

Maintaining harvest fresh apples

- Controlled Atmosphere storage requires accurate carbon dioxide measurements

Producing oxygen for some serious "paperwork"

- Vaisala contributes to a trouble-free air separation process

Watch your home like a hawk

- WeatherHawk home automation solutions incorporate Vaisala's weather measurement know-how

Bringing out the beauty of wood

- Veneer drying with humidity control



*Controlled Atmosphere (CA) storage is a widely used technique for long-term storage of freshly picked fruits and vegetables. **Page 4.***



*Home automation has evolved over the past 15 years from remote lighting and audio/visual controls to very sophisticated total environment home control systems. **Page 15.***



*With today's growing focus on global warming and the need to reduce energy consumption, evaporative cooling needs to be revisited as an important cooling alternative. **Page 20.***

Contents

- 3** Business not as usual
- 4** Maintaining harvest fresh apples
- 6** Keep it cool
- 8** A perfect combination of old and new
- 9** Extend your measurement range
- 11** A breath of fresh air
- 12** Producing oxygen for some serious "paperwork"
- 14** Clean beach, happy swimmers
- 15** Watch your home like a hawk
- 17** Bringing out the beauty of wood
- 19** Vaisala engineers a solution
- 20** Cool down, the environmental way
- 23** Coping even with chemical interference
- 24** Detect moisture in oil
- 28** Small device - big performance
- 29** Strong under pressure
- 30** Briefly noted

Vaisala in Brief

– We develop, manufacture and market products and services for environmental and industrial measurements.

– The purpose of these measurements is to provide a basis for a better quality of life, cost savings, environmental protection, improved safety and better performance.

– We focus on market segments where we can be the world leader, the preferred supplier. We put a high priority on customer satisfaction and product leadership. We secure our competitive advantage through economies of scale and scope.

Cover photo:

Shutterstock

Editor-in-Chief:

Marikka Nevamäki

Publisher:

Vaisala Oyj
P.O. Box 26
FI-00421 Helsinki
FINLAND

Phone (int.):

+ 358 9 894 91

Telefax:

+ 358 9 8949 2227

Internet:

www.vaisala.com

Design and Artwork:

Sampo Korkeila

Printed in Finland by:

SP-Paino

ISSN 1238-2388

Business not as usual

With today's growing focus on the need to reduce energy consumption, energy-efficient technological solutions are becoming increasingly popular. It is not only a matter of preserving the environment for future generations, it is also about improving efficiency and reducing costs - in short, good business. Energy efficiency has proved to be a cost-effective strategy for businesses. In the long-term, efficiency measures cost less than the energy itself. The returns on investment speak for themselves.

Energy issues in China present a primary example of the magnitude of the challenge. China's environmental markets are experiencing strong growth, and the Chinese wish to make use of the best environmental know-how and technology available to solve their mounting environmental problems.

The Finnish Environmental Cluster for China (FECC) is a two-year project that aims to build a network involving Finnish environmental businesses, like Vaisala, in the Chinese markets. Vaisala participated in the China - Finland Cleantech Conference held in Finland in August. The conference provided a venue for environmental companies and research organizations to meet and exchange ideas. The FECC work continues with the goal of

reporting some concrete cooperation success stories in the near future.

Economic growth and sustainable development can go hand-in-hand. A country's development does not have to follow the accustomed, environmentally destructive path, if provided with the right partners and support.

Advanced technology plays a significant role in energy-efficiency issues. Vaisala is the global leader in environmental measurement technologies that promote better quality of life, environmental protection, safety, efficiency and cost-savings. Vaisala provides tools to support energy-efficient heating and cooling solutions. Other examples, also presented in this magazine, are the inexpensive and energy-efficient use of CO₂ as a refrigerant, and the use of oxygen in pulp bleaching, contributing to more environmentally friendly paper production. Vaisala equipment helps you to reach the best results technology can provide.

I would like to take this opportunity to thank you, our customers, for choosing to do business with Vaisala. We strive to reward you with increasingly better support and services. Let's continue to do business that is - not as usual - but more beneficial for all parties. ■



Kjell Forsén
CEO

A close-up photograph of a woman with curly brown hair and blue eyes, wearing a green shirt. A single green apple is balanced on top of her head. She is looking slightly to the right of the camera with a neutral expression.

Maintaining harvest fresh apples

Controlled Atmosphere storage requires accurate carbon dioxide measurements

Controlled atmosphere (CA) storage is a widely used technique for long-term storage of freshly picked fruits and vegetables. Historically, CA storage has been the primary method for the long-term storage of apples. Through a biological process called respiration, apples take in oxygen and generate carbon dioxide, water, and heat.

Controlled Atmosphere storage is an entirely natural process that reduces the effects of respiration to a minimum by controlling the environmental conditions surrounding the stored fruit. CA storage makes it possible to buy crisp, juicy apples year round. Many cultivars of apples can be preserved for a remarkable 9 – 12 months in CA storage, as opposed to only 2 – 3 months if using refrigerated storage.

Optimal conditions important

In order to effectively preserve apples the storage atmosphere must have a controlled amount of humidity, oxygen (O₂), carbon dioxide (CO₂) and temperature. The essence of CA storage is the range for O₂ and CO₂ concentrations, which both must be kept between 0.5 to 2.5%. The precise optimum concentrations vary for different varieties of apples (i.e. Golden Delicious apples may need different conditions than Jonagold apples, etc).

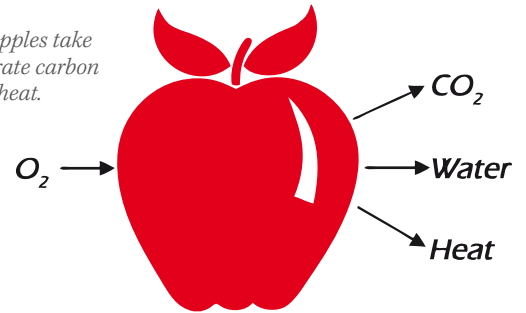
The relative humidity is kept in the range between 90 to 95%. High relative humidity slows down water loss and enhances storage life of the produce, but humidity too close to saturation encourages bacterial growth. Temperature in the storage container is maintained



CA storage makes it possible to buy crisp, juicy apples year round.

Apple respiration: apples take in oxygen and generate carbon dioxide, water, and heat.

Storage Control Systems Inc's CO₂ scrubber called the Series II Smart Scrubber.



around 1°C, the lowest possible temperature before damage to tissue occurs.

Carefully designed process

The typical process for CA storage begins by filling a storage chamber with apples. Some chambers are large enough to contain up to 400 tons of apples. The refrigeration apparatus is then activated to achieve the target temperature of 1°C. During cooling, the windows or other chamber openings are left open to prevent a possible collapse due to pressure changes.

When the desired storage temperature is reached, the room is sealed with an airtight CA door. Once sealed, a nitrogen generator is started to purge the O₂ concentration in the chamber from 21% (found in normal air) to approximately 3%. Once this level is reached the fruit will continue to reduce the O₂ concentration through the respiration process. If the O₂ concentration were to ever fall to zero the apples would suffer unwanted and irreversible fermentation reactions in the fruit. If O₂ levels drop below the safe concentration, outside air is added to the chamber to raise O₂ concentration to the intended level.

In addition to generating CO₂, the apples also generate ethylene gas which accelerates ripening. Increased levels of CO₂ will halt the ethylene production and therefore slow the ripening process of apples dramatically. However, if the CO₂ concentration is too high it may terminate the life of the apple by destroying appearance, flavor, and nutritional value. In order to maintain the CO₂ at the desired level, the excess CO₂ must be removed from the air in the chamber.

Gas analyzers are used to monitor and control the addition and removal of O₂

and the reduction of CO₂ through the course of the storage period. Because of their responsibility to control the desired gas concentrations in the chambers, these analyzers are critical to the operation of the entire system.

From bags of lime to more sophisticated methods

Years ago, chamber operators used hydrated lime to control the CO₂ in the fruit store. Bags of lime were loaded on pallets and placed into the store which absorbed all the CO₂ that was emitted from the apples, eventually leaving the store with no CO₂. Lime (calcium oxide, CaO) absorbs CO₂ and in turn reacts to form calcium carbonate (limestone, CaCO₃). Once all the lime was converted to calcium carbonate, the operator was forced to manually vent or flush the room with nitrogen to control the CO₂ level.

Nitrogen generators require large, high-power air compressors that can be costly to run with continuous usage. A carbon dioxide scrubber is a more efficient and affordable tool for removing and controlling CO₂ inside a fruit store. CO₂ scrubbers not only remove CO₂, but also remove some volatile organic carbons (VOCs) and ethylene, allowing optimal storage of fruit.

Seriously smart CO₂ scrubbers

Storage Control Systems, Inc. is a company that specializes in gas analyzers, nitrogen generators and CO₂ scrubbers for CA storage systems. Having been in the business for over 25 years, they are one of the longest established CA companies in the world.

SCS supplies a unique CO₂ scrubber called the Series II Smart Scrubber. This scrubber consists of two cylindrical beds

containing activated carbon. Activated carbon is a porous adsorbent material, meaning that the carbon dioxide molecules are attracted to and adhere to the surface of the carbon media. The activated carbon gradually becomes saturated, so it is necessary to periodically purge the beds with fresh air to remove the CO₂. The unit is programmed to adsorb on one bed, while purging with fresh air on the other to allow for continuous scrubbing. The Series II Smart Scrubber is also programmed with a "DeOx" cycle to minimize oxygen feedback to the CA room.

The Series II Scrubber uses a programmable logic controller (PLC) with a color touchscreen interface to carry out its control and sequencing functions. The PLC operator interface allows simple programming of CO₂ concentrations, resulting in highly effective fresh fruit storage regimes.

The Vaisala CARBOCAP® Carbon Dioxide Module GMM221 is used to monitor the CO₂ output from the beds, which controls the switching of the process from scrubbing to regenerating or vice versa at the most efficient point. Also, a snapshot of the CO₂ coming from the room is taken at the beginning of the cycle using the GMM221. This information is logged into the PLC, which uses the readings to set the optimal scrub and regeneration set points.

The Vaisala carbon dioxide sensor is highly stable, very reliable, does not require routine calibration and is able to read gas concentration levels over several months to an accuracy of <0.5%. This is critically important for successful long-term fruit storage and requires minimal maintenance by the operator. ■

Ulla Mattila
Application Manager
Vaisala
Helsinki, Finland
and

Penny Hickey
Application Sales Engineer
Vaisala
Boston, MA, USA

Keep it cool

Measuring carbon dioxide in refrigeration applications

CO₂, a widely used refrigerant in the early 20th century, was largely replaced by the chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants in the 1940s. The damaging effect of the CFCs and HCFCs on the ozone layer became evident in the 1970s. These compounds are also effective greenhouse gases contributing to the climate change. Consequently, a gradual phasing out has been taking place in order to replace these compounds in various applications. The Montreal Protocol was opened for signatures in 1987 to phase out the ozone-depleting chemicals, including CFCs and HCFCs, resulting in nearly all countries joining the effort to protect the ozone layer. Simultaneous re-inventing of natural refrigerants has taken place. The re-birth of CO₂ refrigeration was initiated by the pioneering work of Gustav Lorentzen in the 1980s and his invention of the trans-critical CO₂ heat cycle.

Many factors promote the use of CO₂ as a refrigerant. It is inexpensive and energy-efficient. In addition, it has good heat transfer properties and is compatible with most materials. The challenges related to process design, high operating pressures and downtime safety issues can be overcome with modern technology. From an environmental point of view, CO₂ does not cause ozone depletion and has lower global warming potential than the traditional refrigerants. As a result, CO₂ refrigeration has found numerous applications in food and industrial processing, cold storages, food retail and transfer, and sports facilities. It is also emerging in car and residential air-conditioning.

Detecting leakage of colorless and odorless gas

CO₂ is a non-toxic and non-flammable gas. However, it does not support life and exposure to elevated concentrations of CO₂ can induce a risk to life. The effects

of various concentrations of CO₂ on human health are summarized in Table 1. Unlike ammonia, it is impossible to detect leakage of the colorless and odorless CO₂ from the refrigeration system without proper sensors.

To ensure the safety of personnel in a CO₂ refrigerated facility, CO₂ transmitters should be installed in every human occupied space and as close to potential leakage points as possible. The number of transmitters should be based on risk assessment. Ventilation and air flow should be considered when planning transmitter installations. Carbon dioxide is twice as heavy as air and sinks and pools low to the ground, displacing oxygen in the air. Therefore, appropriate installation locations for the transmitters are at floor level.

Safety and system integrity are key issues

McAlpine Hussmann Ltd. has experience of integrating Vaisala CARBOCAP[®] Carbon Dioxide GMT220 Series Transmitters as leak detectors in CO₂ refrigeration applications.

McAlpine Hussmann Ltd. provides solutions for the display and refrigeration needs of supermarkets and grocery stores throughout Australasia. Their product range includes refrigerated and non-refrigerated display merchandisers, refrigeration systems, evaporative condensers, heat exchange coils, beverage coolers and walk-in coolers and freezers. They also offer installation, service and maintenance and aftermarket service through their service organization.

“Safety and system integrity are key issues,” says Rob Whitehead, Application Engineer from McAlpine Hussmann Ltd. in New Zealand. “Local codes state that any refrigerated space open to public access must have local leak detection and alarms. We decided to go a step further and alarm every refrigerated room as

well as the plant room. Each room has a local visual alarm set to activate at 3,000 ppm and a second set-point at 5,000 ppm programmed into the control system supplied by John McDaniels at Computer Process Controls. Having a separate programmable alarm point means we have been able to set the lower limit for the local alarm and know that the operators cannot adjust the set-points or isolate the alarm.”

Vaisala sensors are accurate and durable

Rob Whitehead lists the requirements for CO₂ transmitters: “The leak detector has to be sturdy, have a remote sensor and a display. It needs to be able to talk to the control and alarm system.”

The Vaisala CARBOCAP[®] Carbon Dioxide Transmitters GMT221 and GMT222 are especially designed for harsh and humid environments. The operating temperature range of the GMT221 transmitter is specified as -20 to +60°C. The transmitters have been tested in temperatures down to -40°C using both a constant low temperature and a rapid temperature gradient from -40°C to +70°C. The temperature dependency has been modeled down to -30°C. “The Vaisala system has allowed us the flexibility of mounting the detector units outside the refrigerated rooms at sufficient height to avoid the risk of mechanical damage,” says Rob Whitehead.

The Vaisala CARBOCAP[®] sensors are accurate and durable. They have excellent stability in terms of time and temperature, which will reduce maintenance costs over the years. The Vaisala sensors enable reliable carbon dioxide detection for the wellbeing of people working in carbon dioxide refrigerated spaces or people enjoying an exciting ice hockey game in a carbon dioxide refrigerated ice stadium. ■



Many factors promote the use of CO₂ as a refrigerant.

Concentration	Effect
350–450 ppm	Typical atmosphere
600–800 ppm	Acceptable indoor air quality
5000 ppm	Average exposure limit over 8 hours
3–8%	Increased respiration and headache
above 10%	Nausea, vomiting, unconsciousness
above 20%	Rapid unconsciousness, death

Table 1: Effects of different concentrations of CO₂ on human health.



A perfect combination of old and new

Vaisala CARBOCAP® carbon dioxide measurement technology celebrates ten years in business

Nondispersive Infrared (NDIR) gas sensing has been recognized as one of the most powerful tools for gas analysis for decades. Over time, advances have been made in NDIR gas sensing devices: infrared light sources, infrared filters, sensor optics and sensing algorithms to name but a few. Seldom, however, has there been such a profoundly new and innovative method introduced to NDIR gas sensing as when the Vaisala CARBOCAP® carbon dioxide sensor was introduced in 1997. As great inventions often are, it was a combination of the tried and trusted with something totally new – combining NDIR gas sensing and hundred-year-old optical principles with silicon micromechanics.

In 1897, exactly one hundred years before CARBOCAP® was invented, French physicists Charles Fabry and Alfred Pérot

published their most important article on what we today call the Fabry-Perot Interferometer (FPI). Based on the interference of light reflecting back and forth between two mirror surfaces, the device acts as a bandpass filter permitting only a certain wavelength of light to pass through it. The first devices were large, weighed several tens of kilos, and were used for accurate determination of lengths and wavelengths.

From drawing boards to product launch

The first ideas on silicon micromachined optical filters were discussed at Vaisala already in the very early 1990's. "First we were thinking of an optical pressure sensor with a remote readout using fibre optics," recalls Ari Lehto, one of the technology pioneers and key figures behind the CARBOCAP® technology, now the Professor of silicon technology at the Helsinki University of Technology.

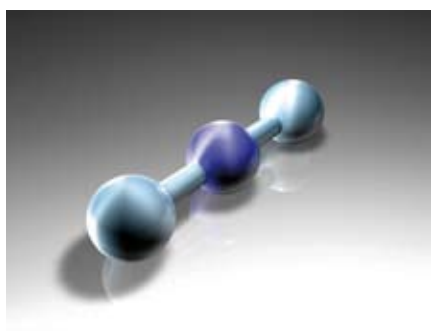
The technical ideas were combined with the business intent of entering the gas measurements market with proprietary technology, and the project gained direction and momentum. Finally in 1997, after several years of intense technology development and countless cycles of trial and error, the first CARBOCAP® products

were launched. Christer Helenelund, Product Line Manager for CARBOCAP® products for eight years, looks back at the hectic moments before the launch: "At one point before the launch we observed some stability problems and identified altogether 12 possible sources for drift that had to be analyzed. It later turned out that not one of them was the correct one!"

A good product keeps getting better

The sensor structure has evolved and improved significantly from those days, but the Vaisala CARBOCAP® Carbon Dioxide Transmitter GMD/W20 products that were then launched are still going strong and proving their robustness and stability in HVAC installations around the world. In ten years, the CARBOCAP® product family has grown towards more and more demanding applications. Today the CARBOCAP® technology is known as the state-of-the-art NDIR technology in a wealth of CO₂ measurement applications ranging from pharmaceutical CO₂ incubators to ecological carbon cycle research.

We wish the lively ten-year-old all the best on its way to growing into an energetic teenager! ■





Maria Uusimaa
Application Manager
Vaisala
Helsinki, Finland

Extend your measurement range

The upgraded CO₂ probe goes “underground”

Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 has recently been upgraded with improved features especially for ecological measurement applications: in addition to the slightly new appearance of the probe, the most noticeable new feature is the extended measurement range, up to 2% CO₂. The low end of the measurement range, the 0–1000 ppm range, also has improved linearity and temperature dependency. Both changes enable increasingly reliable and accurate ecological measurements.

The GMP343 was launched three years ago. The probe was designed for the ecological CO₂ measurement segment. It is successful in a variety of research applications, such as soil respiration measurements, plant growth chamber control,

and measurements in lakes and even oceans. The probe has also been used in boundary layer measurements with a tethered sonde as well as in an ecological measurement station application in the Helsinki Testbed. Furthermore, OEM customers manufacturing total organic carbon (TOC) analyzers have found the GMP343 suitable for integration with their measurement equipment.

Below-ground soil respiration measurements

One of the most successful applications for the GMP343 in the ecological segment has been a particular niche of soil respiration measurements, where soil CO₂ is measured below ground in a vertical profile. However, the measurement range

of the probe has not been wide enough for all below-ground CO₂ measurements since in some soil types and conditions the CO₂ concentration can rise multi-fold from the ambient CO₂ background concentration of 370 ppm.

The growing need for the below-ground soil respiration measurements has called for an extension of the measurement range, whereas the growing interest in atmospheric CO₂ concentration measurements, such as urban air CO₂ measurements, encouraged us to improve the probe's performance in the ambient CO₂ concentration measurement range.

The upgraded GMP343 is calibrated at the factory at three new CO₂ concentration points, which adds up to a total



Figure 1. The open path, diffusion aspirated model (left) and the flow through model (right) of the upgraded GMP343.

of seven gas calibration points (0, 200, 370, 600, 1000, 4000 ppm and 2%). The new temperature compensation is applied to each probe individually, and each upgraded probe is calibrated at four temperature points (-30, 0, 25, and 50°C).

We know how to make reliable sensors

The GMP343 uses the renowned Vaisala CARBOCAP® measurement technology. The absorption of infrared (IR) light is measured in this technology by using small silicon-based, electrically tunable Fabry-Perot Interferometer (FPI) acting as a tunable bandpass filter. The FPI is continuously measuring not only the CO₂ absorption band but also a reference band. Because of this, a true reference measurement, and, therefore, a stable CO₂ measurement can be obtained. Only a single IR detector is used for measuring

both the absorption and the reference bandwidths, which eliminates the errors commonly present in NDIR sensors with two IR detectors. The true reference measurement enables good stability of the sensor both in terms of time and temperature. It is worth emphasizing that the temperature stability also results in a good stability with flow, which is an important feature, especially in diffusion-based sensors.

The upgraded GMP343 comes as a diffusion-based or a flow through-based model (Figure 1) and features low power consumption and small size compared to traditional CO₂ equipment designed for the ecological segment. The probe also sustains harsh environments and can be installed outdoors without complicated protection or shelters. ■

The GMP343 uses the renowned Vaisala CARBOCAP® measurement technology.

A breath of fresh air

New CO₂ transmitter for demand controlled ventilation

The Vaisala CARBOCAP® CO₂ sensors have proven their accuracy and durability during their ten-year presence on the market. They have an excellent long-term stability, which decreases maintenance costs over the years.

The superior performance of the CARBOCAP® sensors largely results from the stable reference provided by the electrically tunable Fabry-Perot Interferometer (FPI). With the tunable FPI filter not only the CO₂ absorption is measured, but also a reference wavelength. This internal reference measurement compensates effectively for any changes in the optical path, like light source intensity changes and contamination. This type of reference is a unique feature in the CO₂ transmitters on the HVAC market, separating CARBOCAP® products from competitors that have either no reference measurement at all or indirect reference measurement based on assumed background CO₂ level.

Especially in applications with a round-the-clock occupancy (e.g. hospitals, workplaces, residential buildings, homes for the elderly), the background CO₂ level reference just doesn't work. The true internal reference measurement of Vaisala CARBOCAP® CO₂

transmitters provides years of stable CO₂ measurements.

New and improved tools from Vaisala

The new GMW115 Transmitter and GMM112 Module are both designed especially for DCV (Demand Controlled Ventilation) applications with the CO₂ measurement range of 0...2000 ppm. The GMW115 Transmitter replaces the GMW25/45 Transmitters, offering reliable and stable CO₂ measurements for standard DVC needs (see long-term stability data in Figure 1).

The GMM112 is a compact diffusion aspirated module especially designed for OEM applications. The GMD/W20 series transmitters are still available for applications where wider measurement range or optional outputs are required.

Good indoor air quality is important

Most of us spend 90 % of our time indoors. Consequently, good indoor air quality is important to our wellbeing. Every human being is a source of carbon dioxide, increasing the CO₂ level in human occupied spaces. Thus the introduction of fresh air by a ventilation system is needed

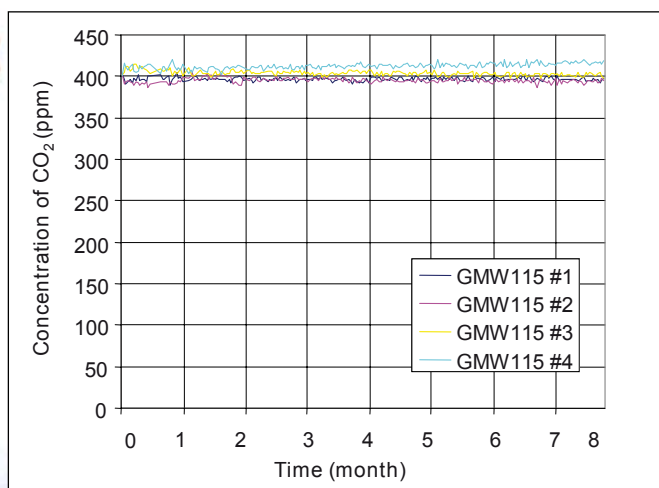
for a pleasant environment. Problems arise when, in order to save energy, the ventilation system is not used to bring in sufficient amounts of fresh air.

Guidelines for indoor CO₂ concentrations

The CO₂ level can be used as an indicator for indoor human presence. A high CO₂ level is a sign of poor ventilation and often an indication of other unpleasant odors in the air. Since in many buildings the ventilation need varies during the day, DCV is an economical way to ensure good air quality. By controlling the ventilation system using CO₂ measurement, good indoor air quality can be provided energy-efficiently.

The limits for indoor CO₂ levels differ slightly in different countries, but for example ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) recommends the CO₂ levels not to exceed 700 ppm above outdoor ambient levels. OSHA (U.S. Occupational Safety and Health Administration) has set a limit for the CO₂ concentration in the workplace to 5000 ppm for prolonged periods. ■

Figure 1: Long-term stability of GMW115 transmitters.





AGA oxygen production plant provides oxygen for the Kaukas pulp mill.

Hannu Valo
Mechanics Engineer
and

Maria Uusimaa
Application Manager
Vaisala
Helsinki, Finland

Producing oxygen for some serious “paperwork”

Vaisala contributes to a trouble-free air separation process

The Vaisala SPECTRACAP® Oxygen Transmitter OMT355 is an analyzer-type instrument that can be used in a variety of measurement applications. It has a measurement range of up to 100% O₂. The transmitter is used in O₂ production at the UPM-Kymmene Kaukas pulp mill in Finland. The oxygen used in pulp production can contribute to a more environmentally friendly paper production process.

The OMT355 oxygen transmitter is an optical, tunable diode laser oxygen analyzer for industrial gas measurements. Its measurement range enables its use in various gas manufacturing processes, such as in inert gas - typically nitrogen - manufacturing, or in oxygen production.

At the Kaukas mill the OMT355 is used in an oxygen production facility managed by the AGA Corporation.

The AGA Corporation is part of the Linde Group, the world's leading gas producer. AGA's main gas products are oxygen, nitrogen and argon, which together generate half of the company's revenue. At the Kaukas site the AGA oxygen production plant provides oxygen for the pulp mill.

More environmentally friendly paper production

The Kaukas paper mill uses bleached sulfate pulp in its coated printing paper products. Oxygen and ozone bleaching have partly substituted chlorine in

pulp bleaching and have thus contributed to more environmentally friendly paper production. The oxygen bleaching process employs oxygen to remove lignin, which in the course of time shades the paper product yellow.

Oxygen is produced from air at the AGA Kaukas site. Air is a gas mixture mainly composed of nitrogen (78%), oxygen (21%) and argon (1%). These gases can be produced from plain air with air separation methods. There are various methods for air separation, but at Kaukas oxygen is produced with a specific separation method called the Pressure and Vacuum Swing Adsorption (PVSA) process. The raw materials required in the process are air and electricity. The

OMT355 in air separation

- 0 – 100% O₂ measurement range
- Can be used in both N₂ and O₂ manufacturing
- Typical applications include inert gas manufacturing or oxygen production
- Easy installation, long-term stability, ease of calibration check
- Fast response time, insensitive to process flow rate and small variations in process pressure
- No complicated sampling systems required

PVSA method is especially suitable for small to medium-sized production facilities when the required oxygen purity is significantly lower than 100% O₂.

Separating air with the PVSA method

The PVSA method is based on pressurizing and depressurizing a container with a selective molecular sieve. The conditions inside the process vary as oxygen is separated from air: pressure is needed to push air through the filter; vacuum is required in the regeneration of the system and removal of nitrogen from the molecular sieve.

In the PVSA process, ambient air is pressurized with an air compressor. The compressed air is then fed to the adsorbers to remove the unwanted content, which in

oxygen manufacturing is mostly nitrogen. The two adsorbers, several cubic meters each, are filled with synthetic zeolite mineral acting as a molecular sieve or filter. The gas content changes when traveling through the sieve. The oxygen molecules pass through the sieve with minor restriction, while nitrogen molecules get trapped in the zeolite's structure. In other words, oxygen is enriched and nitrogen is adsorbed.

When saturated with nitrogen, the adsorber performance is no longer sufficient. Excess nitrogen needs to be removed with filter regeneration. The regeneration is accomplished by utilizing a vacuum to draw the nitrogen molecules out of the filter media. A typical setup contains two tanks filled with zeolite. One tank is used to adsorb nitrogen while the other is being regenerated. The cycle time of the process is typically less than one minute - that is, one tank filters air for a minute followed by one-minute regeneration.

Simple installation directly into the process possible

The Vaisala OMT355 with in-line or sample cell installation options is highly insensitive to variations in process gas velocity, and slightly changing pressure within the operating pressure range only has a minor effect on the measurement. These special properties of the instrument enable simple installation directly into the process (in-line) or installation with a simple sampling system requiring minimal sample conditioning, also ensuring a fast response time for the measurement.

In PVSA processes both installation methods can be used. At the AGA Kaukas site the installation was made at a Y junction combining the two adsorbers with a very simple sample drawing system consisting of a 6 mm tube, a rotameter and a Vaisala-supplied sampling cell.

“The robustness of the OMT355 would easily have enabled direct (in-situ) installation to the process, which is far too demanding for other products, but the critical maintenance schedule at the pulp mill did not allow it this time,” says Heimo Märkälä, who is responsible for plant instrumentation and automation maintenance at AGA production sites. “During the test period it became evident that the pressure and vibration tolerances of the OMT355 are excellent.”

Durable tool for preventive maintenance

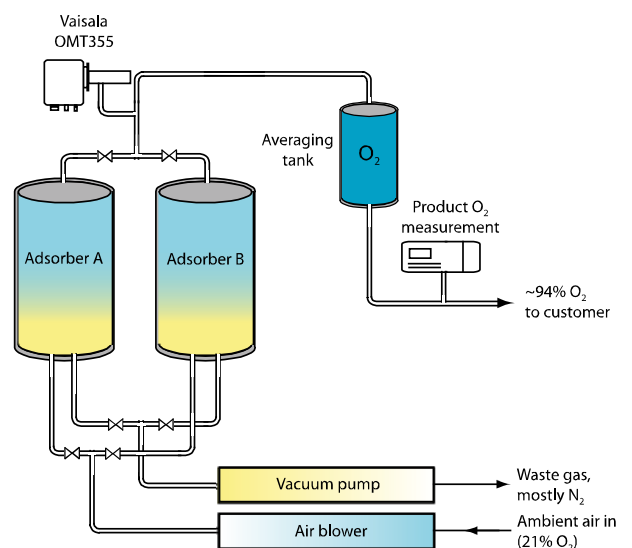
In a PVSA process, the oxygen content of the produced gas changes as the zeolite degrades or there is a malfunction in the valve system. Currently, the adsorber temperatures and pressures are monitored by the control system, but the reaction time of these measurements is slow and cannot predict mechanical failure before it is too late.

“With the OMT355 we can see potential problems before they cause serious degradation in the process performance and can use that information for preventive maintenance,” says Heimo Märkälä. “I can see potential for this product in preventive maintenance, and for product O₂ measurement - it is easy to install, has excellent environmental tolerance and a quick response time at very reasonable cost.” ■

Heimo Märkälä demonstrating the OMT355 installed at the AGA Kaukas plant.



Schematic diagram of the pressure and vacuum swing adsorption (PVSA) oxygen manufacturing process.





Clean beach, happy swimmers

Vaisala at the Presque Isle State Park

The new Tom Ridge Environmental Center (TREC) is located at the entrance to Presque Isle State Park in Erie, Pennsylvania. TREC is open year-round, offering visitors an insight to what they can expect to experience at Presque Isle State Park and the surrounding Great Lakes Region.

TREC also serves as a center for research, contributing to conservation efforts and promoting environmental awareness, helping to preserve the unparalleled beauty of Presque Isle, the site of Pennsylvania's only lakeshore.

The Regional Science Consortium is one of the many educational and research organizations establishing residence in the Tom Ridge Environmental

Center at Presque Isle. The Consortium is a collaborative, non-profit organization that focuses on and coordinates educational and research projects for Lake Erie and the upper Ohio River Basin.

The Consortium's objective is to have all branches of science working collaboratively in order to share expertise, equipment and ideas while sharing researchers and students as well. One of the Consortium's most recent educational and research tools is a Vaisala Weather Transmitter WXT510 network with NexSens Technology real-time radio telemetry. Systems are installed on the TREC Tower and near the Lake Erie shores at Presque Isle State Park.

The monitoring system

Two site locations were selected within the Presque Isle State Park to monitor weather. The first weather station location was selected near Presque Isle's Lake Erie shoreline, while a second weather station location was selected on top of the TREC's 75-foot tall glass tower.

Researchers at the Consortium selected the Vaisala equipment to measure six important weather parameters at two locations in Presque Isle State Park. The WXT510 simultaneously measures wind speed and direction, liquid precipitation, barometric pressure, temperature, and relative humidity. Complementing the Vaisala weather sensor is a global solar radiation sensor.

Safe swimming

The weather data collected by the WXT510 is used to augment a Predictive

Model for the determination of E. coli contamination on the beaches of Presque Isle. It is part of a complex system that provides information for making decisions regarding beach advisories and/or restrictions to swimming.

Both the Vaisala Weather Transmitter WXT510 and the pyranometer feature a plug-and-play interface to NexSens' real-time data logging systems. Furthermore, the complete data logging and sensor system package is conveniently mounted to a 2" mast.

At user-specified intervals throughout the day, weather data is logged into the NexSens 4100-iSIC data loggers and sent via radio telemetry to a radio base station within the Center. There, iChart software collects the weather data and automatically posts it to NexSens' web datacenter. This allows virtually unlimited access to the weather data for Consortium members throughout the United States to use the data in their research or to remotely determine weather conditions for planning sampling trips at Presque Isle.

Increasing the amount of real-time data

Looking ahead, the Regional Science Consortium is considering adding other real-time environmental monitoring venues that will complement the weather data logging system, including buoy-based water quality monitoring devices on Lake Erie. ■

Further information:
www.RegSciConsort.com



Nicole Phinney, an intern at the Regional Science Consortium, pictured at one of the weather station sites.



*WeatherHawk Series 500 Weather Station
with the Vaisala Weather Transmitter
WXT510.*

Watch your home like a hawk

WeatherHawk home automation solutions incorporate Vaisala's weather measurement know-how

WeatherHawk, a division of Campbell Scientific, Inc., identified the high value home automation weather station market in 2003 for its standard WeatherHawk fully self-contained meteorological station. By 2005, it became apparent that the best product for this application was a product that did not look like a traditional weather station. Based on that reality, WeatherHawk began the design of its new WeatherHawk 500 Series low profile home automation weather stations and selected the Vaisala Weather Transmitter WXT510 as the primary sensor module. The selection of the WXT510 was based on its specifications,

modern self-contained design, and excellent support provided by Vaisala.

What is a home automation weather station?

A microclimate is very simply the climate of a specific place within the climate of a larger area. Microclimates can be very different from the climate of the overall larger area. This fact is evident when you hear the weather report for a large city and note that the weather condition in the countryside is different than it is in the city.

It is this difference in the regional and microclimate conditions that has

created a market for high specification weather stations on high value homes. If a homeowner wants to control home features/functions, or make local plans based on weather, they cannot rely on a regional weather report, so many are using a home weather station for their microclimate information.

Home automation, as a technology products market, has evolved over the past 15 years from remote lighting and audio/visual controls, to very sophisticated total environment home control systems. The level of integration now includes both indoor and outdoor sensors and controllers for virtually any function

you can imagine in a home. The market also has unique product and application characteristics that make it a difficult long cycle sales/support challenge. Although it is global in nature, the home automation market is strongest in the United States where over 40,000 homes valued at over US \$1 million were built in 2004. Of that number, about 15% have a high level of home automation and a significant percentage of those are candidates for a home weather station.

At a home, a weather station measures the ambient conditions that create a homeowners microclimate. With that information and a connection to the Internet, various home automation systems can control home features/functions in a near immediate response to changes in the microclimate. In addition, any one of several independent weather services can use home weather station data to better predict the weather at that home for five-ten days into the future to facilitate homeowner recreational planning.

For homeowners that travel, or those that have more than one residence, current weather conditions at any of their homes can be automatically updated on their personal websites for access over the Internet from anywhere in the world. This enables them to make recreational and travel decisions to homes in remote locations that may not have reliable weather information.

The Vaisala Weather Transmitter WXT510 enabled WeatherHawk to design a low profile, visually pleasing, yet rugged and reliable, fully self-contained weather station that meets the aesthetic requirements of all but the toughest architectural restrictions. ■

WeatherHawk 511 Home Automation Weather Station.

WeatherHawk weather stations integrated with a home control system enable automatic responses to:

- changes in solar radiation
 - window coverings open or close to protect expensive carpets and furnishings from the effects of UV, and the activity provides a perception that the home is occupied
 - sidewalk lighting automatically turns on for safety and security
- changes in outdoor air temperature
 - walkway and driveway heating melts snow and ice for safety
 - optimizes pool and spa heating system functions
- changes in wind velocity and direction
 - controls sprinklers and fountains to eliminate overspray
 - closes storm shutters to protect windows from wind blown debris (hurricanes, typhoons and tornados)
- daily calculation of evapotranspiration for use by an irrigation controller
 - optimizes landscape irrigation to save water

To gain the most value from a home weather station a home owner needs a system that will:

- seamlessly connect to their chosen home control system
- connect to the Internet using software on their home control system, or their PC
- have minimal maintenance and no user calibration requirements
- have a range of mounting options
- look good to meet the architectural compliance requirements of many neighborhoods.



*UPM's WISA veneers
bring the natural beauty
of wood to life.*

Liisa Åström
Application Manager
Vaisala
Helsinki, Finland

Bringing out the beauty of wood

Veneer drying with humidity control

One of the world's leading forest product groups, UPM, produces among other things special veneers that are marketed under the WISA brand. At Lohja Veneer mill in Finland, some 14,000 m³ of veneer made from birch and pine is produced annually for markets across the world. The main end use applications of this beautiful material are furniture, doors and interior decorations of different kinds. In the veneer drying process, the plant counts on Vaisala's dewpoint transmitters that can take the heat.

Veneer refers to thin slices of wood, typically between 0.5 and 3.0 mm. Veneer is spliced into sheets, and can then be glued and pressed onto core panels of different materials to obtain furniture, doors and interior decorations. The decorative end uses set high demands on the control of the veneer production process. The drying process plays a key role as accurate dewpoint control ensures that the best quality veneer is obtained at all times.

Veneer making step-by-step

In veneer production, one of the first steps is cooking the log. Next, the wet log is flat sliced, much like salami is sliced at the delicatessen. Veneer is fed into a press dryer, where it travels between two conveyors through the high temperature dryer. In modern dryers, separate zones allow tight control and adjustment of the internal temperature and humidity of the dryer. The veneer exits the dryer, sheet by sheet, ready to be graded, cut into matching size sheets and bundled.



The veneer sheets are passed through the dryer and collected by operators at the end of the line.

A state-of-the-art mill

Sami Janhunen works as a Plant Engineer at UPM’s Veneer Mill in Lohja, Finland. His responsibilities include maintaining and developing the production equipment at the plant. A major project was realized roughly a year ago, when a large part of the equipment was modernized to meet the highest quality, capacity and work safety requirements. This was done in co-operation with Raute, the world market leader as a supplier of mill-wide projects to the veneer-based wood product industry. At this time, the equipment supplier Raute chose to include Vaisala DRYCAP® Dewpoint Transmitters DMP246 as humidity control instruments for the dryer. This product has since been replaced by the DMT346.

Previously, there was no measurement of humidity in the dryer at Lohja mill, and running the process depended on the operators’ good experience and craftsmanship. Still today, professional skills are important, and there is no set of parameters as precise as the human eye to evaluate the appearance of veneer. However, on-line measurement data gives a whole new basis for controlling the process.

Quality through dewpoint control

Janhunen explains: “Quality is our main driver, and there the drying process has

an important role. The veneer must be dried well for it to be flat, flexible and suitable for further processing. Our customers continue to splice the veneer into sheets, and to succeed in that, the veneer moisture content must be at a suitable and even level. Too dry veneer may cause problems in splicing because it becomes brittle and may break. From the veneer manufacturer’s point of view, over-drying is uneconomical in terms of energy and capacity losses and decline in veneer quality.”

Direct installation with no sampling systems

The humidity inside a dryer is measured with Vaisala DRYCAP® Dewpoint Transmitters DMP246, which are directly installed into different zones of the dryer. No complicated sampling systems are needed. The measurement information is connected to the operating system of the dryer, which connects all relevant information needed to control the dryer operation. The data of this PLC-based system may be accessed from remote monitors at the operator’s location and changes to operating procedures are made on touch screens.

Janhunen says the Vaisala equipment meets their expectations well: “The units follow the process changes in a satisfying way. They play their part in the plant upgrade that has been positive for us in every way.” ■



The Vaisala DRYCAP® Dewpoint Transmitter DMT346, as its predecessor DMP246, can be directly installed into temperatures up to 350 °C (662 °F).

UPM Special Veneer Plant Engineer Sami Janhunen (left) together with Vaisala Sales Engineer Jukka Kalliokoski.





Vaisala DRYCAP® products include a selection of instruments for fixed installations and portable use.

Jan Grönblad
Product Line Manager
Vaisala
Helsinki, Finland

Vaisala DRYCAP® key features:

- Dewpoint measurement at low dewpoints
- Excellent long-term stability
- Fast response time
- Recovers from saturation

Vaisala engineers a solution

Vaisala DRYCAP® technology celebrates 10 years of happy customers

The Vaisala DRYCAP® technology was developed according to customer needs to measure low humidity with reliable technology. Customer problems with low humidity measurements, i.e. low dewpoint measurements, related to poor accuracy. Vaisala professionals were able to solve the challenges.

Old technologies unsatisfactory

There were some clear reasons why the then existing technologies could not offer better performance. The traditional relative humidity instruments that were successfully used for higher humidity measurements, typically from ambient levels up to saturation, were not accurate enough in very low humidity, where the relative humidity is approaching 0%RH. In terms of dewpoint, this means dewpoint temperatures below -10 °C.

Second, the typical technology that was used for low humidity measurements was an Aluminium Oxide sensor that was sensitive enough down to very low dewpoints (typically -70 to -80 °C Td). However, it was also sensitive to drift, which meant it required calibrating several times per year to keep the ±2 °C Td accuracy. Continuous calibration was costly and difficult.

The third option was to use an analyzer type of instrument with a purchase price ten times that of a dewpoint transmitter. A typical example of this is a condensation hygrometer that can offer very high

accuracy (even up to ±0.1 °C Td), but only if regularly maintained, typically daily.

Superior Vaisala measurement performance

With the new technology invented at Vaisala, all the problems of the old technologies were solved. The DRYCAP® technology is based on a thin-film polymer sensor. The polymer sensor is known to be a very stable and reliable technology. The DRYCAP® technology also applies autocalibration, a patented key feature that eliminates the sensor drifting at the dry end and allows dewpoint accuracy in the long-term. This technology combination offers performance that fulfills the market requirements, is easy-to-use, is cost-effective and has a very low need for maintenance.

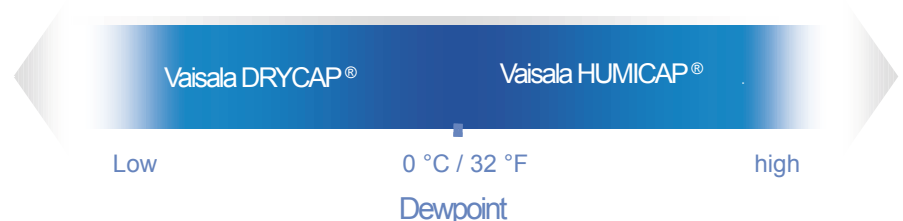
During the past 10 years a wide product range has been built up utilizing the superior DRYCAP® measurement performance. Today, the technology is available from a small-size low-cost dewpoint transmitter to a dewpoint transmitter

with a wide variety of options, including display, alarm and datalogging features.

Flexible tool for industrial applications

Another important feature of the DRYCAP® sensor technology is that it works extremely well as a portable tool, where the sensor is typically stored in ambient air and used only briefly to measure very dry gas or air. Thanks to DRYCAP® performance, the sensor adapts to dry conditions very quickly.

Vaisala DRYCAP® dewpoint sensor technology is used in industrial applications where the humidity of a gas, typically air, is very low. Typical applications are in compressed air or the plastic molding industry or in dry storage where the humidity is low (below 10%RH). A special model for extreme temperatures up to +350 °C is also available for high-temperature drying processes. This shows how flexible and suitable the technology is for industrial dewpoint measurements. ■



Vaisala DRYCAP® is one of the most reliable dewpoint measurement technologies for low dewpoint measurements and Vaisala HUMICAP® for high dewpoint measurements.



Cool down, the environmental way

AZEVAP's evaporative cooling technology with a Vaisala touch

Larry Kammerzell
Managing Principal
AZEVA
Phoenix, AZ, USA

With today's growing focus on global warming and the need to reduce energy consumption, evaporative cooling needs to be revisited as an important cooling alternative for buildings, industrial facilities, and gas turbine inlet air. An evaporative cooler uses as little as 1/8th the power of a traditional cooler or chiller system, yet industry has been backing away from the use of this cooling method due to significant disadvantages of legacy technology. Among the problems are:

- Reduced cooling effectiveness as the wet bulb and relative humidity increase
- High rate of media scaling and the associated need for frequent replacement of the media
- Reliability of the water level control system with associated consequences of flooding and high maintenance
- Water entrainment and corrosion of cooler components, ductwork, and facility
- Stagnant water and associated mold and fungus health issues
- High water usage rates
- Short cooler life

AZEVA, LLC has developed a new and innovative approach utilizing advanced technology that addresses these traditional disadvantages.

At the heart of the AZEVA technology is the AZFlow[®] water distribution and metering system. This non-circulating system determines and applies just

enough water to the media to makeup for cooling evaporation and achieve the desired cycles of concentration in the discharge water. This is a dramatic change from the conventional recirculating coolers which bath the media with water pumped from a sump. At an average application rate greater than 2.5 times the evaporation rate, a conventional cooler often has water entrainment issues at lower air velocities and increased salinity of the water leading to an increase in the rate of media scaling.

High efficiency even after several years

Published papers on cooling tower media and experience with recirculating coolers using 12" media, show cooler evaporative efficiency degrading relatively quickly over the first couple of months of operation from a high of ~ 80% to less than 70%. AZFlow[®] coolers have a demonstrated ability to operate scale free and to achieve and maintain efficiencies of 85% to 90% even after several years of operational service without changing or cleaning the media.

As the relative humidity and wet bulb temperature rise, the theoretical amount of cooling that can be achieved by evaporation decreases. Poor efficiencies in conventional coolers further reduce the achieved cooling. The high efficiency of the AZFlow[®] coolers means they are able to extend their effectiveness under these adverse conditions, that is, the extra several degrees of cooling provided >>>

An evaporative cooler uses as little as 1/8th the power of a traditional cooler.

by the AZFlow® system often achieves the desired cooling objective.

This high efficiency also facilitates the adaptation of the cooler into an effective energy recycle, indirect, and two stage cooler configurations with the addition of an air to air heat exchanger. AZEVAP has married a patent pending air to air heat exchanger design with the AZFlow® cooler to arrive at configurations that yield cool temperatures even under adverse ambient conditions. With this, the historic drawbacks to the use of evaporative cooling have been addressed.

Save water

The AZFlow® metered water application system facilitates the elimination of the standing water sumps, recirculating pumps, and water makeup float valve which are the source of several of the deficiencies listed above. The AZFlow® metered water application system saves water by both reducing the number of coolers required and reducing the amount of water discharged as bleed water to limit or avoid scale formation. The AZFlow® coolers discharge less than 10% of the water discharged as bleed water by other coolers. With no stagnant water and only fresh chlorinated water used to wet the media, the health issues of stagnant water and growth of mold and fungus are greatly reduced or eliminated.

Leadership in Energy and Environmental Design

The building design and construction industry has instituted the LEED program (Leadership in Energy and Environmental Design) as a way to gauge how effective a building is in supporting energy and water conservation and other environmental sustainability. LEED'S points are awarded for innovation, water saving, energy saving, and elimination of CFC and chemical usage. AZEVAP's AZFlow® coolers renew the potential for the use of evaporative coolers throughout industry to achieve facility cooling objectives while saving energy, saving water, and reducing greenhouse gas emissions. The AZFlow® coolers provide a means of capturing a number of these points on new and conversion building projects supporting higher levels of LEED certification.

Maximum benefits with Vaisala measurements

In order to achieve the maximum benefits of the AZFlow® system, it is critical to have

AZFlow® Metal Building Install: This through-the-wall installation was designed to position the cooler in an ideal location for building air flow while minimizing the required support structure.



reliable and accurate relative humidity and temperature measurements. After careful evaluation of humidity sensing technologies and manufacturers, the Vaisala HUMICAP® Humidity and Temperature Transmitter Series HMT100 was selected as the measurement and control device.

The measured air temperature and relative humidity along with airflow data are gathered and communicated with an I/O processor to a proprietary algorithm in a Linux-based controller. This algorithm correlates the instantaneous water evaporation rate and the water application rate and delivers the required volume of water across the cooling pad such that the pad never gets too wet or dry. The system accomplishes this by determining the on and off times of the water application valve in order to keep the pad saturated.

Energy-saving pays off

The AZFlow® cooler came about by designing a low flow water distribution system and taking advantage of advancements in control system technology and hardware. In particular, today's technology enables the sensing of critical parameters that impact the evaporation rate. It also allows the programming of the sophisticated algorithm that accounts for these parameters and their impact on the water evaporation rate into a stand alone micro processor and controller that meters the correct volume of water onto the media. This was accomplished using a patented water distribution system with an embedded Opto 22 SNAP control system.

All cooler system control processes and acquired data are accessible through

a web-based human-machine interface. This interface allows: viewing the full set of system input parameters and resulting cooler performance, setting and acknowledging alarms, and establishing and setting fail safe contingency actions.

After deploying its AZFLOW® coolers within its own facilities and realizing tremendous productivity, energy, and water savings, AZEVAP has installed coolers in commercial and government facilities. An early version of the AZFlow® cooler installed at the landmark Bank of America office building in downtown Phoenix in 2003 paid for itself in savings in a little more than two months. ■

About AZEVAP LLC

Founded in 2001 to fill a need for evaporative coolers manufactured as industrial process equipment, AZEVAP's founders and engineers Larry and Don Kammerzell reviewed the history of evaporative cooling and looked at the fundamental problems associated with the process. In developing the AZFLOW cooling technology they combined a number of engineering disciplines to solve the problems that have limited the effectiveness of evaporative cooling.

Further information
www.azevap.com.

Simo Ikonen
Project Manager

and

Timo Ranta-aho
Product Line Manager
Vaisala
Helsinki, Finland

Coping even with chemical interference

New generation Vaisala HUMICAP® relative humidity sensor

In most humidity measurement applications, the sensors are also exposed to chemicals other than water vapor. Vaporized chemicals can diffuse into the sensor and cause disturbances in the measurements. Such vapors are present in most environments, even in normal office air. Chemical vapors are also inherent in many industrial applications. For example air pollutants (NO_x, SO₂, etc.), disinfectants and different organic solvents are often present in ambient air. As the responses to some gases and vapors are very slow, in many cases several weeks or months, the effects are often described as “drift” or “aging” of the sensor and not as chemical interference.

The chemical interference or drift can be dealt with by setting the calibration interval according to the conditions or by improving the sensor’s ability to withstand chemicals. In some cases heating the sensor can either remove a chemical from the active polymer or prevent entry.

Chemical resistant polymer and special new structure

Vaisala has introduced a new generation Vaisala HUMICAP® relative humidity sensor, the HUMICAP®180R. This new type of capacitive humidity sensor has been developed especially to cope with chemical interference. The resistance to chemical interference has been achieved by developing a new type of chemical resistant polymer and a special new structure. The structure slows down

the migration of adverse chemicals or completely prevents them from entering the active polymer layer. The chemical resistant active polymer and the structure of the capacitive sensor further contribute to the stability of the sensor. In contrast to earlier sensor versions developed to withstand demanding chemical environments, these improvements have been obtained without compromising the other key properties of the sensor such as high humidity stability, sensitivity and hysteresis.

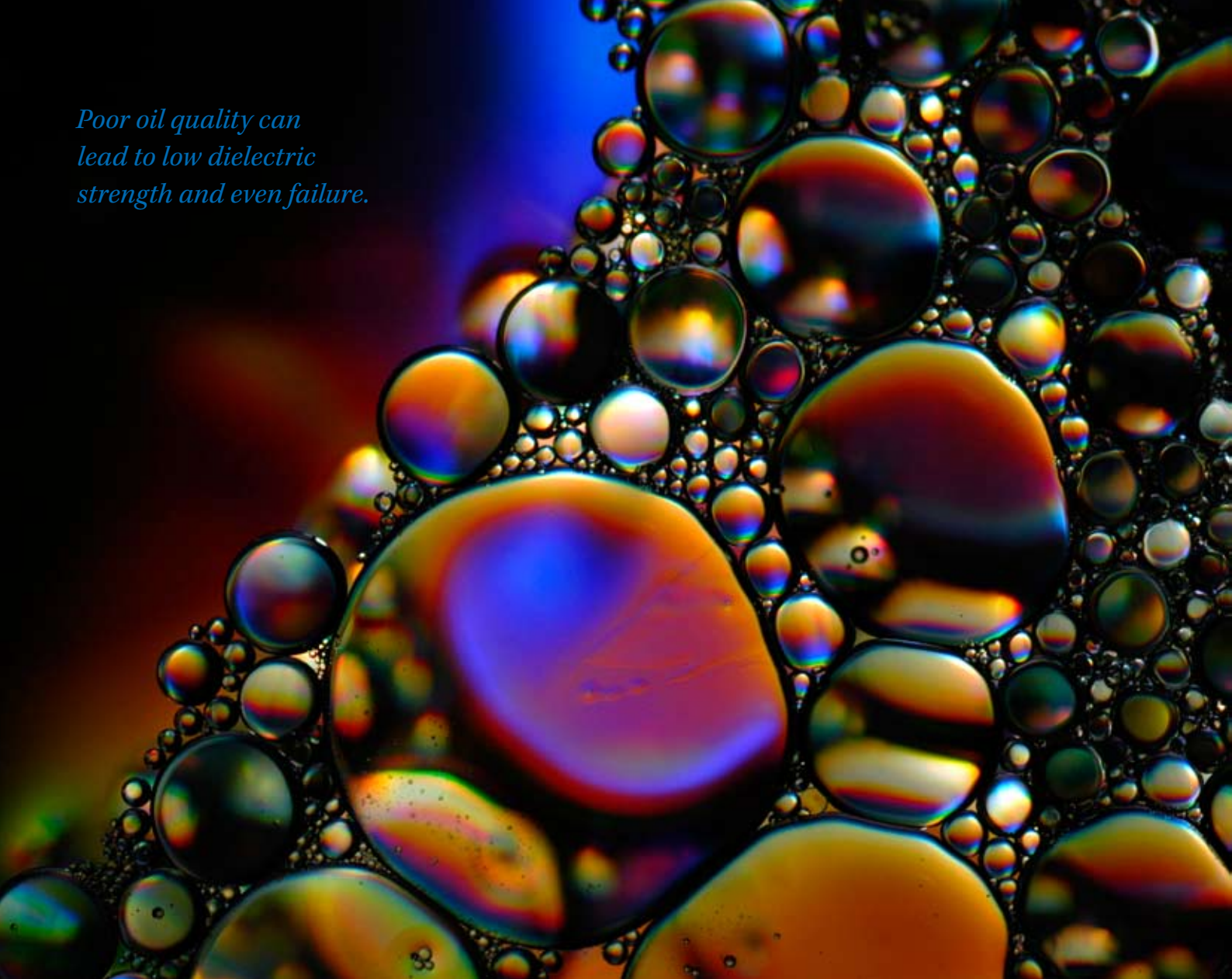
Field tests show high stability

The new Vaisala HUMICAP® sensor has been tested both in laboratory conditions as well as in typical humidity sensor applications¹. The tested humidity sensors show significantly lower measurement error in most of the test environments compared to the reference sensors. The sensors perform better both in laboratory high chemical concentration tests as well as in long-term field stability tests. The results from the experiments show that the new structure and the polymer make the sensor highly resistant to chemical interference and therefore provide an improved long-term stability for the relative humidity measurement.

¹ IKONEN S., STORMBOM L., RANTA-AHO T., *Chemical Interference Test Results of a Novel Humidity Sensor, 5th International Symposium on Humidity and Moisture – ISHM 2006, Rio de Janeiro, Brazil (2006)*



Poor oil quality can lead to low dielectric strength and even failure.



Colin Feely
Plant Maintenance Engineer
Powercor Ltd
Melbourne, Australia

Detect moisture in oil

Transformer moisture monitoring and dehydration

Powercor Australia is Victoria's largest electricity distributor. Powercor has been running a program of on-line moisture monitoring on transformers using both permanently installed and portable moisture in oil probes, including the Vaisala HUMICAP® Moisture Meter MM70.

Poor oil quality can lead to low dielectric strength and even failure. Oil treatment or replacement can address most oil quality issues but in the case of moisture which is held in the paper insulation of the windings and windings support

structures, the moisture quickly recovers. Moisture monitoring provides a way of tracking this recovery, and on-line drying provides a way of managing the moisture in oil so that the oil dielectric margin is maintained.

Moisture in oil measurement

The moisture probes measure two quantities:

1. a_w - water activity, a relative saturation of "active" dissolved moisture, a fraction from 0 to 1.

2. T - temperature of the oil in degrees Celsius.

The probes also have an optional inbuilt algorithm which provides an output in ppm. New oil formula is the factory default, and others can be programmed if known. In general, ppm values from the probes are lower than those from Karl Fischer (KF) tests to determine the water content of oil samples. This is possibly due to bound water in particles being captured by the Karl Fisher test.

The Karl Fisher moisture relative saturation results are defined as “Rs” in the following. All transformers referred to here are 66/22kv core form.

Moisture monitoring with permanent probes

Twelve Powercor transformers have been fitted with permanent probes. Each provides two analogue outputs to the Supervisory Control And Data Acquisition (SCADA) system, ppm and temperature. The transformers selected for monitoring were those with known oil quality issues, in general fairly old and in some cases heavily loaded. Most have been subject to oil regeneration or replacement in recent times.

The preferred location for the probe where transformers have detached radiator banks is the lower drain valve of the return oil line from the radiator to the main tank. This puts the probe in the oil flow from the thermo-siphon of the transformer. Where radiator banks are not detached, the chosen location was one of the lower radiator drain valves for similar reasons. The probes have a sliding type seal, which means they can be very simply installed through the drain valve with no outages required.

Figure 1: moisture variation, 10 MVA ONAN transformer.

Figure 1 of the 10 MVA ONAN transformer demonstrates the effect of a load increase and a hot day. Note how moisture peaked at 60 ppm and did not recover for several days. The last KF moisture level from oil sampling was 30 ppm. A sustained high load during hot weather on this unit could lead to excessive moisture and a consequently low dielectric margin. On-line monitoring has shown that this unit is a good candidate for dehydration.

Figure 2: moisture comparison example (SCADA) - Scale is in ppm.

Permanent SCADA connection enables comparisons to be made between sister units sharing the same load and conditions. The transformer showing the least moisture levels was subject to an oven dry out some five years before.

Figure 3: moisture recovery following new oil retrofill. Scale is in ppm/deg C.

In figure 3, a 20 MVA ONAF transformer, oil volume 17000 liters, oil change was completed on October 28th, 2005 and

Figure 1.

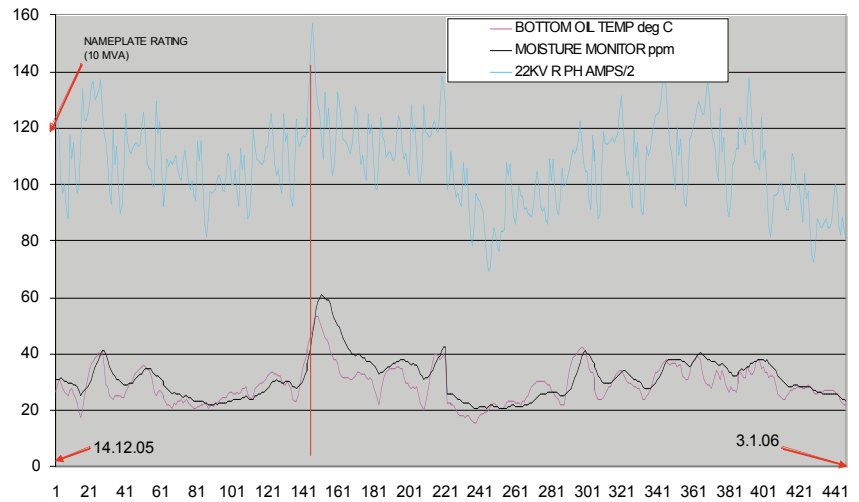


Figure 2.

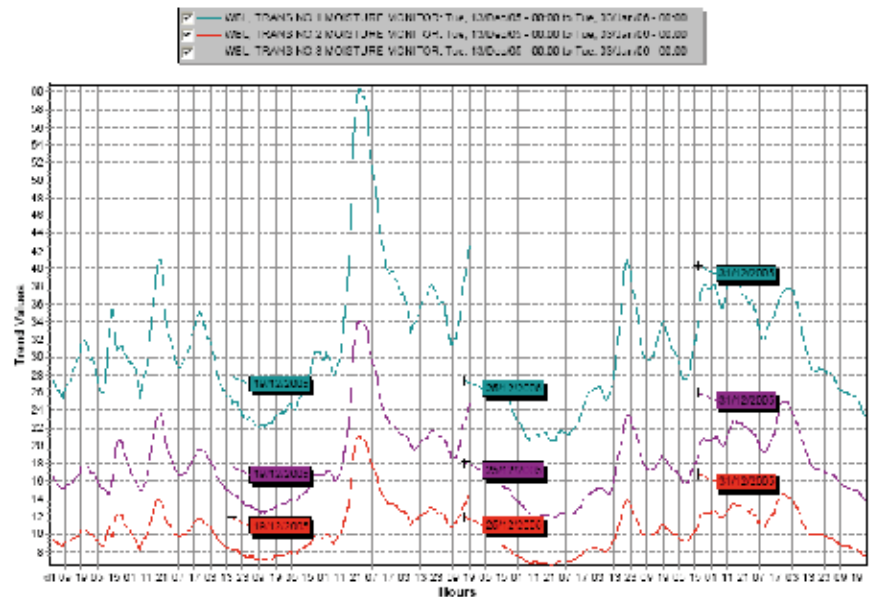


Figure 3.

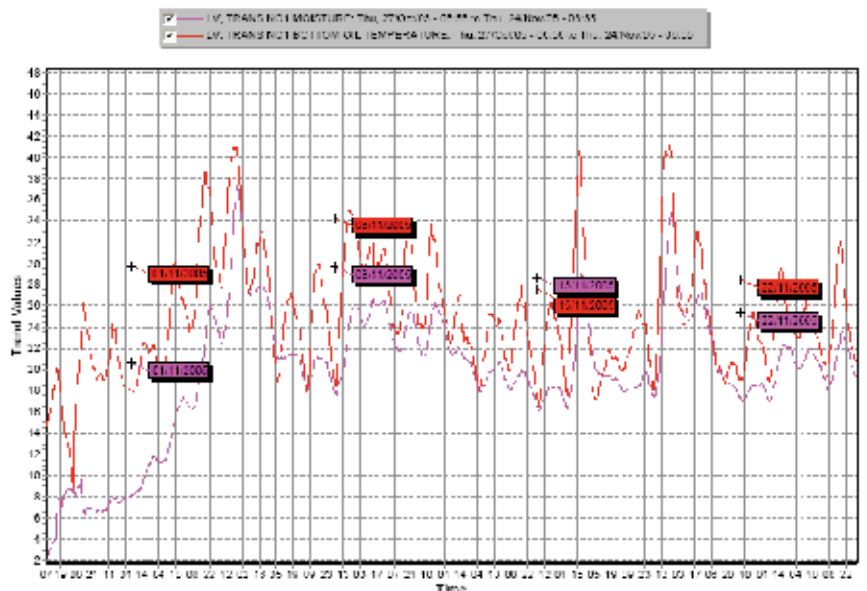


Figure 4.

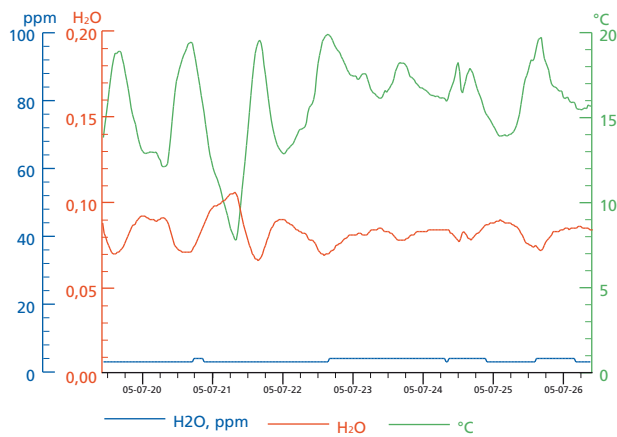


Figure 5.

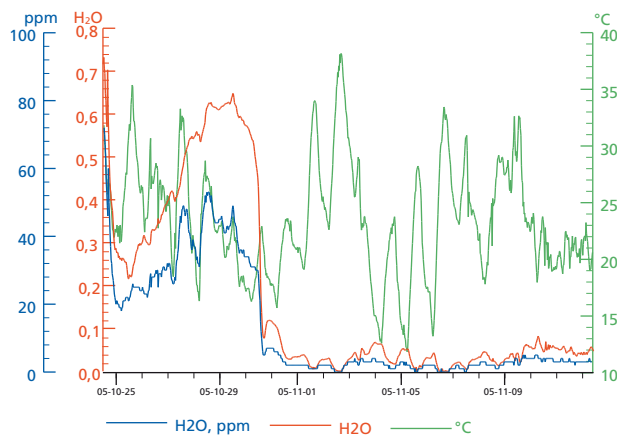


Figure 6.

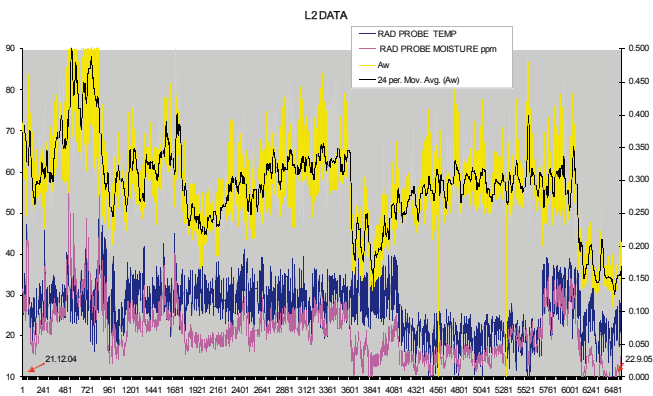
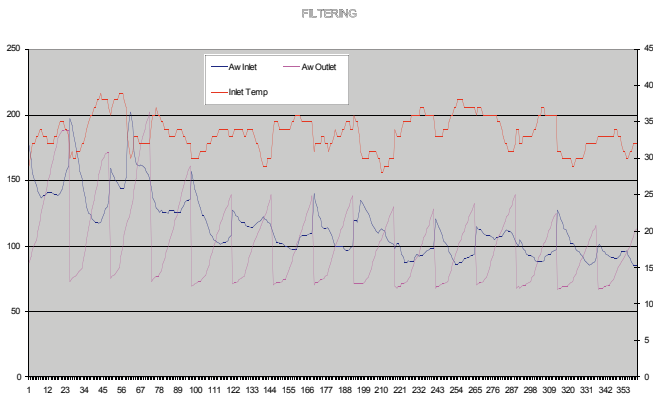


Figure 7.



the contractor sampled the oil at 11 ppm (KF). Within a few days the probe data revealed that moisture levels had recovered and ranged from 16 to 37 ppm.

Portable probes

Portable probes have also become available, and Powercor has obtained three of these from Vaisala. So far, they have been used on 20 transformers. These probes have a battery power supply and enough memory to store data at hourly reading intervals for about 30 days, which is about the life of the battery. Once again, the locations chosen are generally radiator drain valves to ensure a flow of oil past the probe. These portable probes allow flexibility in that a large number of sites can be monitored. A probe can be installed and programmed to log data in a few minutes. A return visit to the site is required to download the data, clear the memory for the next logging cycle and recharge the battery if required.

Figure 4: low moisture -66KV regulator.

In figure 4, an oil sample showed unexpectedly high moisture and low dielectric, KF of 43 ppm @ 22 C (Rs =0.7) Dielectric = 36 kV. This was unexpected since the unit

had been oven dried out in the recent past. A portable probe was quickly installed and the data showed low moisture levels. A second oil sample confirmed this - KF of 9 ppm @ 15C (Rs =0.2) Dielectric = 82 kV. The initial oil sample was probably contaminated.

Figure 5: dramatic reduction in moisture.

Figure 5 is from a 10/18 MVA ONAF transformer. The reduction in moisture coincided with the commissioning of a new transformer at the station, which reduced the load significantly on this unit.

In summary, the portable probes are providing a very convenient and cost-effective means to monitor any transformer which has valves in the appropriate locations. Transformers without such fittings could also be fitted with probes in the main tank drain or sampling valves. However, without a flow of oil over the probe, the results may be inaccurate or unrepresentative of the general oil mass.

Dry outs with molecular sieve units

Powercor has two molecular sieve on-line dryers. These units are trolley-mounted and remove moisture by simply pumping

the oil through filter cartridges containing the molecular sieve material. They are fitted with a single moisture probe, which can monitor either incoming or outgoing oil. This is determined by the position of a bypass valve. When the outlet oil moisture equals (or exceeds) the inlet oil moisture, the filter cartridges may have reached saturation, indicating that they should be replaced. Each cartridge can theoretically hold one liter of water and there are four cartridges per dryer. The cartridges are quite expensive and at present there are no recycling options available.

These units are designed to take inlet oil from the main tank at the bottom, and return oil to the conservator. This design has the advantage of avoiding any Buchholz Relay (sudden pressure relay) issues should air get into the system. It has the disadvantage of exposing the newly dried oil to the conservator head space. In Powercor's case, this head space is open to the atmosphere. These dryers have been used on nine transformers to date and a summary of the results follows.

Table 1: molecular sieve dryer results of some transformers

Please note: Oil parameters are from oil samples (i.e. KF and dielectric breakdown

tests) with the exception of the “S3” and “L2” later oil parameters, which are from probes.

The estimated removed moisture is based on the number of cartridge replacements and the moisture readings from the dryer inlet and outlet. Although the filter cartridges have a rated capacity of one liter, it was felt that, as moisture content reduced, they would stop removing moisture at less than that. In order to prove this, weighing canisters were made up, and cartridges were weighed submersed in oil when new and again when “full”. The resultant average weight increase was 641 grams, indicating a moisture content of 0.641 liters. It has been estimated that each filter set removes 2.6 liters of moisture at moisture levels of 10-20 ppm. It was also found that dryer performance improved markedly with the addition of an extra sealing washer in the filter clamping arrangement.

The dryers were not run continuously but were switched off for periods to allow moisture levels to recover. A general rule of thumb for deciding when to cease filtering was when moisture levels remained consistent at less than 20ppm, or 0.2 Aw. The Vaisala monitoring probes have proved valuable in assessing this.

Figure 6: monitoring dry out.

Figure 6 shows data from a permanent probe on the “L2” transformer during dry out over a 10 month period. Note the moisture reduction from the dryer, followed by moisture recovery as a new equilibrium between the moisture in cellulose and moisture in oil is reached. Note also that as the moisture levels reduced, the degree of variation in moisture over each daily load cycle also reduced.

Paper filter dryer

Powercor has more recently purchased another on-line dryer which has a paper filter. This unit removes moisture by pumping the oil axially through a filter paper roll. Moisture migrates from the oil to the paper as long as the paper is drier than the oil. The unit has a quite sophisticated Programmable Logic Controller (PLC) controlled system which can re-dry the paper filter after each filter cycle. The unit is fitted with moisture probes on inlet and outlet oil and has a data logging and remote monitoring facility.

The dryer is fitted with a moisture trap so actual moisture removed can be collected.

Table 1.

Unit	Pre dry out oil	Date on	Date off	Dry hrs	Estimated removed moisture	Post dry out oil	Later oil parameters
C2 5 MVA ONAF 11000 liters	28ppm 25c(.41Rs) 22kv	30.7.04	17.8.04	386	1.5 liters	18ppm 20c(.32Rs) 58kv	20ppm 24c(.31Rs) 55kv 8 months later
C3 5 MVA ONAF 15080 liters	41ppm 25c(.60Rs) 24kv	30.7.04	8.11.04	1039	4.2 liters	20ppm 29c(.25Rs) 73kv	31ppm 26c(.44Rs) 55kv 6 months later
S3 10/13 MVA ONAF 14800 liters	31ppm 23c(.49Rs) 22kv	6.12.04	21.6.05	1039	8.0 liters	13ppm 22c(.22Rs) 80 kv	80 ppm peak, normal range 25-40 ppm from SCADA-6 months later
L2 10/13 MVA ONAF 14800 liters	41ppm 20c(.58) 17kv	8.12.04	21.9.05	2563	14.0 liters	10ppm No temp 80 kv	17-27 ppm from SCADA 4 months later

Table 2.

Transformer	Pre dry out oil parameters	Dryer connected	Dryer removed	Hours of drying	Removed moisture collected	Post dry out oil parameters
W1 10/18MVA ONAF 17300 liters	23ppm 30c(.28Rs) 36kv	10.5.05	7.7.05	600	2.9 liters	10ppm 24c(.15Rs) 80kv
W2 10/18MVA ONAF 17300 liters	25ppm 29c(.29Rs) 44kv	7.7.05	13.9.05	853	2.6 liters	5ppm 21c(.09Rs) 81kv
W3 10/18 MVA ONAF 15897 liters	38ppm 23c(.6Rs) 37kv	13.9.05	14.12.05	827	3.1 liters	13ppm 31c(.15Rs) 83kv

This unit has the advantage of a lot longer filter life than the molecular sieve units.

The dryer is connected with inlet oil taken from the main tank bottom drain valve and outlet oil delivered to the top oil drain valve. Dry outs have been carried out on three transformers so far and a fourth one is in progress.

Table 2: results from dryer which has a paper filter.

Please note: Oil parameters are from oil samples (i.e. KF and dielectric breakdown tests). As these dry outs are recent, follow-up oil monitoring has not yet been carried out. Some recovery of moisture levels is anticipated. This dryer also has the facility to run in “analysis” mode, whereby the filter is bypassed and oil is circulated and monitored by one of the moisture probes. This provides a monitoring as well as a drying capacity.

Figure 7: typical filtering data.

Please note: left axis (Aw) scale is 0 to 0.250; right axis (inlet oil temp) scale is 0 to 45 deg C. This example shows the characteristic saw-tooth pattern as the filter fills with moisture and is re-dried. Note

the steady reduction in inlet oil moisture. The filtering time in this example has been set longer than necessary (12 hrs) as outlet moisture is overshooting inlet moisture.

Sustained effort required

On-line moisture monitoring can provide a valuable condition monitoring tool for transformers which have moisture issues, and also for revealing transformers which may have moisture issues perhaps undetected by routine oil sampling.

A common observation is that a single heavy overload-over temperature event can rapidly increase moisture in oil levels as moisture is driven from the cellulose and, significantly, the return of moisture to earlier levels may take quite a long period of time.

However, monitoring alone will not fix anything. It is the action taken arising from monitoring which can deliver condition improvement. On-line drying usually delivers a rapid improvement in oil quality, but this improvement may not be permanent. Subsequent monitoring is prudent and will often result in another drying cycle being made. Effective on-line drying requires a sustained effort which may be required for many months. ■



Timo Ranta-aho
Product Line Manager
and
Petri Hautaniemi
Project Manager
Vaisala
Helsinki, Finland

Small device - big performance

Compact Vaisala BAROCAP® Barometer PTB110

Vaisala has introduced a new series of barometers, the Vaisala BAROCAP® Barometer PTB110 to replace the very successful PTB100/101 series analog barometers. The new barometers are compact and small in every respect - except their overall performance.

The PTB110 is a microcontroller based barometer designed both for accurate barometric pressure measurements at room temperature as well as for general environmental pressure monitoring over a wide temperature range. The barometer provides alternative pressure scales within the range of 500...1100 hPa. The operating temperature ranges from -40 °C up to +60 °C. Both voltage and frequency outputs are available.

Patented Vaisala technology provides long-term stability

The BAROCAP® silicon capacitive absolute pressure sensor, developed by Vaisala, is the heart of the barometer. The sensor combines the outstanding elasticity characteristics and mechanical stability of single-crystal silicon with a proven capacitive detection principle, providing excellent long-term stability. All PTB110 barometers are calibrated at the factory as traceable to NIST (National Institute

of Standards and Technology, USA) and supplied with a multipoint calibration certificate.

Low power consumption

Connecting/disconnecting the barometer is easy with a removable terminal connector. A DIN rail mounting option enables the barometer to be mounted on a 35 mm wide standard mounting rail. The barometer consumes very little power, making it very suitable for battery or solar power operated systems where low power consumption of the system is essential. The PTB110 can also be set to shutdown mode. Here one of the input terminals is used as an external power on/power off trigger, which lowers the overall power consumption even further. After switching the power on, the barometer responds very quickly. Within 500 ms, full accuracy pressure output is available.

The compact PTB110 is suitable for a variety of applications, such as environmental pressure monitoring, data buoys, laser interferometers, and in agriculture and hydrology. Thanks to its very low power consumption, the barometer is particularly ideal for different data logger applications. ■



The Vaisala BAROCAP® Barometer PTB110 can be used in data buoys, among other applications.

Strong under pressure

New barometer generation for atmospheric pressure measurement

Timo Ranta-aho
Product Line Manager
and

Petri Hautaniemi
Project Manager
Vaisala
Helsinki, Finland

Since its introduction in 1995, the Vaisala BAROCAP® Digital Barometer PTB220 has become a network and reference barometer used by several meteorological institutes and various customers in different industrial and laboratory applications. Now we are introducing the next generation successor for this barometer: the Vaisala BAROCAP® Digital Barometer PTB330 with several new and improved features.

Important parameter in many applications

In meteorology, air pressure and its changes are related to low and high pressure fronts and their movements. According to the World Meteorological Organization (WMO), analyzed pressure fields are a fundamental requirement of meteorology. It is imperative that these pressure fields are accurately defined as they form the basis for all subsequent preconditions of the state of the atmosphere. The atmospheric pressure measurements should be as accurate as technology allows¹.

Atmospheric pressure is also a crucial parameter in aviation and important in several industrial type applications, such as accurate laser interferometric measurements. Other measurements like exhaust gas analysis in engine test benches may also require pressure measurement.

As accurate as technology allows

The pressure measurement of the PTB330 is based on the Vaisala BAROCAP® sensor providing high measurement accuracy and excellent long-term stability. PTB330 provides two alternative accuracy classes: class A accuracy for the most demanding applications, such as using the PTB330 as a barometric reference, and class B accuracy for more conventional use. The calibration of the PTB330 is traceable to NIST (National Institute of Standards and Technology, USA).

The PTB330 provides the pressure output with a pressure unit chosen by the customer. In addition to instant pressure, it also calculates the WMO pressure

trend and tendency code. The pressure trend indicates the amount of pressure change, and the tendency code the nature of the pressure tendency during three hours preceding the time of observation. Furthermore, the PTB330 can calculate and output the QNH and QFE pressures used especially in aviation. The QNH represents the pressure reduced to sea level, based on the altitude and temperature of the observation site, and the QFE the air pressure at the airfield elevation.

Added reliability through redundant measurement

According to the customer choice, the PTB330 can incorporate one, two or three BAROCAP® sensors. This unique feature enables the customer to achieve a redundant pressure measurement. In the case of two or three sensors, the barometer compares the readings of the different pressure sensors all the time and provides information on whether these are within a set internal difference criteria. This way the user gets a stable and reliable pressure reading at all times, as well as a pre-indication of when service or recalibration is needed.

Display that speaks your language

As an option, the PTB330 can also incorporate a graphic display, together with an intuitive menu-based interface. With the display the outputs and units can easily be selected by the user. The display language can be chosen from English, German, French, Spanish, Swedish, Finnish, Japanese and Russian.

Through the graphical display the user can see the trends of the selected parameters in six different time windows, the longest of these being a one-year history of active operation of the unit. With movable cursors, the values at individual time spots can be referred to and the minimum and maximum values observed.

Alternative connections

The voltage supply ranges from 10...35 VDC, allowing the PTB330 to be also

used in battery powered applications. An external AC supply enables the barometer to be connected to all universal mains AC supplies.

The PTB330 provides several different communication signals. The standard output is RS232 but optionally an RS485 serial line can also be used. An optional USB connection cable enables the barometer to be connected through its service port to a USB port of a PC. Linear voltage and current output for pressure are also available.

The PTB330 can be connected to a PC either via a terminal program or using a specific Windows® software application to transfer the measured data, which can be further processed and copied to other Windows® programs.

Various installation possibilities

The housing of PTB330 is IP65 rated, enabling the unit to be installed outdoors. The installation can be carried out in many different ways. The unit can be mounted as such or using a separate wall mounting plate that also enables the easy detachment of the barometer. With the mounting plate and a DIN rail kit the unit can be easily connected to a standard DIN rail. A pole installation kit with a rain shield is also available for mounting the PTB330 onto a vertical pole. The Vaisala Static Pressure Head Series SPH10/10 is available to minimize wind induced error for the measured static pressure.

The Vaisala BAROCAP® Digital Barometer PTB330 is the latest step in the continuous development of high accuracy and high stability barometers. The Vaisala BAROCAP® sensor represents the highest barometric pressure measurement quality.

¹ Guide to Meteorological Instruments and Methods for Observation, WMO - No. 8, Sixth Edition, (1996)



China – Finland cooperation grows stronger

The Finnish Environmental Cluster for China (FECC) is a two-year network project that aims to build a network involving Finnish environmental businesses in the Chinese markets. The Chinese partners include the Chinese Science and Technology Commission, National Development and Reform Commission, Environment Protection Bureau and the Economic Development Commission. The project was launched in June 2006 with the Finnish Ministry of Trade and Industry.

Establishing real working contacts

The project aims at engaging companies, investors and public-sphere actors in co-operation to create an operating model that would support environmental business operations and that would be suitable for the Chinese operating environment.

Thanks to the project, important networks and connections have been established between China and Finland, enabling cooperation between businesses and organizations on national, regional and local levels. Vaisala participates in this important network.

China - Finland Cleantech Conference in Lahti

The China - Finland Cleantech Conference was held in Lahti, Finland on 13–17 August 2007. The conference provided a



Hannu Talvitie introducing Vaisala products to the Chinese visitors.

venue for environmental companies and research organizations to meet and exchange ideas. Vaisala was one of the event participants.

The Chinese guests also visited Finnish companies, research institutions and reference projects in different parts of Finland. Vaisala headquarters in Vantaa received visitors on August 16th, including representatives from universities, businesses as well as the Chinese Embassy in Finland.

Vaisala goes to Mars

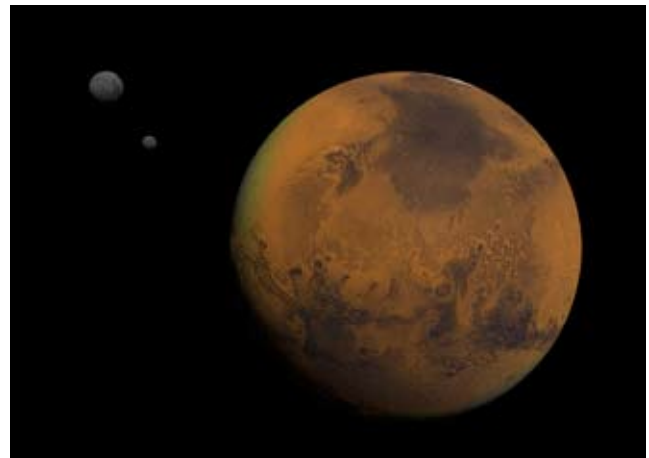
The University of Arizona-led Phoenix Mars Lander mission roared into space on August 4th 2007, and began its journey to seek evidence of water on our neighboring planet.

After a nine-month, 423-million-mile journey, the Lander is scheduled to arrive on Mars on May 25th 2008.

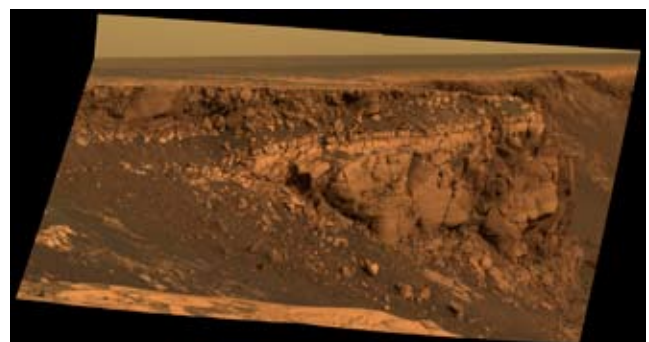
The \$420 million mission will collect and analyze soil and ice samples from the Martian arctic region for about three months. It will touch down at a site farther north than any previous Mars landing, and robotically dig to underground ice and run laboratory tests assessing whether the site could ever have been hospitable to microbial life.

Throughout the course of the Phoenix Mars Lander surface operations on Mars, a Meteorological Station built by the Canadian Space Agency will record the daily weather of the Martian northern plains. It will be using temperature and pressure sensors, as well as a light detection and ranging (LIDAR) instrument. With these instruments, the Meteorological Station will play an important role by providing information on the current state of the polar atmosphere and how water is cycled between the solid and gas phases in the Martian arctic.

The Finnish Meteorological Institute has contributed a pressure measurement instrument based on Vaisala's reliable sensor technology to the Meteorological Station. Atmospheric pressure on Mars is very low and requires a sensitive sensor for measurement.



Cape St. Vincent, one of the many promontories that jut out from the walls of the Victoria Crater on Mars. Courtesy NASA/JPL-Cornell.



New in Vaisala websites

Vaisala.com updates

The Vaisala.com website got a new front page layout in May. Along with the facelift, the site was divided into two main sections, Industrial Instruments and Weather Measurement, to better serve our customers.

New localized websites

Last year the Vaisala Instruments division reported that its localized web pages will appear in two new languages. The Portuguese site was launched during the summer and especially serves our Brazilian customers. The Spanish site is coming next with a focus on Latin-American customers. Both sites concentrate on the Industrial Instruments offering.

<http://www.vaisala.com/br>

Knowledge Center for industrial instruments

We are updating our existing websites regularly, and have made numerous smaller updates to our application and product pages. As an additional highlight, we have launched a new Knowledge Center in the Industrial Instruments section.

The Knowledge Center serves as an easy channel for details on our products and information on how to use them. We have also included sections for calibration and measurement theory. If you do not find an answer to your questions, feel free to send them to Vaisala Experts to answer.

<http://www.vaisala.com/Instruments/KnowledgeCenter>

Chat live with Vaisala Instruments experts

Since December 2006 you have been able to engage in live chat with Vaisala Instruments experts through our website. The live chat is operated by our knowledgeable sales staff all over the world. Thanks to our global coverage, you can now get almost round-the-clock service without having to



call overseas. If there are no operators online, you can leave a message and be contacted by your local representative as soon as possible.

Locate “Maria” on the right-hand side of the Industrial Instruments pages, and start chatting with Vaisala experts.

Product Advisor tool

Are you having trouble finding a suitable Vaisala instrument or comparing the specifications? With the recently launched Product Advisor on Vaisala.com it is easy to narrow our product offering to match your needs and then compare the products side-by-side. Currently we have included instruments measuring humidity, dewpoint, moisture in oil, barometric pressure, carbon dioxide, oxygen and wind.

<http://www.vaisala.com/Advisor>

Vaisala Humidity Calculator 2.0

The Vaisala Humidity Calculator was updated several times during the past year. Now it is time for a major update as we plan to bring in the much-requested wet bulb calculation feature in the near future. Visit the Humidity Calculator pages to stay up to date with the latest version.

<http://www.vaisala.com/HumidityCalculator>

Contact the Vaisala News team

Marikka Nevamäki
Editor-in-Chief

For subscriptions, cancellations, feedback and changes of address, please contact the Vaisala News team by sending an email to vaisala.news@vaisala.com

Thank you for your interest.



Europe

Vaisala Oyj

P.O. Box 26, FI-00421 Helsinki
FINLAND
Telephone: +358 9 894 91
Telefax: +358 9 8949 2227

Vaisala Oyj

Malmö Office
Drottninggatan 1 D
S - 212 11 Malmö
SWEDEN
Telephone: +46 40 298 991,
in Sweden: 0200 848 848
Telefax: +46 40 298 992,
in Sweden: 0200 849 849

Vaisala GmbH

Hamburg Office
Schnackenburgallee 41
D-22525 Hamburg
GERMANY
Telephone: +49 40 839 030
Telefax: +49 40 839 03 110

Vaisala GmbH

Bonn Office
Adenauerallee 15
D-53111 Bonn
GERMANY
Telephone: +49 228 24 9710
Telefax: +49 228 249 7111

Vaisala GmbH

Stuttgart Office
Pestalozzi Str. 8
D-70563 Stuttgart
GERMANY
Telephone: +49 711 734 057
Telefax: +49 711 735 6340

Vaisala Ltd

Birmingham Operations
Vaisala House
349 Bristol Road
Birmingham B5 7SW
UNITED KINGDOM
Telephone: +44 121 683 1200
Telefax: +44 121 683 1299

Vaisala Ltd

Newmarket Office
Unit 9, Swan Lane
Exning
Newmarket
Suffolk CB8 7FN
UNITED KINGDOM
Telephone: +44 1638 576 200
Telefax: +44 1638 576 240

Vaisala SAS

Paris Office
2, rue Stéphenon
F-78181 Saint-Quentin-en-Yvelines
FRANCE
Telephone: +33 1 3057 2728
Telefax: +33 1 3096 0858

Vaisala SAS

Marseille Office
2, rue de Beausset
13001 Marseille
FRANCE
Telephone: +33 4 8866 1751
Telefax: +33 1 3096 0858

North America

Vaisala Inc.

Boston Office
10-D Gill Street
Woburn, MA 01801
USA
Telephone: +1 781 933 4500
Telefax: +1 781 933 8029

Vaisala Inc.

Columbus Office
1372 Oxley Road
Columbus, Ohio 43212
USA

Vaisala Inc.

Boulder Operations
194 South Taylor Avenue
Louisville, CO 80027
USA
Telephone: +1 303 499 1701
Telefax: +1 303 499 1767

Vaisala Inc.

San Jose Office
6980 Santa Teresa Blvd
Suite 203
San Jose, CA 95119-1393
USA
Telephone: +1 408 578 3670
Telefax: +1 408 578 3672

Vaisala Inc.

Tucson Operations
2705 East Medina Road
Tucson, Arizona 85706,
USA
Telephone: +1 520 806 7300
Telefax: +1 520 741 2848
U.S. Toll Free 1 800 283 4557

Vaisala Inc.

Houston Office
1120 Nasa Road 1 Suite 220-E
Houston, TX 77058
USA
Telephone: +1 281 335 9955
Telefax: +1 281-335-9956

Vaisala Inc.

Minneapolis Operations
6300 34th Avenue South
Minneapolis, MN 55450
USA
Telephone: +1 612 727 1084
Telefax: +1 612 727 3895

Vaisala Inc.

Westford operations
7A Lyberty Way
Westford MA 01886
USA
Telephone: +1 978 692 9234
Telefax: +1 978 692 9575

Vaisala Inc. Regional Office Canada

37 De Tarascon
Blainville
QC J7B 6B7
CANADA
Telephone: +1 450 430 0880
Telefax: +1 450 430 6410

Asia and Pacific

Vaisala KK

Tokyo Office
42 Kagurazaka 6-Chome
Shinjuku-Ku
Tokyo 162-0825
JAPAN
Telephone: +81 3 3266 9611
Telefax: +81 3 3266 9610

Vaisala Pty Ltd

Melbourne Office
3 Guest Street
Hawthorn, VIC 3122
AUSTRALIA
Telephone: +61 3 9815 6700
Telefax: +61 3 9815 6799

Vaisala China Ltd.

Beijing Office
Floor 2, EAS Building
No. 21, Xiao Yun Road
Dongsanhuan Beilu
Chaoyang District
Beijing 100027
People's Republic of China
Telephone: +86 10 8526 1199
Telefax: +86 10 8526 1155

Vaisala China Ltd.

Building 1
17B China Phoenix Building
Shennan Avenue
Futian District
Shenzhen C-518026
People's Republic of China
Telephone: + 86 755 8279 2442
Telefax: + 86 755 8279 2404

Vaisala Shanghai

contact address
6F 780 Cailun Lu
Pudong New Area
201203 Shanghai
People's Republic of China
Telephone: + 86 21 5132 0656
Telefax: + 86 21 5132 0657

Vaisala Regional Office Malaysia

Level 9, West Block
Wisma Selangor Dredging
142-C Jalan Ampang
50450 Kuala Lumpur
MALAYSIA
Telephone: +60 3 2163 3363
Telefax: +60 3 2164 3363

Middle East

Vaisala UAE

contact address
P.O.Box : 9197
Khalifa Al Naboodah Building
1st Floor
Sheikh Zayed Road
Dubai
United Arab Emirates
Telephone +971 4321 9112
Telefax +971 4321 9113