

# Outages Happen 24/7. So Should Monitoring.

/ PREVENT POWER TRANSFORMER  
FAILURE WITH HELP FROM VAISALA



**VAISALA**

# Power Transformer Monitoring that Works



*There's nothing worse than an unplanned outage, in terms of both lost revenue and the damage to your reputation and brand. In the typical big utility, on average six transformers fail every year.*

*So what can be done?*

Here's the good news: 50% of power transformer failures can be prevented with the right online monitoring tools for moisture levels and dissolved gases in power transformer oil.

Moisture reduces the insulating properties of transformer oil, resulting in more rapid aging of the transformer. Traditionally, oil moisture readings have been taken at periodic intervals. However, because moisture levels can change rapidly due to temperature variations of the transformer oil, periodic sampling is not sufficient.

Dissolved gas analysis (DGA) is a critical component in preventing power transformer failure. Dissolved gas levels in transformer oil can

indicate the existence of a fault, and the rate of change in these levels can be used to determine its severity.

But if your monitors give false alarms or require regular maintenance, they can end up wasting time and money while failing to predict an imminent failure.

You need a monitor that does all the work for you – sampling, analysis, and calibration – and only alerts you when there is an issue with the transformer. A monitor you can install, trust, and forget.

That's why we created the Vaisala range of monitors for power transformers. They provide real time, trouble free monitoring for your power transformers – with no false alarms.

# Make Your Assets Work for You



We know the pressures you face in this industry. An aging installed base, expensive and time consuming refurbishment or replacement, and untold costs if there is a power transformer failure.

Online monitoring is supposed to fix this. But each false alarm costs time and money when someone needs to visit the site and take samples. Even worse, false alarms can mean that people stop paying attention to the monitors. Not only is this a waste of your investment, but it can also lead to warning signs being missed.

Vaisala has a better way. Our online monitors for power transformers have been designed from the ground up to eliminate false alarms and provide reliable long-term trends. You get the data you need to safely extend the life of your power transformers and simplify key investment decisions: like when to maintain or refurbish existing units.

Best of all, you get the data you need to avoid power transformer failure, which not only saves you money, but also protects your reputation.

The end result? Your assets working for you, not the other way around.

## You Can Count On Vaisala

Vaisala has been creating measurement devices for 80 years. Our instruments and systems are used in over 150 countries in industries where failure is not an option, including airports, pharmaceuticals, and power generation. In fact, over 10,000 companies in safety and quality-critical sectors already rely on Vaisala.

Vaisala sensors are so reliable they're used in the harshest places on earth - like arctic, maritime, and tropical environments - and even on Mars.

# The Vaisala Optimus™ OPT100 DGA Monitor for Transformers



*The Vaisala Optimus OPT100 DGA Monitor delivers out-of-the-box performance, completely eliminates false alarms, and gives you the best long-term stable measurements of any device on the market – without maintenance.*

## Dependable Data

- Sensor optics are protected from contamination
- Vacuum gas extraction is independent of oil temperature, pressure, and type
- Unique autocalibration eliminates long-term drift
- IR sensor technology designed and optimized in Vaisala cleanrooms
- Spectral scanning for better gas selectivity
- Excellent signal/noise ratio means no averaging

## Robust Construction

- Hermetically sealed structure tolerates vacuum and pressure variation
- No consumables to replace or service
- IP66-rated and temperature-controlled housing withstands harsh conditions
- Stainless steel and aluminum components and piping
- Magnetic gear pump and magnetic valves

## Smart Design

- Self-contained plug-and-play monitor that can be installed in less than two hours
- Browser-based user interface means no additional software needed
- Continuous real-time monitoring allows for trending, analysis, and correlation to, for example, load patterns
- Self diagnostics provide self recovery after disturbances



## How is the Vaisala Optimus DGA Monitor Different?

The Vaisala Optimus DGA OPT100 Monitor for Transformers is the culmination of decades of listening to customers' needs and researching existing devices, as well as leveraging our 80 years of experience making sensors and measuring equipment for safety-critical industries and harsh environments.

## No More False Alarms

The monitor's IR sensor has been designed and optimized in Vaisala cleanrooms. Vacuum gas extraction means no data fluctuation due to oil temperature, pressure, or type, while hermetically sealed and protected optics prevent sensor contamination. The end result? A monitor that completely eliminates false alarms.

## A Device That Works Anywhere

Stainless steel pipes, IP66-rated temperature controlled housing, and a magnetic pump and valves mean superb performance and durability – from the arctic to the tropics. There are also no consumables to service or replace.

## Intelligent Features for Hassle-free Monitoring

The Vaisala Optimus DGA OPT100 Monitor for Transformers uses a browser-based interface that completely eliminates the need for additional software. The device can be installed in less than two hours – just connect the oil and power and it's ready to go. And in case of a disturbance like power loss, self diagnostics allow the device to self recover.

## Measurement Parameters

- Hydrogen  $H_2$
- Carbon monoxide  $CO$
- Carbon dioxide  $CO_2$
- Methane  $CH_4$
- Ethane  $C_2H_6$
- Ethylene  $C_2H_4$
- Acetylene  $C_2H_2$
- Moisture  $H_2O$

# The Vaisala MHT410

## Hydrogen Monitoring You Can Trust



### Moisture and Hydrogen Measurement

- Vaisala's proven moisture-in-oil technology has been used for over 15 years by leading power industry customers in over 30 countries
- You can get both relative saturation of oil as water activity value and calculated ppm values
- Measurement is immune to oil contaminants
- Hydrogen is a general signal gas that is quickly generated in various transformer failures
- Direct H<sub>2</sub> measurement from oil with non-consumable sensor guarantees long-term field operation
- Easy and fast measuring - installation in minutes, via ball valve. Transformer does not need to be off-loaded

*The Vaisala MHT410 Moisture, Hydrogen, and Temperature Transmitter is a cost-effective and dependable solution for monitoring insulating oil in power transformers. Unlike conventional solutions, the Vaisala MHT410's sensors directly measure transformer oil to provide non-stop trend data.*

The transmitter can be easily installed and mounted onto an operational transformer in minutes by one person, with no field adjustments necessary. The MHT410 is also robust: its non-membrane technology means it can handle both under-pressure and over-pressure conditions. Furthermore, there are no pumps, hoses, batteries, valves, or other sensitive wear parts that could fail or lead to outages.

# Vaisala HUMICAP® and DRYCAP® Sensors

## Dependable Moisture and Dew Point Measurement



### Vaisala HUMICAP® Sensors – Continuous Online Moisture Measurement

Vaisala offers a full line of transmitters with this sensor, from fixed HMT units to portable HM units.

The Vaisala MMT330 Moisture and Temperature Transmitter measures transformer oil moisture online, providing an accurate real-time picture of the transformer's condition. The transmitter monitors moisture levels in all ambient and operating conditions, and is compatible with all types of insulating oil. Installation is easy, and the device can be directly connected to the substation data collection system.

The Vaisala MM70 Hand-held Moisture and Temperature Meter is a lightweight meter for spot checks to identify transformers with moisture issues. Because the probe can be inserted directly into the process through a ball valve, there's no need to drain the oil or shut down the transformer.



### Vaisala DRYCAP® Sensors – Ensure Dry Insulation with Dew Point Measurement

Vaisala offers a full line of transmitters with this sensor, from fixed DMT units to portable DM units.

When building a new transformer or overhauling an installed unit, the cellulose insulation needs to be dried completely by applying heat and vacuum. After drying, the tank is purged with dry nitrogen or air. Dew point measurement is crucial to confirming the final dryness after the nitrogen/air purge, ensuring a thorough drying process. But how do you know when dry is really dry?

Vaisala's fixed DRYCAP Dewpoint and Temperature Transmitter Series DMT340 and portable DRYCAP Hand-Held Dewpoint Meter DM70 allow you to quickly and reliably verify specified moisture levels.

# Vaisala Monitoring Solutions for Power Transformers

*Vaisala offers a full range of online monitoring solutions for all your power-transformer needs.*

## Vaisala Optimus™ OPT100 DGA Monitor for Transformers

A comprehensive multi-gas monitor for your most critical transformers. It delivers out-of-the-box performance with no maintenance, eliminates false alarms, and offers the best long-term measurement stability on the market.

## Vaisala MHT410

An early-warning online monitor for power transformers that gives hydrogen trend and moisture data with no false alarms or maintenance.

## Vaisala HUMICAP® MMT330 and MM70

A fixed transmitter or handheld meter for power transformers that gives reliable relative humidity, moisture, and temperature readings for oil – with no false alarms.

## Vaisala DRYCAP® DMT340 and DM70

A fixed transmitter or handheld meter for quality control and spot checking humidity levels in power transformers in the factory or after refurbishment or transport.



OPT100



MHT410



MMT330



DMT340



MM70



DM70

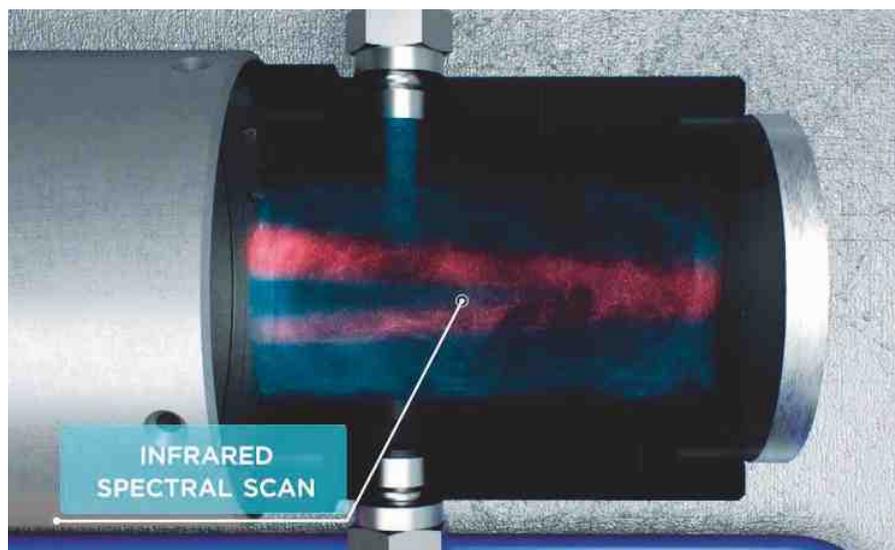
# The Vaisala Optimus™ DGA Monitor Technology Overview

*The Vaisala Optimus DGA Monitor gives our customers trouble-free online monitoring of fault gases in power transformers, with no false alarms. The monitor doesn't require frequent maintenance and is designed to be safe and reliable – even in harsh and demanding operating environments. More information about the key technology components and functions is given below.*

## Sensing Technology

The sensing technology for carbon oxides and hydrocarbons is based on infrared (IR) light absorption, where different gases have unique absorption characteristics. The extracted gases are compressed in the optical module and the gas mixture is exposed to IR light from microglow light sources.

The optical module scans a wide range of IR wavelengths and analyzes IR absorption as well as the shape of absorption peaks to offer good selectivity for different detected gases and their concentrations. This proprietary measurement method eliminates interference from other



evaporative hydrocarbons present in transformer oil, preventing cross-sensitivity.

Moisture is measured directly in the oil with our capacitive thin-film polymer HUMICAP® sensor, which has been used for transformer monitoring for 20 years. Hydrogen is also measured directly in the oil with the same solid-state sensor technology used in the Vaisala MHT410 transmitter.

## IR Sensor Elements

All IR sensor elements, light sources, filters, and detectors are based on microelectromechanical systems (MEMS) with single crystal wafers. These elements are designed and optimized for the Optimus DGA Monitor and are manufactured in Vaisala cleanrooms. To maximize reliability, there are no moving parts in the optical measurement module.

## Gas Extraction

Gases are extracted from transformer oil under partial vacuum, meaning very low absolute pressure at a



controlled temperature. Vacuum extraction results in more complete gas separation than the traditional headspace method, increasing measurement reliability. This is also true when the pressure of total dissolved gases is far below saturation, for example after a transformer degassing process.

As vacuum extraction is significantly less dependent than the headspace method on gas solubility in oil (Ostwald coefficients), there is no need for any temperature or oil specific compensation. The gas extraction method used in the Optimus DGA Monitor is derived from the principle presented in the publication IEC 60567:2005 “7.3 Vacuum extraction by partial degassing method”.

## Optical Components

Traditionally, optical components can be subject to internal or external contamination. With the Vaisala Optimus DGA Monitor, internal gas extraction and oil handling mechanics are built and controlled so that contaminating compounds from oil cannot gather on the optical surfaces. Any external contamination is eliminated with a fully hermetic structure, which means ambient air cannot contact any part of the optical module.

## Auto-calibration

The Optimus DGA Monitor has several proprietary and unique automatic functions that can detect and eliminate known drift mechanisms of IR-based technologies, such as a decrease in light source intensity or changes in filter transmission.

## Dissolving Gases

After the extracted gases have been analyzed, they are dissolved back into the oil. The automatic dissolving process is carefully controlled and monitored. There are special secondary mechanical structures to prevent any gas bubbles from leaving the monitor and entering the transformer. After the gases are dissolved, the oil is returned to the transformer in the same condition as it was taken. The dissolving process and hermetic structure of the oil and gas handling parts also eliminates the risk of flammable gases accumulating in the instrument housing.

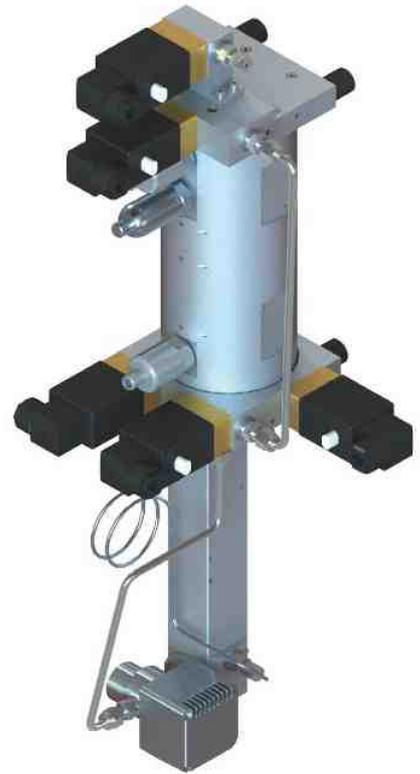
## Hermetic Mechanical Structure

All mechanical parts and structures in contact with oil and gas are made of aluminum or stainless steel, and there is no plastic piping in contact with the oil. As the whole structure is hermetically sealed, no oxygen or moisture from ambient air can enter the system and contaminate the transformer oil, even in the unlikely case of device failure. The risk of oil leakage is also minimized under all circumstances.

## Self-diagnostics

The Optimus DGA Monitor continuously tracks internal functions during measurement cycles by comparing the different parameters and settings to carefully pre-defined reference values. The unit constantly records the status of integral elements like sensors, valves, and the pump. To confirm leak-free operation, the tightness of the structure that is in contact with oil and gases is continuously monitored with pressure sensors both under vacuum and during gas compression into the optical module.

In case of sudden power loss, the device stops operating and closes all valves automatically. Once mains power recovers, self-diagnostics automatically identify the status of the monitor and the measurement cycle phase before running the device to a safe starting point to continue normal operation. The unit records all main operational parameters into a self-diagnostics log file, which can be downloaded and analyzed remotely in case of any abnormal phenomena occurring.



*The oil handling unit for the Optimus DGA Monitor is made of aluminum and stainless steel, providing a robust and reliable structure in even the most harsh and demanding operating environments.*

# Vaisala HUMICAP® Sensor for Measuring Relative Humidity

*In 1973, Vaisala introduced HUMICAP®, the world's first thin-film capacitive humidity sensor. Since then, Vaisala has become the market leader in relative humidity measurements, and thin-film capacitive humidity sensors have developed from one company's innovation into a global industry standard.*

Vaisala HUMICAP sensors guarantee quality and reliability, with their reputation for accuracy, excellent long-term stability, and negligible hysteresis.

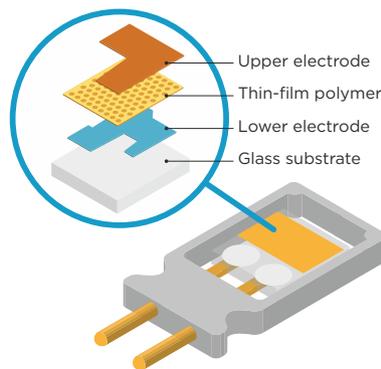
## How It Works

HUMICAP is a capacitive thin-film polymer sensor consisting of a substrate on which a thin film of polymer is deposited between two conductive electrodes. The sensing surface is coated with a porous metal electrode to protect it from contamination and exposure to condensation. The substrate is typically glass or ceramic.

The thin-film polymer either absorbs or releases water vapor as the relative humidity of the ambient air rises or falls. The dielectric properties of the polymer film depend on the amount of absorbed water. As the relative humidity around the sensor changes, the dielectric properties of the polymer film change, and so does the capacitance of the sensor. The instrument's electronics measure the capacitance of the sensor and convert it into a humidity reading.

### HUMICAP in Brief

- A capacitive thin-film polymer sensor
- Full measurement range 0...100 %RH
- Accurate to  $\pm 1$  %RH
- Traceable humidity measurement
- Nearly 40 years on the market



Structure of the HUMICAP sensor.



Family of HUMICAP sensors.

### HUMICAP's Unique Benefits

- Excellent long-term stability
- Insensitive to dust and most chemicals
- Chemical purge option for stable measurements in environments with high concentrations of chemicals
- Sensor heating for measurements even in condensing environments
- Full recovery from condensation

## HUMICAP® - The Story of Innovation

Until the early 1970s, hair hygrometers were commonly used in radiosondes. At that time, reliable humidity measurement was an unresolved challenge and to solve this, Vaisala began developing a new type of humidity sensor using semiconductors and thin-film materials. The revolutionary HUMICAP humidity sensor was introduced two years later, in 1973, at CIMO VI congress.

HUMICAP was a radical innovation that changed humidity measurements for good. The new technology was groundbreaking: the sensor had no moving parts, and due to the advanced use of semiconductor and thin-film technologies, it was amazingly small. The sensor had a fast response time, good linearity, low hysteresis, and small temperature coefficient.

Despite the fact that the innovation was designed for a new type of a radiosonde, the greatest interest came from elsewhere: people working in environments as diverse as greenhouses, bakeries, warehouses, construction sites, brick and timber kilns, and museums. The need for reliable humidity measurement was common to all, and instruments that could do this accurately were few and far between.

By 1980, a variety of products based on HUMICAP technology - from hand-held meters to industrial transmitters, calibrators, and other accessories - were being sold in over 60 countries. Since its birth, HUMICAP has been part of Vaisala's core business, propelling the company to industry leadership in the field of humidity measurement.

# Vaisala DRYCAP® Sensor for Measuring Dew Point

In 1997 Vaisala introduced DRYCAP®, a new type of dew point sensor based on thin-film polymer technology. Since its launch, the DRYCAP product family has grown to encompass a huge range of applications, from drying processes to compressed air and dry chambers. The DRYCAP sensor is particularly renowned for its reliable performance in hot and very dry environments.

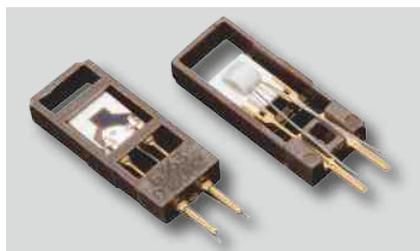
## How It Works

DRYCAP's unrivalled performance is based on two innovations: the proven capacitive thin-film polymer sensor and the auto-calibration function.

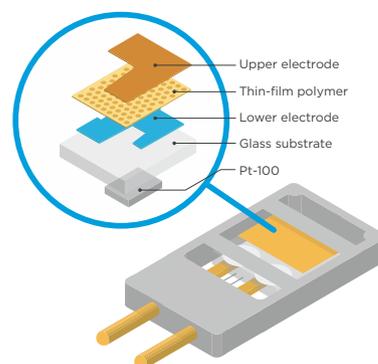
The sensor's thin-film polymer absorbs or releases water vapor as the surrounding humidity increases or decreases. The dielectric properties of the polymer change as the humidity around the sensor changes, as does the capacitance of the sensor. Capacitance is converted into a humidity reading. The capacitive polymer sensor is bonded together with a temperature sensor, and dew point is calculated from the humidity and temperature readings.

Vaisala's patented auto-calibration function optimizes the measurement stability at low dew points.

The sensor is heated at regular intervals during the automated auto-calibration procedure. The humidity and temperature readings are monitored as the sensor cools to ambient temperature, with offset correction compensating for any potential drift. This enables the DRYCAP sensor to deliver accurate measurements in the long term, dramatically reducing the need for maintenance.



DRYCAP sensors.



Structure of the DRYCAP sensor.

## DRYCAP in Brief

- Thin-film polymer sensor with unique auto-calibration function
- Wide measurement range, dew point measurement down to -80 °C (-112 °F)
- Accuracy  $\pm 2$  °C ( $\pm 3.6$  °F)
- NIST-traceable dew point measurement

## DRYCAP's Unique Benefits

- Excellent long-term stability, with recommended 2-year calibration interval
- Rapid response time
- Withstands condensation and recovers rapidly
- Resistant to particulate contamination, oil vapor, and most chemicals

## The DRYCAP Story

The DRYCAP story began in the mid-1990s following an unresolved measurement challenge. Traditional humidity instruments were not accurate enough at very low humidities, while commonly used aluminum oxide sensors were prone to drift and required frequent calibration. There was strong demand for accurate, easy-to-use, cost-effective, and low-maintenance dew point instruments.

Vaisala's solution was to combine the highest quality polymer technology with a patented key feature - auto-calibration - that would eliminate sensor drift in very dry conditions. The result was the stable, reliable, and accurate DRYCAP sensor.

The first DRYCAP products were launched in 1997, and this highly successful innovation is still going strong today.

DRYCAP also led the way for the next great innovation: the world's first transmitter that monitors both dew point and process pressure simultaneously, aimed at compressed air customers worldwide. The story continues.

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