0x012C	Gas level caution alerts for present values	16-bit field	0 = Oxygen above maximum limit 1 = Oxygen below minimum limit 2 = Nitrogen above maximum limit 3 = Nitrogen below minimum limit 15 = Any caution alert active in this register

Register number	Address	Register description	Data format	Bit order
12	0x000B	Gas level caution alerts for 24 hour average ROC values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 15 = Any caution alert active in this register
302	0x012D	Gas level caution alerts for 24h average ROC values	16-bit field	0 = Oxygen above maximum limit 1 = Oxygen below minimum limit 2 = Nitrogen above maximum limit 3 = Nitrogen below minimum limit 15 = Any caution alert active in this register
13	0x000C	Gas level caution alerts for 7 day average ROC values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 15 = Any caution alert active in this register

Register number	Address	Register description	Data format	Bit order
303	0x012E	Gas level caution alerts for 7 day average ROC values	16-bit field	0 = Oxygen above maximum limit 1 = Oxygen below minimum limit 2 = Nitrogen above maximum limit 3 = Nitrogen below minimum limit 15 = Any caution alert active in this register
14	0x000D	Gas level caution alerts for 30 day average ROC values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 15 = Any caution alert active in this register
304	0x012F	Gas level caution alerts for 30 day average ROC values	16-bit field	0 = Oxygen above maximum limit 1 = Oxygen below minimum limit 2 = Nitrogen above maximum limit 3 = Nitrogen below minimum limit 15 = Any caution alert active in this register

Register number	Address	Register description	Data format	Bit order
15	0x000E	Gas level alarms for present values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 8 = Moisture in oil 9 = Relative moisture in oil 11 = TGP above maximum limit 12 = TGP below minimum limit 15 = Any alarm active in this register
305	0x0130	Gas level alarms for present values	16-bit field	0 = Oxygen above maximum limit 1 = Oxygen below minimum limit 2 = Nitrogen above maximum limit 3 = Nitrogen below minimum limit 15 = Any caution alert active in this register

Register number	Address	Register description	Data format	Bit order
16	0x000F	Gas level alarms for 24 hour average ROC values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 15 = Any alarm active in this register
306	0x0131	Gas level alarms for 24 hour average ROC values	16-bit field	0 = Oxygen above maximum limit 1 = Oxygen below minimum limit 2 = Nitrogen above maximum limit 3 = Nitrogen below minimum limit 15 = Any alarm active in this register
17	0x0010	Gas level alarms for 7 day average ROC values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 15 = Any alarm active in this register

Register number	Address	Register description	Data format	Bit order
307	0x0132	Gas level alarms for 7 day average ROC values	16-bit field	0 = Oxygen above maximum limit 1 = Oxygen below minimum limit 2 = Nitrogen above maximum limit 3 = Nitrogen below minimum limit 15 = Any alarm active in this register
18	0x0011	Gas level alarms for 30 day average ROC values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 15 = Any alarm active in this register
308	0x0133	Gas level alarms for 30 day average ROC values	16-bit field	0 = Oxygen above maximum limit 1 = Oxygen below minimum limit 2 = Nitrogen above maximum limit 3 = Nitrogen below minimum limit 15 = Any alarm active in this register

A.4.3 Status registers

Only the first bit of each status bit field is used.

Table 35 Status registers (read-only)

Register number	Address	Register description	Data format	Notes
1	0x0000	Device stopped	16-bit field	0 = Device measuring normally 1 = Device stopped (either automatically or by administrator), being initialized, or being uninstalled
3	0x0002	Measurement reliability	16-bit field	0 = Measurement is unreliable because of high ambient temperature 1 = Measurement is reliable
4	0x0003	Gas alerts muted	16-bit field	0 = Gas level alerts operating normally 1 = Gas level alerts muted
5	0x0004	Combined cautions • Gas level present values • Gas level 24h avg ROC • Gas level 7 day avg ROC • Gas level 30 day avg ROC	16-bit field	0 = No cautions are active 1 = At least one caution is active
6	0x0005	Combined alarms • Gas level present values • Gas level 24h avg ROC • Gas level 7 day avg ROC • Gas level 30 day avg ROC	16-bit field	0 = No alarms are active 1 = At least one alarm is active

A.4.4 Test value registers

Read the known test values from the test registers to verify the functionality of your Modbus implementation.

Table 36 Test value registers (read-only)

Register number	Address	Data format	Test value
201	0x00C8	16-bit unsigned integer	12345
202	0x00C9	32-bit unsigned integer	1234567890
	0x00CA		

Register number	Address	Data format	Test value
204	0x00CB	64-bit unsigned integer	1234567890123456789
	0x00CC		
	0x00CD		
	0x00CE		
208	0x00CF	16-bit integer	-12345
209	0x00D0	32-bit integer	-1234567890
	0x00D1		
211	0x00D2	64-bit integer	-1234567890123456789
	0x00D3		
	0x00D4		
	0x00D5		
215	0x00D6	32-bit float	1.23456
	0x00D7		
217	0x00D8	64-bit float	1.23456789
	0x00D9		
	0x00DA		
	0x00DB		

A.5 Exception responses

Table 37 Modbus exception responses

Code	Name	Reason
01	Illegal function	Unsupported function code
02	Illegal data address	Register address or Object ID out of valid ranges
03	Illegal data value	Otherwise invalid request

Accessing unavailable (temporarily missing) measurement data does not generate a Modbus exception. “Unavailable” value (a quiet NaN for floating point data or 0x8000 for integer data) is returned instead. An exception is generated only for any access outside the applicable register ranges.

A.6 Modbus communication examples

Reading acetylene value

Device address used in the following examples is 240 (0xF0).
The values returned by the device differ depending on the measurement conditions. Your device may not return the same values.

Request	
Bytes on the line (hexadecimal)	**Description**
(silence for > 3.5 bytes)	Start of Modbus RTU frame
0xF0	OPT100 address
0x03	Function (Read Holding Registers)
0x00	Register address (Acetylene)
0x16	
0x00	Number of 16-bit registers to read (2)
0x02	
0x30	Modbus RTU checksum
0xEE	
(silence for > 3.5 bytes)	End of Modbus RTU frame

Response	
Bytes on the line (hexadecimal)	**Description**
(silence for > 3.5 bytes)	Start of Modbus RTU frame
0xF0	OPT100 address
0x03	Function (Read Holding Registers)
0x04	Number of data bytes
0x40	Value of first register (least significant word)
0x40	
0x00	Value of second register (most significant word)
0x00	
0x0E	Modbus RTU checksum
0xE8	

Response	
(silence for > 3.5 bytes)	End of Modbus RTU frame

Communication description	
Register number	23 (1-based Modbus register number) = address 0x0016 (0-based address used in actual communication).
Data format	Two 16-bit Modbus registers interpreted as IEEE 754 binary32 floating point value, least significant word first.
Returned value	0x40400000, which is binary32 representation of 3 (ppm).

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Technical support



You can contact Vaisala technical support at vaisala.my.site.com/myvaisala or helpdesk@vaisala.com. You can find all our support channels at vaisala.com/support.

When contacting technical support, provide the following as applicable:

- Product name, model, and serial number
- Software/Firmware version
- Name and location of the installation site
- Name and contact information of a technical person who can provide further information
- Diagnostics package for the application

If applicable, also provide the following details:

- What failed (what worked / did not work)?
- Where did it fail (location and environment)?
- When did it fail (date, immediately / after a while / periodically / randomly)?
- How many failed (only one defect / other same or similar defects / several failures in one unit)?
- What was done when the failure was noticed?
- What was connected to the product and to which connectors?
- What is the input power source type, voltage, and what else (such as lighting, heaters, and motors) was connected to the same power output?
- Are all parts connected and grounded properly? Take a photo to help the troubleshooting.

Warranty

For warranty terms and conditions and the warranty claim process, see vaisala.com/warranty. Note that warranty coverage may not apply if the product is damaged due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. See the applicable supply contract or Conditions of Sale for details of the warranty for each product.

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