

# APPLICATIONS COMPENDIUM

For the process industry

## ■ PREFACE

Dear reader,

This compendium comprises a selection of sample applications, which demonstrate how KROHNE has solved these industry-specific measurements to the satisfaction of our customers.

Whether it is standard or demanding applications with advanced requirements, our knowledge and experience of our customer's processes is key to addressing these challenges. Using this expertise, allows us to provide the appropriate measuring device, or if required by the application – to engineer complex measuring solutions.

We hope you will enjoy browsing through our various examples on the measurement of flow, level, temperature, pressure as well as process analysis.

If you require any further information on any of these applications, or if you have a challenge that we can solve for you, please don't hesitate to contact us: [application@krohne.com](mailto:application@krohne.com)

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**KROHNE**

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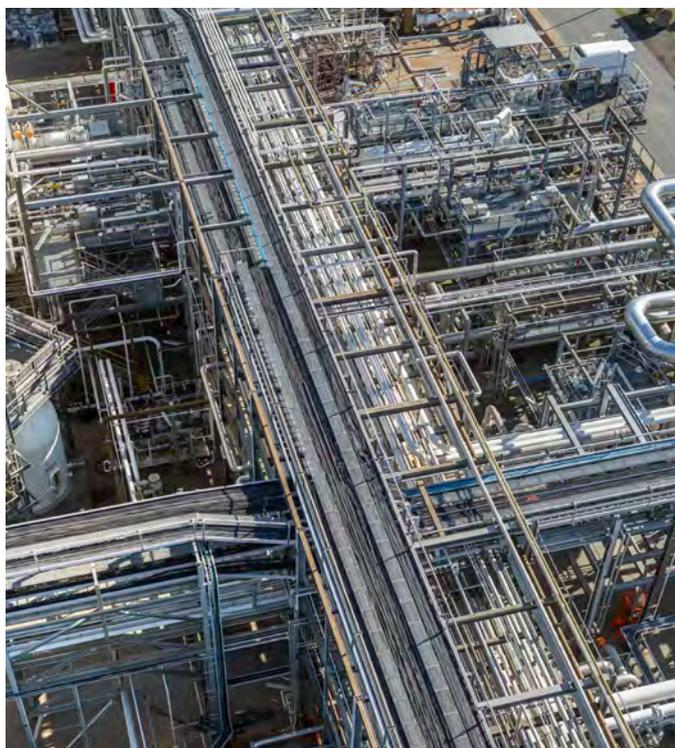
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## APPLICATION NOTE

Chemical

### Flow measurement of aldehyde reaction products with entrained air

- Mass flow measurement to ensure a minimum flow
- Constantly high measurement quality despite variable gas content in liquid medium
- Integration in control system as safety-critical application

#### 1. Background

A chemical company in the wider Rhine-Main region, Germany, operates a production plant for aldehyde reaction products. These are used as intermediate products in the pharmaceuticals industry and agriculture as well as curing agents in the manufacture of epoxy resins.

#### 2. Measurement requirements

There is PCT safety equipment in place for the production process to ensure the safety of the plant and to minimise the risk to human health and the environment. The design is such that the safety function is controlled using a continuous mass flow measurement by two measuring devices operating in series. The measurement deviation of the two devices is monitored as part of the safety concept. The liquids are transported at +70°C / +158°F and at a density of approx. 1 kg/l or 0.036 lb/in<sup>3</sup>. Due to the chemical properties of the media and the nature of the process, there is recurrent gas entrainment.

The customer has used mass flowmeters by a competitor in the past. However, the gas contained in the medium significantly compromised the measuring performance of these devices. For example, when gas bubbles occurred, the measuring devices automatically switched to error mode. There were also major deviations in the readings. It was, therefore, impossible to obtain continuous, reliable measured values.

The operator set about looking for a new technical solution to maintain the PCT safety function, which would be able to measure continuously and reliably in spite of the occasionally very high gas content.

## 3. KROHNE solution

The customer opted for the OPTIMASS 6400 C. This Coriolis mass flowmeter with twin bent tube design was supplied in a stainless steel version (1.4404 / 316L). It was connected by flange. Due to spatial conditions, the device was installed at the highest point of the plant section, upstream of a descending pipe and on the suction side of a pump.

Unlike other widely available mass flowmeters, the OPTIMASS 6400 is immune to the negative effects of entrained air. Thanks to the patented functionality of "Entrained Gas Management" (EGM™), the measuring device can continuously measure the mass flow, even if entrained gas occurs. Instead of switching to error mode or freezing at the last stable measured value to circumvent the loss of measuring signal, the OPTIMASS 6400 can track the actual frequency of the measuring tube and reliably calculate the flow.



PCT safety equipment with OPTIMASS 6400 fitted in series

## 4. Customer benefits

With the OPTIMASS 6400 C the operator can reliably and continuously keep track of the flow and ensure that it does not drop below the minimum. Thanks to their EGM functionality, the two mass flowmeters continue to measure, even when there is a high gas content in the medium. The chemical company no longer has to shut down its plant for safety reasons because of deviations between the two measured values.

Unlike the mass flowmeters previously used, KROHNE's devices work continuously. For the customer, this means more than just safe operation of the plant. The company also avoids unnecessary downtime and makes considerable cost savings as the PCT safety equipment can be operated without interruption. This means a permanent increase in the quality and volume of the product.

## 5. Product used

### OPTIMASS 6400 C

- Standard measuring device for SIL and process applications in the chemical industry
- Suitable for applications with gases and liquids
- With Entrained Gas Management (EGM™): Stability with entrained gas (gas concentrations 0...100%)
- For cryogenic (-200°C / -328°F), high temperature (+400°C / +752°F) and high pressure applications (200 barg / 2900 psig)
- Measuring tube made of stainless steel, Hastelloy or Duplex
- Advanced diagnostic functions and status displays in accordance with NAMUR NE 107
- High accuracy for custody transfer (approved to OIML R117, R137, MI-005, MI-002)
- HART®, FF, PA, DP, Modbus



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## APPLICATION REPORT Chemical Industry

### Measurement of aggressive phosgene derivatives at BASF

- Mass flow measurement on loading road tankers with chloroformates and acid chlorides
- Determination of the fill quantity for invoicing purposes
- Consistently high measurement accuracy despite corrosive process liquids

#### 1. Background

At its parent plant in Ludwigshafen, the chemical company BASF manufactures phosgene derivatives such as chloroformates and acid chlorides, which are used in the production of plastics, pharmaceuticals and packaging. Road tankers must be filled with these highly corrosive and poisonous media in order to transport and deliver them to various BASF plants.

#### 2. Measurement requirements

For invoicing purposes, the chemical company needs exact information about the delivered amount of chloroformates and acid chlorides. This requires a reliable mass flow measurement of the liquids filled into the tanks at a flow rate of 60 t/h, a temperature of 50° C / 122° F and a density of 1000 to 1500 kg/m<sup>3</sup> or 1686 to 2529 lb/yd<sup>3</sup>. Because these are very aggressive media, the technical measurement solution must provide a high degree of chemical resistance. Previously, BASF used mass flowmeters from another manufacturer, but they could not withstand the aggressive properties of the process liquids and could not deliver consistent measuring results.

## 3. KROHNE solution

BASF chose to install four OPTIMASS 7300 C Tantalum meters. KROHNE's meter is the first flowmeter in the world with one single, straight measuring tube made of tantalum, which makes it particularly suitable for use with highly corrosive media. The Tantalum alloy used is designated Ta10W and consists of 10% tungsten and 90% tantalum. The tungsten content guarantees higher measuring tube stability. The chemical resistance of tantalum is comparable to that of glass.

Each mass flowmeter, nominal diameter DN 50 / 2", was flange mounted in a pipeline with particularly robust enamel coating. The measuring point in the filling station is also electrically heated to protect the process liquid from frost. As the meter is installation insensitive, no inlet and outlet runs were required for the installation.



Mass flow measurement of aggressive chloroformates and acid chlorides

## 4. Customer benefits

Using the OPTIMASS 7300 C Tantalum, BASF can continuously monitor the amount of phosgene derivatives delivered and can accurately invoice each delivery, based on the measurement results.

This chemical company has used the OPTIMASS 7000 Tantalum meter since 2009 without interruption. The mass flowmeter measures the aggressive media continuously and precisely without having to service the instrument or replace it regularly due to corrosion. Because the OPTIMASS 7000 does not require a flow splitter, practically no product deposits are found in the pipe and it is easy for BASF to clean the straight meter tube.

In contrast to the existing twin U-tube meters, in which both the flange and the flow splitter consist of tantalum, with the OPTIMASS 7300, only the measuring tube and the raised face are made of tantalum. This creates a significant cost benefit for BASF.

## 5. Products used

### OPTIMASS 7300 C

- The only single straight tube meter available in 4 materials – titanium, tantalum, Hastelloy C22, Duplex
- Reliable measurement of mass and volume flow, density, temperature and solid content
- Low pressure drop
- Largest nominal diameter of any single straight tube meter in the world (DN 80 / 3")
- Highest safety factor with PED approved secondary containment (up to 100 bar / 1450 PSI)
- Any installation position, self-draining and easy to clean



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# APPLICATION REPORT

Chemical

## Mass flow measurement of a gas mixture

- Measurement of a product with low density (relatively high temperature / low pressure)
- Mixture of different gases in different concentrations
- Installation in hazardous environment (ATEX zone)



### 1. Background

French chemicals company ARKEMA runs a production facility in an industrial area of the Pierre Bénite commune near Lyon, France. The facility is operated in accordance with enhanced safety requirements due to the dense population. Fluoride derivatives are manufactured at this location. The use of reliable, accurate measuring devices manufactured using appropriately high-performance materials is a decisive factor when it comes to ensuring production quality.



Measuring gas mixture with the OPTIMASS 6400 C

### 2. Measurement requirements

One production unit in operation since 2003 must measure approximately 20 process media including gases, steam, acids, sulphates and latex. One of the gas mixtures consists of difluoroethylene (VF2) and up to 20% hexafluoropropylene (HFP). The medium has a density between 5 and 7.5 kg/m<sup>3</sup> / 0.3 and 0.47 lb/ft<sup>3</sup>.

The maximum flow rate is 700 kg/h / 25.7 lb/min at a process temperature of 80 °C / 176 °F and a pressure of 1.5 bar / 21.75 psi. An accuracy of ±0.35% of measured value was specified for this measurement. The pressure drop may not exceed 60 mbar / 0.87 psi. Since these gases are flammable, the measuring device must have Ex approval in accordance with ATEX.

## 3. KROHNE solution

The OPTIMASS 6400 C mass flowmeter was chosen. The KROHNE device features a twin V-shaped measuring tube made of stainless steel (316L). It was supplied in nominal size DN 25 / 1".

The OPTIMASS 6400 is a standard measuring device for process applications in the chemical industry. It provides maximum measuring accuracy and repeatability. Thanks to its patented flow splitter, the mass flowmeter also enables an optimised flow profile. This reduces pressure loss to a minimum.

To prevent the buildup of condensation from influencing the measurement it is generally recommended that the measuring device be installed in a horizontal pipeline with the bent dual measuring tube above the longitudinal axis of the pipe. However, since condensation was not a factor in this application, the device could be installed with the converter above (see image). The NAMUR installation length (as per NE132) also makes it easy to replace the device at this measuring point.



OPTIMASS 6400 installation

## 4. Customer benefits

Using the OPTIMASS 6400 has helped ARKEMA considerably increase the accuracy and repeatability of measurement and allowed them to better meet the production quality criteria. KROHNE fully complied with the quality requirements that ARKEMA had for the measurement. The OPTIMASS 6400 is only one of many KROHNE measuring instruments used in a wide variety of measuring points in the facility.

## 5. Product used

### OPTIMASS 6400 C

- Mass flowmeter for maximum performance in the process industry (DN 10...300 / ½...12")
- For liquid and gas applications
- For cryogenic (-200 °C / -328 °F), high temperature (+400 °C / +752 °F) and high pressure applications (up to 200 bar / 2900 psi)
- With Entrained Gas Management (EGM™): Stability with entrained gas (gas concentrations 0...100%)
- Stainless steel (316L) measuring tube, Hastelloy or Duplex
- Approved for hazardous areas (including ATEX, cFMus, IECEx, NEPSI)
- Approved for custody transfer in accordance with OIML R117, R137, MI-005, MI-002



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# APPLICATION REPORT Oil & Gas

## Flow measurement of slop reflux at a refinery

- Reprocessing the residue of heavy crudes in the production of naphthenic specialty oils
- Mass flow metering of slop oil to improve distillation operations
- High Temperature (HT) application with up to 400 °C / 752 °F



### 1. Background

The Nynas refinery in Nynäshamn, Sweden, produces specialty oils. Naphthenic specialty oils and bitumen are the core business products of the company. Unlike other refineries that process lighter crudes for the production of conventional fuels, Nynas processes heavy crudes to distill their special products. In order to increase distillation efficiency, Nynas also reprocesses the slop residue of crude oil, which is the lighter part of crude oil obtained during distillation.

### 2. Measurement requirements

In order to better handle the variability of the slop oil before reprocessing it, the slop reflux has to be controlled. Slop oil is a challenging medium. It is a thick and viscous fluid by nature and is recirculated at temperatures up to 400 °C / 752 °F. Depending on the heaviness of crude oil, the slop reflux can also be corrosive.

Medium	Slop oil
Flow rate	270...16,000 kg/h / 10...588 lb/min
Temperature	320...400 °C / 608...752 °F
Pressure	3.5 barg / 51 psig
Density	758 kg/m <sup>3</sup> / 47.3 ft/m <sup>3</sup>
Viscosity	5 cSt (at operating temperature)

Nynas had already tried to master this application using mass flowmeters from competition. However, as these instruments were certified to only 350°C / 662°F, they were often failing in the application. Nynas was therefore searching for a reliable and accurate mass flowmeter to be used at one of their distillation units.

## 3. KROHNE solution

KROHNE supplied an OPTIMASS 6400 F in stainless steel (DN 50 / 2"). The Coriolis mass flowmeter turned out to be the flowmeter of choice in this HT application as it provided the necessary accuracy even at high temperatures of up to 400 °C / 752 °F. The flowmeter with twin V-tube design was vertically installed in the insulated sloop reflux line.

To ensure the consistently high temperature of the medium, the device has been equipped with an insulation jacket and was connected to a heat tracing system. The OPTIMASS 6400 was provided as a remote version, allowing the converter to be separately installed up to 20 m / 65.6 ft from the flow sensor.

The meter allowed for a smooth set up and configuration. It enabled a seamless integration into the existing DCS (distributed control system) and asset management system of the customer.



OPTIMASS 6400 F with insulation jacket and connected to heat tracing system

## 4. Customer benefits

Nynas has been very satisfied with the OPTIMASS 6400. The meter has provided excellent accuracy and repeatability at high temperatures and handled the specific process conditions exceedingly well. It has been very robust and very reliable for the customer's operations. This way, Nynas has been able to model and optimize the distillation unit very effectively, also helping the company to troubleshoot and solve problems in the distillation column successfully.

## 5. Product used

### OPTIMASS 6400 F

- Standard Coriolis mass flowmeter for the process industry
- Entrained Gas Management (EGM™): Continuous measurement even at gas concentrations of up to 100% and sudden void rate changes
- For cryogenic and high temperature applications (-200°C...+400°C / -328...+752)
- Optional insulation / heating jacket
- Communication: HART®, FOUNDATION fieldbus™, PROFIBUS™
- Custody transfer applications: OIML R 117-1/MID MI-005 (liquids), OIML R 137 /MID MI-002 (gases)
- ATEX, IECEx, FM, Gost etc.

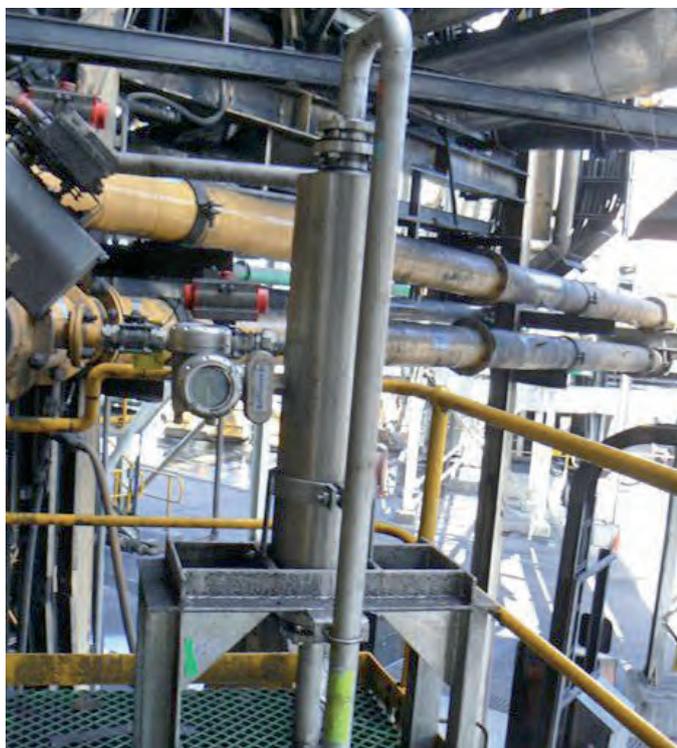


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## APPLICATION NOTE Minerals & Mining

### Non-radiometric density measurement of tailings thickener underflow

- Measuring abrasive concentrated solids at coal handling and preparation plant in Australia
- Underflow density loop to improve water recovery and underflow withdrawal
- Reliable alternative to density measurement with nuclear density gauges

#### 1. Background

A coal handling and preparation plant in Queensland, Australia, has a production capacity of more than 10 million tonnes of coking coal per year. Adjacent to one of the country's largest and most established open cut coal mines, the plant sizes, crushes and removes impurities from the raw coal. As the coal preparation involves water based processes, a great deal of highly abrasive flotation tailings have to be disposed of on a regular basis. For water recovery purposes and to save costs with impoundment construction, a density thickener is used as part of a tailings disposal system. During the thickening process suspended solid particles separate from the liquid stream by gravity settling. While the clarified liquor overflows to the top and gets recovered, the solids settled to the pulp bed are removed from the thickener through the tailings underflow, which is the final disposal stage before the tailings are pumped to the tailings dam.

#### 2. Measurement requirements

An efficient tailings disposal facility is highly dependent on a reliable thickener underflow density measurement. Only if the required underflow density is obtained can the rate of underflow withdrawal be efficiently regulated and the amount of water in the underflow is kept as low as is practical. Traditionally, radiometric density measurement has been employed on thickener underflow lines as they provide a non-contact solution to measure abrasive concentrated solids streams. Since the high total cost and regulatory requirements of owning radiometric devices is becoming prohibitive in a competitive, cost and labour intensive production environment, the plant operator decided to optimise their tailings disposal schemes by applying a non-radiometric density solution that is compliant with environmental regulations.

## 3. KROHNE solution

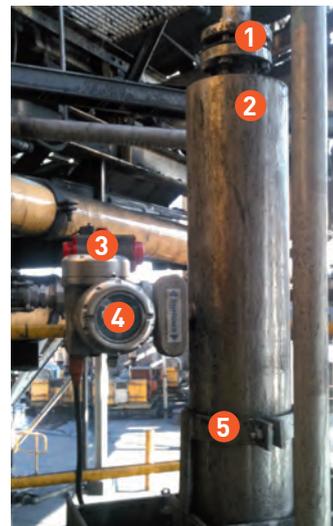
The customer decided in favour of the OPTIMASS 7300 C for non-radiometric density monitoring. KROHNE was selected because of their knowledge and expertise in abrasive slurry applications enabling them to highlight potential problems so they are mitigated during the design, planning and installation of the mass flowmeter. The Coriolis mass flowmeter with a Titanium flow tube was mounted on the tailings thickener underflow line. In order to keep the heavy abrasive particles evenly dispersed in the carrier fluid, the OPTIMASS was installed into a vertical pipeline (DN 50 / 2"). The density measurement is sent to a DCS via a current output of 4...20 mA so as to control the underflow pump and to regulate the underflow solids concentration.

## 4. Customer benefits

Using the OPTIMASS for density control on the underflow, the plant operator is always able to assess their tailings thickener efficiency, allowing them to take immediate steps if the thickener underflow runs below or above the required setpoint. Applying non-radiometric density monitoring gives the plant engineers the information needed to optimise the thickener for the intended duty. In essence, the plant benefits from reduced capital and operating costs, as well as reduced environmental impact.

The single straight mass flow measuring tube of the OPTIMASS provides a robust and reliable alternative to nuclear density gauges, allowing the plant operator to optimise its tailings disposal scheme without using nuclear source material. There are no disposal costs for nuclear waste, documentation and administrative controls. Wipe tests and ongoing training of on-site radiation safety officers to perform calibration are no longer required.

Making the OPTIMASS a permanent part of the thickener process also enables the customer to effectively reduce water consumption, e.g. by avoiding filling the tailings dam with solids that contain too much water. Water can be efficiently recirculated, which is an additional advantage to the customer as the plant is located in an area of water scarcity.



1. Transition pieces to protect against abrasion,
2. Single vertically installed measuring tube with no flow splitters or bends to suffer premature failure,
3. Stainless steel housing for harsh environment,
4. Easy to change display orientation,
5. Insensitivity to installation including clamping

## 5. Product used

### OPTIMASS 7300 C

- The only single straight tube meter available in 4 materials – titanium, tantalum, Hastelloy C22, Duplex
- Reliable measurement of mass and volume flow, density, temperature and solid content
- Low pressure drop
- Largest nominal diameter of any single straight tube meter in the world (DN 80 / 3")
- Highest safety factor with PED approved secondary containment (up to 100 barg / 1450 PSI)
- Any installation position, self-draining and easy to clean



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## APPLICATION NOTE Chemical

### Chemical dosing into liquid mixer

- Fill the mixer in half the time
- Increased mixer efficiency
- Improved homogeneity of mixture thanks to simultaneous supply of reactants

#### 1. Background

A laundry detergent producer operates a test plant in which liquid detergent can be produced using different recipes for test purposes. The liquid mixer has a holding capacity of one tonne.

#### 2. Measurement requirements

The proportions of the reactants must be strictly observed when manufacturing new types of detergent. In addition to demineralised water, alkaline lye and caustic lye, malonic acid and other acids and solvents are dosed into the mixer. Previously, base products had always been added to the mixture sequentially using weighing cells. The operator was looking for a new solution to accelerate the filling process while maintaining high precision.

#### 3. KROHNE solution

One Coriolis mass flowmeter was used for each raw material to measure the quantities that were fed in, making a total of 11 OPTIMASS 7300 in nominal sizes ranging from DN 15 to DN 40. As some of the reactants require increased chemical resistance on wetted surfaces, devices featuring a measuring tube made of titanium were used and the rest of the measuring stations were equipped with stainless steel measuring tubes. Remote converters were installed for improved display readability and to save space.

## 4. Customer benefits

OPTIMASS measuring devices feature a single straight measuring tube without flow splitter or internal objects. This means that the high viscosity of some reactants poses no problems for the mass flowmeter. The customer provided KROHNE with detailed information about the media beforehand so that the devices could be precisely sized and the accuracy could be guaranteed in practice.

Using mass flowmeters offers operators several advantages: The reactants can be extremely accurately added to the mixer simultaneously through the ring lines. This saves a tremendous amount of time compared to dosing using the weighing scales and the mixer can be filled in half the time. This also makes it available sooner for the next mixture which means that twice as many tests can be conducted in the same period of time. At the same time, thanks to the simultaneous supply, the reactants are distributed even before the stirring device in the mixing tank starts, guaranteeing improved homogeneity of the end product. According to the operators, the relatively high initial investment for the mass flowmeters compared to the weighing cells pays for itself in just a few weeks due alone to the higher efficiency of the mixer.



Remote version offers good readability

## 5. Products used

### OPTIMASS 7300 F

- Only mass flowmeter with a single straight measuring tube available in Stainless Steel, Hastelloy, Titanium and Tantalum
- Approved according OIML R 117-1 for mass and volume flow accuracy class 0.3
- Can be installed anywhere, regardless of vibrations
- Minimal pressure loss
- Easily drained and easy to clean



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## APPLICATION NOTE Chemical

### Steam quantity measurement for internal energy balancing

- Measurement of flow, temperature and steam pressure
- Recalculation of the steam mass into energy
- Output of heat consumption to an energy monitoring system

#### 1. Background

A large chemical concern operates its own steam network, from which the individual business units draw off steam, e.g. for heating purposes. The company has installed a primary monitoring system for recording and billing the steam and energy consumption.

#### 2. Measurement requirements

A system to measure the steam entering an administration building has to be set up. The steam flows past the measurement point through a DN 150 insulated pipe with 10 t/h at 4.5 bar pressure and a temperature of 156° C. The density is 2.92 kg/m<sup>3</sup>. Until now, the operating company has deployed a compact orifice flowmeter in combination with a temperature and a pressure sensor to measure the quantity of steam consumed. However, the measurement range of the flow meter was not sufficient to record the wide deviations in the flow volumes of steam. The heat consumption should be output to the monitoring system. Additionally, there is also a requirement to convert the measured steam mass into energy, e.g. kWh.

### 3. KROHNE solution

KROHNE supplied an OPTISWIRL 4070 C DN150 to measure the flow, which has a bigger turn down than an orifice plate. The vortex flowmeter has integrated pressure and temperature compensation and was supplied with a flow conditioner in order to achieve shorter inlet paths. The OPTISWIRL 4070 C unifies three measuring systems. It measures the process pressure, the temperature and the volume flow. Based on this information, the integrated flow calculator calculates the exact mass and energy flow.

### 4. Customer benefits

Thanks to the large measurement range, the operating company can measure the actual steam consumption of the administration building with much more accuracy than before. The customer was particularly impressed the measuring principle integrated in the device as well as the integral flow calculator. A further convincing factor was the fact the device is maintenance-free, as the orifice flowmeter used before had to be dismantled for maintenance and then reinstalled afterwards. A final point was that in terms of purchase costs, the vortex device was significantly less than comparative offer for orifice flowmeter and there was no need to install pressure and temperature sensors.



OPTISWIRL 4070 C with integrated pressure and temperature compensation (pressure loop is located on the back of the unit)

### 5. Product used

#### OPTISWIRL 4070 C

- 2-wire Vortex flowmeter for the measurement of gases, vapours and liquids
- Integrated pressure and temperature compensation and conversion into energy
- Suitable for damp gases, e.g. saturated steam
- High precision and long-term stability
- Process temperature:  $-40^{\circ}\text{C} \dots +240^{\circ}\text{C}$
- Maintenance-free



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## APPLICATION REPORT Food & Beverage

### Vortex flow measurement of carrier air in a sterilisation facility

- Flow control in a packaging machine for the sterile closure of yogurt pots
- Determination of the standard volume flow to maintain operational tolerances
- Optional media balancing to flexibly adjust to future changes in packaging material



#### 1. Background

NSM Packtec GmbH, based in Ahaus, Germany, designs, manufactures and installs high-performance packaging machinery for international companies in the dairy and beverage industry according to customer specifications. NSM's portfolio includes pot molding, filling and closing machines (FFV). These facilities are designed according to an integrated aseptic concept and use hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) for the inline sterilisation of all of the packaging materials.



Sterilisation system

#### 2. Measurement requirements

NSM manufactured a packaging machine with just such a sterilisation system using the H<sub>2</sub>O<sub>2</sub> spray method for a milk processing operation in the USA. In this procedure, the materials to be sterilised are sprayed with a heated H<sub>2</sub>O<sub>2</sub> aerosol that is versatile and non-destructive. Heated, sterile carrier air is fed to an aerosol lantern in order to convey the H<sub>2</sub>O<sub>2</sub> aerosol generated there to a spray chamber. It is then sprayed on to a heat sealing film for sterilisation. The heat sealing film is then applied as a seal for the yogurt pots in the packaging machine. The carrier air must be supplied in a defined quantity to guarantee a consistent, even coating. The plant manufacturer was looking for a suitable flowmeter to accurately monitor the flow of the carrier air even at fluctuating pressures (6...8 bar / 87...116 psi) and temperature conditions (approx. 40 °C / 104 °F).

## 3. KROHNE solution

NSM decided on the OPTISWIRL 4200 C. The DN 25 vortex flowmeter was installed in the non-sterile area of the sterilisation facility. The device measures the standard volume flow of the carrier air for the aerosol lantern. The air is reduced or regulated to the plant operating pressure, cleaned using sterile filters, heated up and conveyed to the aerosol lantern.

Due to fluctuating process conditions, KROHNE recommended using the device with integrated pressure and temperature compensation. This puts the OPTISWIRL 4200 in a position to take into account fluctuating process conditions when calculating the standard volume while guaranteeing correspondingly high accuracy.



OPTISWIRL 4200 C for the measurement of carrier air

## 4. Customer benefits

The OPTISWIRL 4200 C guarantees continuous sterilisation of the heat sealing film used to seal the yogurt pots. As the vortex flowmeter measures pressure and temperature in addition to volume flow, there are no additional installation costs for separate pressure or temperature sensors. In addition, familiar measuring errors are eliminated as the OPTISWIRL 4200 measures all parameters at one single position.

Along with increased accuracy and process reliability, the end customer in the dairy industry also benefits from the possibility of quantity balancing for the measuring device. This makes it possible to flexibly adapt sterilisation and sealing in the face of changing requirements. This way, for example, the sealing of the yogurt pots can be adjusted according to changing film materials and dimensions.

## 5. Product used

### OPTISWIRL 4200 C

- Vortex flowmeter for conductive and non-conductive liquids, gases and steam
- Integrated pressure and temperature compensation for auxiliary and supply circuits with changing process conditions
- Advanced technology for signal filtering
- Measuring range: DN15...300 / 1/2...12"
- Also available with integrated nominal diameter reduction
- Developed according to IEC 61508, Edition 2, for SIL2
- ATEX, IECEX, QPS, NEPSI etc.
- HART®, FOUNDATION™ fieldbus and PROFIBUS® PA



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## APPLICATION NOTE Oil & Gas

### Monitoring energy consumption at an oil and gas field

- Equipping more than 70 bypass lines with gas flow measuring devices
- Vortex flow measurement of natural gas with integrated pressure and temperature compensation
- Detecting technical losses due to soot formation in burners

#### 1. Background

A multinational oil and gas company explores and refines raw oil and natural gas in Northern Serbia. The oil and gas field stations have only recently been refurbished to meet the most complex production processes. All facilities comprise of a wide range of energy consuming devices such as heavy fuel and gas boilers, steam heaters, glycol dehydrators and compressors. Most of the systems are fueled with natural gas from the gas fields.

#### 2. Measurement requirements

In order to control the energy efficiency of each of their gas field stations, the company decided to monitor the natural gas consumption of their systems as well as to detect technical losses due to soot formation in burners. The customer was therefore searching for a cost-effective gas flow measuring technology to be mounted in more than 70 bypass lines. Given the volatile parameters of the medium, it was a requirement that temperature and pressure measurement (4...60 barg / 58...870 psig) be part of the solution. ATEX zone 1 Ex ia approvals were also mandatory.



Vortex flowmeter mounted in a bypass line

## 3. KROHNE solution

The KROHNE representative, WIG DOO BEOGRAD, recommended using the Vortex flowmeter OPTISWIRL 4070 C, thereby prevailing over competitor solutions using turbine meters, rotary gas meters or multivariable transmitters. The operator installed more than 70 Vortex flowmeters from KROHNE at the gas field stations. The instruments were mounted in bypass lines to allow easy dismantling without process interruption. The majority of these lines were meant to be part of a permanent system of piping with different nominal sizes from DN 15 / 1/2" to DN 100 / 4" (classes: 150 lb, 300 lb and 600 lb). At these measuring sites flowmeters with sandwich process connections were used. Five other flowmeters were fitted at mobile metering systems that allow for temporary flow measurement at 14 varying measuring sites. These flowmeters were installed with flanges and all devices have corresponding ATEX approvals (Ex II 2G EEx d ia [ia] IIC T6).



Mobile metering system with a flanged OPTISWIRL 4070 C

The vortex flowmeter measures the operating volume flow of natural gas as well as calculates an accumulated standard volume flow of as low as 4 Sm<sup>3</sup>/h). As all devices also feature integrated temperature and pressure sensors, they can compensate for the unsteady parameters of the medium. Their readings are provided via 4...20 mA HART to a control room, from where they are telemetrically transferred to a SCADA system.

## 4. Customer benefits

The operator of the oil and gas fields now benefits from reliable energy monitoring that enables them to get an accurate overall measurement of their own consumption. The OPTISWIRL is a cost effective alternative to mechanical gas flow meters as it is maintenance-free and features integrated temperature and pressure compensation. It therefore requires no additional instrumentation to compensate for the unsteady parameters of the medium. This also makes the flowmeter a suitable device to control the maintenance requirements of burners and to prevent technical losses. Every time the nozzles of the burners start sooting, the pressure raises which can be effectively detected by the OPTISWIRL. As a result, predictive maintenance can be carried out, preventing costly process interruptions.



Installation of flowmeter with sandwich connection

## 5. Product used

### OPTISWIRL 4070 C

- Vortex flowmeter for measuring operating, standard volumetric and mass flow of conductive and non-conductive liquids, gases and vapours
- 2-wire device with integrated pressure and temperature compensation
- Non-wearing, fully welded stainless steel construction with high corrosion, pressure and temperature resistance
- Optimal process reliability thanks to Intelligent Signal Processing (ISP) – stable readings, free of external influences
- Maintenance-free measuring sensor design



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## APPLICATION NOTE Chemical

### Variable area flow measurement in an analyser container

- Gas measurement for monitoring chemical plants
- Checking air intakes for the detection of phosgene
- Monitoring measurement, reference and purging gas for oxygen analysers

#### 1. Background

A leading technology company designs and builds custom analyser containers for the chemical and pharmaceutical industries. These all-in-one solutions are used to monitor gases in process plants where they indicate leaks or the discharging of highly toxic media, among other things. In addition to monitoring plant safety, the analyser containers are used to continually check product quality.

#### 2. Measurement requirements

The technology company designs analyser containers for chemical companies that process phosgene. The turnkey units comprise three gas monitoring devices that register the discharge of highly toxic phosgene via air intakes and can trigger an alarm for immediate phosgene neutralisation. Reliable and cost-efficient measuring devices are required to check the function of the pumps that supply the gas monitoring systems with intake air. These devices monitor the continuous flow measurement of minimal air quantities.

Three oxygen analysers are also part of the container and are used to analyse the product flows. Flow measurements help guarantee constant sample flows to the analysers. In addition, the oxygen analysers need a consistent supply of clean reference gas and – to avoid hazardous atmospheres – they need to be purged with inert gas. Both gas flows must be technically measured to guarantee function and safety. Only ATEX approved measuring instruments can be considered as technical solutions.



Reference gas and inert gas measurement with DK37 and DK34

## 3. KROHNE solution

KROHNE supplied a variety of variable area flowmeters to equip the analyser container. All of the measuring instruments were supplied in Ex versions. The customer installed a total of 12 type DK800 flowmeters to measure the flow of the gas samples to detect phosgene. The floats with glass cones are particularly well suited to the measurement of extremely small gas quantities, as is required with this gas detection. The measuring devices use a needle valve to provide freely adjustable flow. The DK800 devices use limit switches to control the flow of the gas to the gas monitoring devices – and thus also to control pump function. If the value is too low, the measuring instruments send an alarm to the control room.



Monitoring intake air with the DK800

Three type DK37 flowmeters were also installed. They are used to monitor the amount of sample gas that flows into the oxygen analysers. The flow rate is output via an electronic display and transferred to the control room via linear current output (4...20 mA) in 2-wire technology. 3 DK37 devices were also used to measure the reference gas. 9 DK34 flowmeters were installed to measure the purging gas. The sturdy all-metal measuring devices monitor the nitrogen flow used to purge the housing of the oxygen analyser to neutralise it.

## 4. Customer benefits

The variable area flowmeters are an important prerequisite for reliable, error-free analyser operation. The measuring instruments ensure that the measurement, reference and purging gas are always available in the right quantity for gas analysis. Indirectly, the DK devices also ensure that in the event of a phosgene leak, an ammonia wall can be built up to neutralise it as soon as possible. The measuring devices are also a fundamental component in making the monitoring of product quality and safety possible in the first place. If, for example, the reference gas fails, the oxygen analysis cannot be carried out at all. The measuring instruments also prevent the creation of an explosive atmosphere within the oxygen analysers. With the help of KROHNE devices, the technology company meets all of the requirements of its end customers for a fully functional and safe all-in-one system.

## 5. Product used

### DK37 Variable area flowmeter

- For the measurement and dosing of flows (liquids and gases)
- Approvals for hazardous areas: ATEX, NEPSI

### DK34 Variable area flowmeter

- For the measurement of extremely low flows (liquids and gases)
- Approvals for hazardous areas: ATEX, IECEx, FM, NEPSI

### DK800 Variable area flowmeter

- For the monitoring of extremely small volumes and fine dosing
- Use in hazardous areas (ATEX approval)



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## APPLICATION NOTE Chemical Industry

### Monitoring the flow of reference gas during oxygen analysis of vinyl chloride

- Analysis of oxygen content in the product flow
- Permanent flow measurement of nitrogen (N<sub>2</sub>) as reference gas
- Process reliability thanks to flow alarm when limit value not reached

#### 1. Background

A European chemical manufacturer produces vinyl chloride (VC) which is used as the base material in the production of thermoplastic polymers (PVC) and processed, for example, in the building and packaging industries. In the two-step manufacturing process, crude oil-based ethene is made to react by adding chlorine and the ethene is converted into VC with the help of oxygen through oxychlorination.

#### 2. Measurement requirements

The oxygen content plays a special role in the production of VC. It determines the quality of the end product and the efficient conversion of the base substances during oxychlorination. In addition, with this highly combustible gas composition made up of ethene and oxygen, the oxygen concentration may not exceed the specified limit value for reasons of explosion prevention. An explosion here could cause considerable damage throughout the entire chemical plant. For this reason, the chemical specialist permanently monitors the product flows using an oxygen analyser according to the paramagnetic measuring principle. For the necessary amount of nitrogen to flow through the reference gas, the vinyl chloride producer requires reliable flow measurement and the right dosage of N<sub>2</sub>. ATEX Ex approval is also mandatory

### 3. KROHNE solution

The chemical specialist uses the DK37 variable area flowmeter for the continuous measurement of the reference gas. The KROHNE instrument made of a metal cone is fitted with an electronic display and a dosing valve for flow control. The unit was provided in an intrinsically safe Ex-design.

The 4...20 mA signal output of the DK37 continuously monitors the flow of the reference gas. When the limit values set in the control system are not attained, the sample flow of vinyl chloride can quickly be interrupted and nitrogen inertisation started. If necessary, the customer can also raise or lower the flowrate of the reference medium at any time using the integrated dosing valve.



Nitrogen flow measurement with the DK 37

### 4. Customer benefits

The DK37 is a fundamental component of the entire production process for the customer. The production of vinyl chloride is only possible through reference gas measurement. The variable area flowmeter ensures that the chemical producer always has measurements for oxygen analysis and that he can also monitor the oxygen content of his vinyl chloride flow. In this way, the variable area flowmeter performs an important role in terms of hazard prevention in the production process and in the quality assurance of the end products.

For the customer, the DK37 is the reliable solution which, with a maximum measuring error of 2.5 percent of the measuring result, also measures with sufficient accuracy. The variable area flowmeter is the right instrument for the customer's compact analyser unit as it is permanently stable for use in extremely confined spaces.

### 5. Product used

#### DK37 Variable area flowmeter

- Reliable measurement and dosing of flows of liquid and gaseous products
- Approved for use in hazardous areas as per ATEX
- Electronic or mechanical indicator
- Accuracy: maximum measuring error of 2.5% of measured value
- SIL2-compliant limit switches / SIL1-compliant current output
- Operating pressures up to 130 bar / 1885 psi
- Process temperatures from -80 to +150°C / -112 to +302°F



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## APPLICATION NOTE Iron, Steel & Metal

### Variable area flow measurement for dosing protective gas in industrial furnaces

- Reliable, accurate measurement of protective gas at extremely low operating pressure
- Space constraints necessitate extremely short inlet and outlet runs
- Local analogue display with electrical data output for control

#### 1. Background

A manufacturer produces industrial furnaces heated electrically or with gas. Metal parts and tools are annealed and tempered through heat treatment with these furnaces. This includes, among other things, annealing, post weld heat treatment, tempering and carbonisation.

With many heat treatment processes, the operation must take place in a protective gas atmosphere to avoid undesired reactions such as oxidation and combustion. This requires the industrial furnaces to be gas-proof. Protective gases include nitrogen, argon, helium and forming gas.

With limited gauge pressure, protective gas flows continuously into the furnaces in order to displace the air/oxygen.

#### 2. Measurement requirements

For this application, the protective gas atmosphere is established by nitrogen adjustment control in the range of 15...40 Nm<sup>3</sup>/h.

The supply gauge pressure of 8 bar is reduced to 100 mbar in two steps.

The limited space available necessitates compact installation and short inlet and outlet runs.

A 4...20 mA current output signal must control the adjustment valve of a superimposed system to regulate the desired nitrogen flow.

## 3. KROHNE solution

To measure the nitrogen, KROHNE supplied a DN50, H 250 M40 variable area flowmeter with flange connections.

This measuring device features a local, analogue display that requires no power supply. It also has a 4...20 mA current output with 2-wire connection technology to control the adjustment valve. The 1.6% measuring inaccuracy is absolutely adequate for this measurement task. The modular design of the H 250 M40 allows for simple combination of a mechanical measuring device with highly developed digital electronics, as in this application.



Nitrogen measurement for dosing

## 4. Customer benefits

When it comes to measuring clean products at low flow volumes, variable area flowmeters are the most widely used measuring principle for liquids and gases.

Other measuring principles usually require a minimum density and/or minimum flow velocity whereas variable area flowmeters are specifically designed for the measurement of low gas flows with simultaneously low operating pressure. Other advantages include the low investment and follow-up costs as well as the insignificantly short inlet and outlet runs for installation.



Closer look at local display

## 5. Product used

### H 250 M40 Variable area flowmeter

- Sturdy construction for high pressure, temperature and media resistance
- Wide range of variants from extremely small flowmeters for a few litres per hour up to DN 100 measuring devices for 120 m<sup>3</sup>/h liquid or 2800 Nm<sup>3</sup>/h gas flow
- Many process connection variants: flanged, screwed, clamped, weld-on ends etc.
- Space-saving installation due to short inlet and outlet runs
- Universal Ex concept: Ex i and Ex d
- Local analogue display, operation without power supply or via 2-wire connection with LCD display, also with digital counter as well as current and binary outputs
- Unique and modular conception: from pure mechanics up to analogue output or fieldbus communication
- Measuring inaccuracy 1.6% of measured value according to VDI / VDE 3513, Bl. 2 (qG = 50%)



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## APPLICATION NOTE Oil & Gas

### Measuring seal gas at gas seals in turbo compressors

- Equipping seal gas panels for natural gas compressors
- Variable area flow measurement in accordance with the high safety requirements of IECEx-i
- Metering devices connected to a distributed control system (DCS) via FOUNDATION™ fieldbus

#### 1. Background

For a natural gas transportation project in Queensland, Australia, a leading international supplier of infrastructure solutions manufactures compressors for the compressor stations. The compressors are designed to concentrate natural gas under pressure so that it can be transported. The manufacturer produces turn-key systems for this purpose, fits them with gas seals and equips the compressors with seal gas systems to seal the shafts.



Signal converter of the H250 M40

#### 2. Measurement requirements

The function of the mechanical gas seals is to prevent the flammable natural gas from leaking out and to protect the compressors, which operate under significant pressures and high temperatures. Due to axial movement, the seals are subject to a high degree of wear and can fail, so they are equipped with seal gas systems. These systems flush the seals with nitrogen to generate counterpressure. The objective of the measurement is to determine the amount of nitrogen used (3.0 to 30 kg / 6,6 to 66 lbs per hour) in order to ensure a continuous gas flow over the seals and monitor the amount of leakage.

In order to supply the compressors, the infrastructure specialist needs reliable flow measurement units to assemble such a seal gas system. Because ATEX approvals are no longer accepted in Australia, it was an absolute requirement that the devices be certified in accordance with IECEx-i. Moreover, it was required that all of the information can be transferred to a DCS via FOUNDATION™ fieldbus communication.

## 3. KROHNE solution

KROHNE manufactured over 300 units of the H250 M40 variable area flowmeter with a stainless steel cone, mechanical local display and a FOUNDATION™ fieldbus interface for the compressor manufacturer. The instruments have the required, intrinsically safe design in accordance with IECEx-i and the FISCO model. They were supplied with NPT process connection.

The customer performed the final assembly of the metering skids. The units were mounted onto a seal gas panel on a large frame next to the compressor. The H250 M40 devices measure the flow rate of the seal gas. The measuring results for the nitrogen can be transferred via 2-wire bus line in accordance with the FOUNDATION™ fieldbus standard. With the H250 M40 devices, KROHNE met the customer's extensive operational requirements, which included providing evidence of pressure tests and carrying out radiographic tests, among others, because many of the devices were supplied in the high pressure version.



Variable area flowmeters mounted on gas panels

## 4. Customer benefits

By equipping the seal gas panels with the H250 M40, the compressor specialist met a significant requirement for supplying his customer. This continuous nitrogen flow measurement enables leaks and defective seals to be recognized quickly. In this way, damage to the compressors can be prevented as early as possible.

Because the measuring instruments were supplied with screw process connections, the assembly time was shortened significantly and allowed a flexible, space-saving installation of the devices, in contrast to flange connections. The FOUNDATION™ fieldbus version design enabled direct integration into the end customer's communication network without additional power supply or converters.



Nitrogen flow measurement with the H250 M40

## 5. Product used

### H250 M40 Variable area flowmeter

- Sturdy construction for high pressure, temperature and media resistance
- Wide range of variants from extremely small flowmeters for a few litres or gallons per hour up to DN 100 / 4" measuring devices for 120 m<sup>3</sup>/h / 32,000 GPH liquid or 2800 Nm<sup>3</sup>/h / 100,000 SCFH gas flow
- Many process connection variants: flanged, screwed, clamped, weld-on ends etc.
- Universal Ex concept: Ex i or Ex d
- Unique and modular conception: from pure mechanics up to analogue output or fieldbus communication
- Measuring inaccuracy: 1.6% of measured value according to VDI / VDE 3513, sheet 2 (qG = 50%)



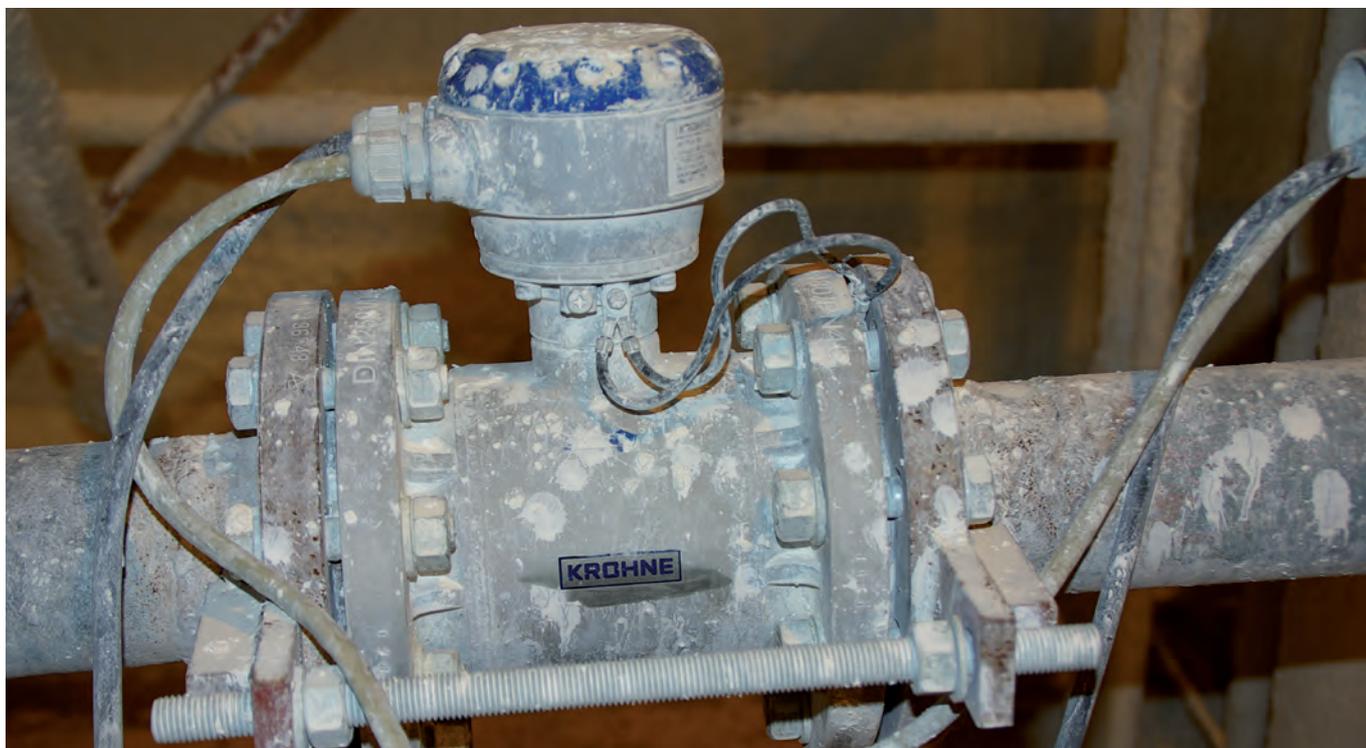
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## APPLICATION REPORT Minerals & Mining

### Flow Measurement of Highly Abrasive Mediums in the Production of Magnesium Oxide



- Highly abrasive magnesium hydroxide slurry with a 53% solids content
- Extended lifetime with extremely robust flowmeter, liner and electrodes
- Cost savings due to less maintenance and increased uptime of operation

#### 1. Background

In the north of The Netherlands lies a unique formation of magnesium salt of unequalled purity at two kilometres below the surface. NEDMAG Industries Mining and Manufacturing B.V. extracts approximately half a million tonnes of magnesium salts each year. Close by, almost on top of these salt formations, the dead burned magnesia plant of NEDMAG Industries is located. NEDMAG is the leading producer of high-purity synthetic dead burned magnesia in Europe and sells high-purity synthetic dead-burned magnesia, magnesium chloride and calcium chloride, both in solution and solid form. Refractories are the main application in which Dead Burned Magnesium oxide (DBM), Nedmag's main core product, is used.



#### 2. Measurement requirements

To produce DBM, clarified magnesium chloride, extracted from a depth of 1500 to 2000 meters below the surface, is brought into contact with dolomite. The resulting chemical reaction gives a mixture of calcium chloride and magnesium hydroxide ( $Mg(OH)_2$ ), which is then filtered in a drum to produce a magnesium hydroxide slurry. For an efficient operation NEDMAG Industries requires an accurate flow measurement of the highly abrasive slurry. The magnesium hydroxide slurry has a high solid content of 53% which results in noisy flow signals. So the converter has to be able to deal with noisy indications. The thick and

abrasive magnesium hydroxide slurry does not only require abrasive resistant liners and electrodes, but the materials should also be resistant to chemical corrosion. The medium has a relatively high pH value. Also the construction of the flowmeter should be very robust in order to withstand the demanding corrosive environment in which it operates.

### 3. KROHNE solution

NEDMAG has selected OPTIFLUX 5300 for this operation based on many years of successful application experience with KROHNE flowmeters. Although it concerns a very harsh application, the KROHNE solution concerns a standard DN 80 OPTIFLUX 5000 flow sensor combined with a standard IFC 300 signal converter. The zirconium oxide ( $ZrO_2$ ) liner of OPTIFLUX 5000 is dimensionally stable, almost as hard as diamond, and has an excellent resistance to corrosion and to abrasive media like magnesium hydroxide slurry. A soft rubber or a polyurethane liner is also abrasive resistant but is not chemically compatible. The ceramic liner, combined with cermet electrodes, prevents excessive wear and provides long-term reliability. The low noise electrodes are flush mounted with the internal diameter so no obstructions in the flow leading to less wear and a more stable flow indication. The OPTIFLUX 5000 sensor is available over a diameter range of DN 15 up to DN 300. The all metal fully welded housing construction provides robustness required for the very corrosive environment. Abrasive slurries form a major challenge for flow converters. A high solid content leads to a high electrical noise (spikes). The IFC 300 signal converter has a high field current of 250 mA, inducing a strong signal voltage, and it makes use of intelligent noise filtering techniques. In addition it offers inbuilt diagnostic functions including "electrode noise", "flow profile" and "settling of field" for correct setting of parameters at installation. The OPTIFLUX 5300 gives a stable and accurate measurement over a long run, and also checks its performance during operation thanks to its diagnostic capabilities.

### 4. Customer benefits

- Increased process efficiency based on an excellent reproducibility and accuracy
- Robust solution in a corrosive environment with a fully welded and stainless steel flow sensor construction
- Minimal wear of liners and electrodes resulting in an extended lifetime
- Cost savings due to less maintenance and increased uptime of operation

### 5. Product used

#### OPTIFLUX 5300

- Ceramic flow tube with fused-in-place Cermet or platinum electrodes
- Highly accurate and long term reliability
- Excellent solution for abrasive and corrosive mediums



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## APPLICATION NOTE Minerals & Mining

### Volume Flow Measurement of Abrasive Slurry at a Large Gold and Copper Facility

- Costs savings due to a reduction in production losses and much lower replacement rate of flowmeters
- KROHNE support in selecting appropriate materials and application engineering
- Rugged polyurethane liner offers excellent resistance to wear with highly abrasive slurries

#### 1. Background

A large gold and copper facility in South East Asia uses electromagnetic flowmeters in its hydrocyclone inlet feed lines. Hydrocyclones are used for the classification of particles in slurries. Relatively light particles are removed with the overflow stream by an upward swirling flow through the vortex finder, and heavier particles are removed with an underflow stream by a downward swirling flow. The value of the total gold production throughput, passing through the four hydrocyclone feed lines, is approximately \$3 Million USD per day.

#### 2. Measurement requirements

In each of the four hydrocyclone feed lines an electromagnetic flowmeter is installed. One of the main selection criteria for flowmeters is minimal maintenance with high measurement integrity over a long period of time. Coarse and fine materials cause major abrasive wear. The maintenance costs of the flow control are driven by the costs of replacing a flowmeter. This not only involves the acquisition price of a new meter, but also includes production downtime, manpower, crane time, the flanging and installation of new flowmeters. Secondly, maintenance costs are driven by the frequency of replacements. The use of inappropriate materials can lead to a meter replacement frequency of three to six months per line. At best a six month replacement frequency will cost the facility \$450K USD per line per year in production losses and \$50K USD for the meter replacement per line per year.

### 3. KROHNE solution

Through appropriate material selection and application engineering, KROHNE has been able to reduce the replacement frequency of the electromagnetic flowmeters from every 6 months to 3 years. The flowmeter of choice is an OPTIFLUX 4300 with a polyurethane liner combined with Hastelloy C electrodes. The meter construction and liner provides the necessary toughness and versatility sought by a customer to maximize the instrument life in such a severe application like cyclone feed lines. The rugged polyurethane liner has an excellent abrasion resistance. The flush mounted Hastelloy C electrodes create less obstruction in the flow and therefore are less subject to wear and noise. The electrodes have a carbide coating which is extremely durable for an extended lifetime. The inner diameter of the flowmeter exactly matches the inner diameter of the connected process pipes. With abrasive applications, even the smallest difference in inner diameter can accelerate wear. The last measure taken is the installation of type 3 protection rings on the inlet of the flowmeter to prevent a difference in the inner bore.

The IFC 300 signal converter offers intelligent noise filtering techniques. The integrated process diagnostic functions of the IFC 300 can be used for appropriate parameter setting and provides information on the status of the sensor, the converter and the process.

### 4. Customer benefits

Based on years of experience in the minerals and mining market, KROHNE has given engineering support in selecting the best solution. This has led to a substantial reduction of maintenance costs and increased the uptime for the customer. Smart material selection has allowed for an important extension of the meter lifetime from 6 months to every 3 years. KROHNE has been able to save the facility \$1.5M USD per line every 3 years.

Reliable flow control has an impact on the throughput and efficiencies for mining and minerals processing and can therefore lead to major reductions of production costs. The customer has seen the value of investing in technology that extends the meter lifetime.

### 5. Product used

#### OPTIFLUX 4300

- A rugged polyurethane liner with an excellent abrasion resistance
- Flush mounted Hastelloy C electrodes with carbide coating for less wear, less noise and no obstruction in the flow
- Type 3 protection rings to prevent further difference of inner bore which can accelerate wear



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## APPLICATION NOTE Chemical Industry

### Management of gas burning process in chemical plant

- Measurement of residual gases in process plant
- Continuous ultrasonic measurement of volume flow and caloric value of hydrocarbon gases
- Measuring accuracy independent of gas density

#### 1. Background

Residual hydrocarbon gases arise as a side product from many chemical processes. In many cases these gases are burned in boilers to generate steam. The composition of the residual gases however is not constant and may change from pure hydrogen gas to heavier hydrocarbon gases as a function of the process they evolved from. If there is no residual gas available, natural gas provided from the grid may be used to fire the boiler. Thus, the caloric value of the gas varies strongly and the burner of the boiler has to be adjusted to the changing gas composition so as to guarantee an optimal burning of the gas with minimal emissions.

#### 2. Measurement requirements

In order to optimise the burning process the measurement has to fulfill two requirements. The First requirement is the adjustment of the burner to the gas composition to have an oxygen/fuel ( $\lambda$ ) ratio of 1 to 1.2. Traditionally, this is measured by a  $\lambda$  sensor in the exhaust gas. This measurement however requires maintenance and re-calibration. A better solution is to measure directly the caloric value of the fuel gas. The second requirement is a repeatable gas flow measurement independent of gas properties. This is of particular importance since the density of the gas alters with its changing composition.

## 3. KROHNE solution

Both measurement requirements can be solved with the OPTISONIC 7300. The 2-beam ultrasonic flowmeter provides an accurate measurement of the volume flow of gas independent of the gas density. The special damping technology of its titanium sensors ensures a highly accurate measurement of the ultrasonic transit time which is directly proportional to the velocity of sound. It also entails an integrated molar mass calculation (according to the formula shown at the right). It requires input of the adiabatic index and the temperature. The first is entered via the menu, the second is provided by an external temperature sensor connected to the flowmeter's 4-20 mA input.

The molar mass of a gas can be determined according to the following

$$M = \frac{\gamma R T_{actual}}{V_o S^2}$$

$\gamma$  = adiabatic index, pre-set value into the flow meter electronics  
 $R$  = molar gas constant, approximately 8.3145 J mol<sup>-1</sup> K<sup>-1</sup>.  
 $T_{actual}$  = Gas temperature in Kelvin.  
 $V_o S$  = velocity of sound of the gas to be measured

## 4. Customer benefits

The customer benefits from an optimised burning process. On the basis of highly accurate measuring results, the burner control can be adjusted according to the caloric value of the residual gas composition so as to minimize emissions (e.g. of NOx) and improve energy efficiency.

The customer stands to gain from a maintenance free installation as the OPTISONIC 7300 has no moving parts that would affect the gas flow. Thus, unlike lambda sensors, the OPTISONIC 7300 offers a much better long term stability and repeatability. Besides this, gas properties such as density and pressure don't have an impact on the quality of the measurement. Without any obstructions, there is also no pressure loss influencing the process. It is an additional value that there is no separate flow computer needed as the OPTISONIC 7300 is available as integrated solution.



OPTISONIC 7300 at chemical plant

## 5. Product used

### OPTISONIC 7300 Ultrasonic gas flow meter

- Excellent accuracy and long term stability
- nominal size: DN100...DN600 / 4" ...24"
- High performance over a wide measurement range
- Diagnostics to validate flow meter and process
- Low investment, low operational costs
- Titanium transducers



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# APPLICATION REPORT Oil & Gas

## Flow volume control of natural gas storage

- Gas transport from onshore to offshore platform
- Ultrasonic gas flow measurement for storage and delivery processes
- Accurate alternative to mechanical gas flowmeters



### 1. Background

With the demand for gas growing, the storage capabilities for gas are increasingly playing a vital role to keep a nation's gas supply secure and flexible. In this respect the Castor Underground Gas Storage (UGS) project has been one of the most important investments in the Spanish gas network in recent years. In the city of Vinarós an onshore plant for the treatment and conduction of natural gas ensures that the gas can be effectively transported and finally stored in an depleted offshore oil field.

### 2. Measurement requirements

The storage terminal operator Escal UGS was looking for a cost effective measurement solution to control the flow volume of the natural gas transported from the onshore storage terminal to the offshore platform, i.e the storage pit, and back from the storage to delivery. This required a redundant flowmeter for the delivery of natural gas to the measurement station as well as a site internal flow control of natural gas and a measurement of the natural gas used as fuel for local consumption.

## 3. KROHNE solution

KROHNE delivered 3 units of the OPTISONIC 7300 F. One device was installed in a special configuration as dual universal ultrasonic gas flowmeter with a nominal size of 30"/600 lbs (DN 750) for delivery of gas to the measurement station. The device is capable of measuring a wide flow range of 0...900.000 kg/h. A second flowmeter, 24"/900 lbs (DN 600), was used for flow control in the gas storage process. A third OPTISONIC 7300, 2"/150 lbs (DN 50), was applied for measuring the local consumption of natural gas as fuel gas.

As demanded by the customer, KROHNE delivered the OPTISONIC 7300 F in accordance with special painting procedure specifications.



OPTISONIC 7300 unit for flow control in the gas storage process

## 4. Customer benefits

In using the OPTISONIC 7300 F the storage terminal operator Escal benefits from an optimised volume control of the natural gas storage. The 2 beam ultrasonic flowmeter offers excellent long term stability and repeatability. No moving parts are used and the device doesn't need recalibration and maintenance. The OPTISONIC 7300 allows for a wide measurement range. Instead of customising a regular but more expensive CT ultrasonic flowmeter, KROHNE individually designed the solution according to the non-CT requirements which makes it a very economical device for the customer's natural gas application.



OPTISONIC 7300 unit for measuring the local consumption of natural gas

## 5. Product used

### OPTISONIC 7300 Ultrasonic gas flowmeter

- High accuracy
- Excellent long term stability
- High performance over a wide measurement range
- Diagnostics to validate flowmeter and process
- Low investment, low operational costs



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# APPLICATION REPORT

Chemical

## On-site verification of process flows at catalyst plants

- Analysing errors in flow measurement processes
- Checking unexpected readings of inline flowmeters
- Avoiding process interruption and expensive opening of pipes



### 1. Background

Albemarle, a leading specialty chemical company, develops and produces catalysts for the petrochemical industry at its site in Amsterdam, the Netherlands. The facility comprises three different plants for fluid cracking catalysts (FFC), hydro processing catalysts as well as for isomerization, methyl chloride, methylamine, melamine and oxychlorination catalysts. These catalysts are used for the production of high quality fuels such as gas, petrol, diesel and kerosene from crude oil.

### 2. Measurement requirements

In order to control the flow process of the large variety of liquids, Albemarle uses over 500 inline meters, most of them electromagnetic flowmeters (EMF). Occasionally one of these meters measures an unexpected flow, showing a big deviation in flow rate or even no flow at all. In the past, Albemarle removed those inline flowmeters from the process in order to test their performance and functionality at the onsite repair department. However, as most of the removed inline flowmeters turn out to be fully functional, most of the errors indeed occur at another point in the process chain. Thus, opening the pipes causes an unnecessary and expensive interruption of the process. The customer was therefore looking for an on-site verification instrument to check the flow reading of the inline meters before dismantling.

## 3. KROHNE solution

KROHNE recommended the Ultrasonic clamp-on flowmeter OPTISONIC 6400. The portable ultrasonic device is battery powered and can be fitted on the outside of piping to measure the flow rate of liquids. As most of the pipes at the production site of Albemarle have only a diameter of DN 40 / 1 ½" and DN 50 / 2", the KROHNE device was delivered with small sensors which meet the requirements of the whole application.

The compact evaluation unit measures the flow velocity, the current volume flow and a variety of diagnostic values. The readings are shown on the large colour LCD in a graphical format. The OPTISONIC 6400 stores the readings in the integrated memory for data logging. They can also be transferred via USB stick to a PC for further analysis.



The OPTISONIC 6400 with mobile signal converter attached to a pipeline

## 4. Customer benefits

The portable clamp-on flowmeter is the suitable diagnostic device for Albemarle to speed up repair and save a lot of effort with all costs involved. Before opening any pipe or removing an inline meter, the chemical company can easily check the process flow whenever a vast deviation of the flow rate is indicated by an EMF.

The OPTISONIC 6400 offers a great deal of other advantages to the customer. Albemarle also benefits from the clamp-on flowmeter whenever one of the inline meters is broken and has to be temporarily replaced. The device can be installed within minutes and easily substitute the EMF, thus limiting downtime and avoiding a long term interruption of the process during repair time.

The clamp-on device also proved to be very useful during the extension of the customer's production site. Before a new production process is launched, the engineers of Albemarle test the process with water in order to detect possible leakage. During this test procedure the OPTISONIC 6400 is used to check the water flow and to diagnose whether the installed pumps really achieve the expected capacity, thus also extending the customer's knowledge of the process even before production is started.

## 5. Product used

### OPTISONIC 6400

- Portable, battery powered ultrasonic Clamp-on flowmeter for liquids
- Suitable for a broad range of process conditions
- No process shutdown required for diagnostic on meters
- Quick start-up and ease of installation (installation wizard)
- For tube diameters from DN 15 (1/2") to DN 4000 (160")



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# APPLICATION REPORT

Chemical

## Establishing energy efficiency

- Accurate flow measurement of superheated steam
- Reduction in energy consumption
- Long-term stable and reliable measurement due to integrated meter verification



### 1. Background

The Pont-de-Claix (Isère) chemical plant used to be operated by Rhône-Poulenc but the activities were then divided and sold to different companies in the chemical sector. Today, Solvay is the provider of utilities including electricity, compressed air and superheated steam. The company operates 3 gas turbines with cogeneration. The energy sources are natural gas and hydrogen, a by-product of production. The distribution of these utility fluids supplies each operator in the Pont-de-Claix plant.



Start of the utilities towards the chemical plant

### 2. Measurement requirements

The customer would like to measure superheated steam at a temperature of 275°C, a pressure of 31 barg and a flow rate of 60 T/h. This will serve to establish energy efficiency in the cogeneration facilities. The customer had previously been using a competitor's vortex flowmeter. Customers of the chemical plant were consuming 900,000 tonnes of steam per year. Since making the new investments, this consumption has been reduced to 350,000 tonnes per year as a result of new, more energy efficient process units being constructed to replace the old ones.

This leads to many requirements for the measuring point:

- it must be able to cover a much larger flow range, particularly at low flows;
- it must measure in both directions because in the event of a stoppage of the steam production facilities, an external source for help must use the same pipelines but in the opposite direction;
- the generated pressure loss must be as low as possible to avoid wasting energy.

**KROHNE**

## 3. KROHNE solution

KROHNE supplied an OPTISONIC 8300 ultrasonic flowmeter with a 10" diameter and a 10" ASA 300 lbs connection.

The device was installed at the production outlet towards the units on a horizontal pipeline made of carbon steel. The required straight inlet/outlet runs were observed to ensure optimal accuracy. The customer insulated the entire installation.

Featuring an integrated mass flow calculation and a direct input for pressure and temperature measurement, the OPTISONIC 8300 is able to provide measurements in t/h (mass flow).



OPTISONIC 8300 ultrasonic flowmeter

Start-up was planned in conjunction with KROHNE customer service. For production reasons, steam supply started one week early, the device was operational immediately.

## 4. Customer benefits

The OPTISONIC 8300 flowmeter meets the customer's requirements, namely a large span, bidirectional measurement and no pressure loss. No regular maintenance is required and the self-diagnostics of the meter guarantees smooth continuous functioning of the device.

The OPTISONIC 8300 has become the reference meter for all the other measurements done by vortex flowmeters and orifice plates.

Solvay has reduced its energy consumption linked to the pressure loss of the previous measuring devices, the possible measuring zone has been extended, measuring accuracy has been improved and process safety has been enhanced thanks to the self-diagnostics. KROHNE Customer Service must perform an annual equipment verification with a verification tool in order to submit a report to the service quality department.

## 5. Product used

### OPTISONIC 8300

- Ultrasonic flowmeter for high temperature gas and steam
- Accurate measurement without pressure loss
- No recalibration, no maintenance



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### Radar (FMCW) level measurement

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### Guided radar (TDR) level measurement

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- Interface measurement on a crude oil separator ..... 56
- Level measurement of DOP plasticizer in a tank ..... 58

### Displacer level measurement

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- Level measurement of hydrofluoric acid in a receiver tank ..... 60



## APPLICATION NOTE Chemical

### Level measurement of liquid sulphur in storage tanks

- Reliable, continuous level measurement of low reflective medium
- Maintenance-free solution: no crusting on antenna
- Instruments easy to set up and use

#### 1. Background

Sulphur (S) is a non-metallic element that melts at 119°C. Its dielectric constant ( $\epsilon_r$  value) decreases as temperature increases up to 159°C, and then increases above that value. It has been used since antiquity, often for fumigation, medicine and bleaching cloth; today it is mainly employed in the production of sulphuric acid, fertilizers, insecticides and fungicides.

Liquid sulphur recovered from gas and oil facilities is either pumped to outside blocks, where it solidifies or to storage tanks for direct shipping in liquid form. The storage tanks are heated to maintain the temperature and hence avoid solidification.

#### 2. Measurement requirements

A chemical plant in Morocco produces fertilizers made from liquid sulphur. The sulphur is stored in 23 tanks, each 18 m high and fitted with heating jackets. These jackets use hot steam to keep the temperature of the sulphur stable at 130°C and to avoid crusting and solidification.

The plant uses air bubbling level transmitters and differential pressure systems to measure the product stored in these tanks. The operation of the air bubbling transmitters not only consumes a lot of gas, but also requires periodic checks of the air generating pumps. The differential pressure systems (Delta P) need frequent cleaning of the upper sensor due to crystallization and regular recalibration of the lower sensor which detunes after a while.

Thus, the plant was looking for a reliable and low-maintenance solution, which is also easy to install and user-friendly. It had to be able to accurately measure low  $\epsilon_r$  values of hot, moving liquids continuously in high tanks and comply with hazardous requirements.

## 3. KROHNE solution

For this application KROHNE provided 23 OPTIWAVE 7300 C non-contact Radar (FMCW) Level Meters with

- DN 150 PN16 flanges
- DN 80 horn antenna
- Antenna heating system using steam

## 4. Customer benefits

Using FMCW radar technology, the meters continuously measure over a wide dynamic range. That is why neither the low reflective medium, nor the tank height or the moving surface during the filling and emptying of the tanks can affect the measurement.

The antenna heating system is directly connected to the hot steam circuit available on site. No other installation steps are necessary. It not only minimizes condensation of sulphur vapours on the horn antenna but also prevents it from crusting as liquid sulphur tends to solidify at temperatures below 120°C. Climbing to the top of the tanks for periodic cleaning or recalibration is no longer necessary: the non-contact radar device does not require any maintenance. Being a 2-wire device, the installation of the meter needs less wiring and configuration is very simple due to the wizard driven setup. A large LCD display with 4-button keypad makes operation easy without opening the housing. Hence, the requirements of the customer in terms of reliability and easy installation are fully met.

This, and the fact that radar technology has no gas consumption at all, significantly reduces the expense and, including the competitive price of the OPTIWAVE 7300 C, makes it a very cost-effective solution for the customer.

## 5. Product used

### OPTIWAVE 7300 C

- Non-contact Radar (FMCW) Level Meter for liquids and pastes
- 2-wire loop powered for minimal wiring expense
- Maintenance-free
- Reliable measurement:  $\pm 3$  mm accuracy up to 10 m and  $\pm 1$  mm repeatability, even in tanks with agitated surfaces or internal objects
- Operates up to a process connection temperature of 200°C
- Measuring range up to 80 m
- Dielectric constant ( $\epsilon_r$  value)  $\geq 1.5$
- PACTware and DTM for commissioning are supplied free of charge
- FMCW technology: excellent value for money
- Ex approved for use in hazardous areas
- Optional antenna heating systems
- Wizard-driven setup

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OPTIWAVE 7300 C with special antenna heating system



DN 80 antenna with heating system



G 3/8 connections for heating system





## APPLICATION NOTE

Chemical

### Level measurement of toxic and combustible acid water

- Storing waste products from nitrobenzene production in storage tanks
- FMCW radar measurement of acid water with organic substances
- Overfill protection in an ATEX Zone 2 environment

#### 1. Background

An international supplier of organic chemicals produces raw materials such as aniline and various hexylamines at one of their sites in the Czech republic. The base chemicals are mainly sold to the rubber, pharmaceutical, agriculture or beverage industries.

As an essential precursor to their aniline production, the specialist chemical company uses nitrobenzene. This organic compound is basically produced through nitration of benzene with acids and water. The production process basically leaves acid water which, however, still contains a residual amount of highly toxic and combustible nitrobenzene. In order to protect the environment these liquid waste products have to be fed into a chemical wastewater treatment plant afterwards. Before the acid water gets cleaned, it is stored in several storage tanks (up to 6 m / 19.7 ft high) at atmospheric pressure.

#### 2. Measurement requirements

Given that even a small amount of nitrobenzene in the acid water causes an explosive environment in the tanks, the level of the 50° C / 122° F warm liquid waste needs to be controlled on a regular basis. Whenever it exceeds a certain maximum level, an alarm is triggered to avoid overflowing and severe damage. The customer previously used devices from an older generation of radar level gauge. However, as they had reached a certain age, the customer was interested in replacing them with newer technology'. Therefore, the customer decided to gradually modernize the storage tanks with state-of-the-art level meters that also fulfill ATEX Zone 2 requirements for hazardous areas. When it came to replacing the first device, the customer was very keen to keep the original wiring for data acquisition to save installation costs.

### 3. KROHNE solution

For this application, KROHNE delivered an OPTIWAVE 5200 C. The non-contact, 2-wire FMCW radar level meter was fitted on the atmospheric tank with a DN 50 / 2" flange connection. The total length is 496 mm / 19.5". Given the long nozzle of the tank, the Wave Horn antenna features a 200 mm / 8" extension. The device was very easy and fast to commission via the local display.

As the device must be suitable for use in the potentially explosive atmospheres caused by the flammable substances in the tanks, an Ex d ia-approved version was provided. The antenna is made of gasket-free PTFE which makes the level meter particularly well suited for measuring the level of corrosive acid water in the tanks. Given the outdoor nature of this application, a weather protection for the device was also mounted.



OPTIWAVE 5200 Ex d ia mounted on tank nozzle

### 4. Customer benefits

The chemical company is benefiting from the reliable and stable measuring values of the KROHNE level device. Whenever the acid water exceeds a given level in the tank the OPTIWAVE 5200 triggers an alarm by transmitting the measured value via 4...20 mA current output to a control room. In doing so, the OPTIWAVE 5200 enables the customer to shut down the process immediately so as to prevent the tank from overflowing. Thus, a very high level of safety for the whole plant can be maintained. The level meter could also be used in a Safety Instrumented System (SIS) as it fulfills SIL2 requirements.

The KROHNE level meter also turned out to be very cost-effective for the customer. No costly process interruptions were necessary during the installation of the device, given the fact that the OPTIWAVE 5200 can be easily commissioned via display and without any special settings or new wiring for data acquisition.

The specialist chemical company is very satisfied with the reliability of the KROHNE level meter and is planning to systematically replace all of the old level gauges with the OPTIWAVE 5200.

### 5. Product used

#### OPTIWAVE 5200 C

- 2-wire / 10 GHz Radar (FMCW) level meter for liquids, pastes and slurries
- Modular housing and antenna design
- Quick coupling system permits removal of the converter under process conditions
- Backwards compatible with all BM70x level meters
- Measuring range: up to 30 m / 98.4 ft
- PACTware™ and DTM provided free of charge and with full functionality
- Remote converter: up to 100 m / 328 ft away from the antenna
- Display text in 9 languages (incl. Russian and Chinese)
- SIL2-compliant according to IEC 61508 for safety-related systems



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## APPLICATION NOTE Water & Wastewater

### Level measurement of lime in a wastewater treatment plant

- Automated stock management of fine powders in a high and narrow silo
- 80 GHz radar (FMCW) for accurate, continuous monitoring of lime consumption
- Optimized supply inventory

#### 1. Background

An industrial wastewater treatment plant in France uses lime to adjust pH and alkalinity in coagulation, flocculation and biological treatment processes. The lime is stored in a conical, tall and narrow silo with a height of 12 m / 39.37 ft and a diameter of 3 m / 9.84 ft.

#### 2. Measurement requirements

The silo level must be continuously monitored in order to ensure the uninterrupted supply of lime for the different treatment processes. Former measuring devices were struggling with the uneven product surface, dust and build-up of this low-reflective medium ( $\epsilon_r$  value: 1.6). Hence, the customer was looking for a more reliable measurement solution and was looking to automate his stock management at the same time.



Wastewater treatment plant

## 3. KROHNE solution

KROHNE proposed the OPTIWAVE 6500 C. The 80 GHz Radar (FMCW) level transmitter for powders and dusty atmosphere was installed with DN100 flange and a flush-mounted DN70 / 2.75" PEEK Lens antenna. Fitted on top of the fibreglass nozzle (230 mm / 9" high) of the silo, it continuously measures the level of lime and transmits the values to the DCS in a control room.

Thanks to the small beam angle of the Lens antenna, this powerful device handles the high and narrow silo even in the presence of internal obstructions.



Flush-mounted Lens antenna



OPTIWAVE 6500 C installed on top of the lime silo

## 4. Customer benefits

The customer benefits from an optimized supply inventory of the plant. The OPTIWAVE 6500 provides accurate continuous level measurement of lime regardless of the dusty atmosphere, uneven product surface or low dielectric constant. The specific algorithms and high signal dynamics of the 80 GHz device are key to providing reliable readings despite these challenging conditions.

As an additional benefit, the level transmitter enables trouble-free installation, commissioning and operation, all of which results in a fast return on investment altogether. The Lens antenna is flush-mounted, meaning there is no intrusion into the tank. This way, the radar device considerably reduces the risk of build-up and keeps maintenance costs to a minimum.

## 5. Product used

### OPTIWAVE 6500 C

- 2-wire 80 GHz non-contact FMCW radar level transmitter for powders and dusty atmospheres
- High dynamics for clear vision despite dusty conditions or low reflective media
- Flush-mounted PEEK Lens antenna with small beam angle (no tank intrusion)
- Unaffected by angle of repose – no need for antenna aiming kits
- Purging system for flange connection without antenna extension
- 112 mm; 4.4" antenna extension for long nozzles
- Extensive choice of process connections: threaded  $\geq 1\frac{1}{2}$ " and flange  $\geq DN50 / 2$ "
- Measuring distances up to 100 m / 328 ft
- $\pm 2$  mm;  $\pm 0.08$ " accuracy
- Process conditions up to  $+150$  °C /  $+302$  °F, 40 barg / 580 psig
- Quick setup assistant for easy commissioning
- Empty tank spectrum function that eliminates false reflections
- Large backlit LCD display with 4-button keypad and text displayed in 12 languages
- Free PACTware™ DTM with full functionality



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## APPLICATION NOTE Chemical Industry

### Level measurement in spherical chlorine storage tanks

- Level measurement as part of overfill protection in accordance with WHG [Wasserhaushaltsgesetz]
- Observance of maximum permissible filling height in chlorine tanks
- Improved tank management thanks to continuous, non-contact measurement

#### 1. Background

One of the world's largest raw material suppliers in the chemical industry operates 60 production facilities around the world. At one of the facilities in Germany, chlorine is produced and then stored in spherical storage tanks before it is further transported. Chlorine is an aggressive substance which is hazardous to water. Hence, in Germany its storage is subject to the Wasserhaushaltsgesetz (WHG), a German law which relates to the use and protection of water.

#### 2. Measurement requirements

Due to technical specifications, the spherical chlorine storage tanks may only be filled to a certain height. Typically, the level in spherical tanks is monitored using vibration fork level switches mounted on the roof and featuring ATEX approval. As the maximum permissible level in this case is a few meters below the level of the roof of the tanks, it is possible to monitor with vibration fork level switches but there is no ATEX approval available for this length of vibration fork. That is why the operator was looking for an alternative solution.

### 3. KROHNE solution

One OPTIWAVE 7300 radar level meter was installed on each spherical tank. The devices are fitted with stainless steel horn antennas and were mounted to the existing flange connectors. They provide non-contact measurement of the chlorine level via FMCW radar pulses. The OPTIWAVE 7300 features both ATEX and WHG approval and can thus be used as part of the overflow protection according to WHG.



The spherical chlorine storage tanks may only be filled up to a predetermined height

### 4. Customer benefits

The operator now has continuous level measurement for the entire height of the tank. It does not only detect the maximum permissible level once it has been reached but instead can redirect the supply of chlorine to another tank in time or draw out of the full tank. Tank management at the facility has been significantly improved thanks to the new solution.



On the roof of the spherical tank: OPTIWAVE 7300 installed on the existing flange connectors

### 5. Product used

#### OPTIWAVE 7300 C

- Non-contact radar level meter for liquids and pastes
- 2-wire FMCW 24...26 GHz radar
- Optionally available as 4-wire design
- Continuous, non-contact level measurement
- Pre-configured ex-works
- Simple start-up thanks to installation wizard
- Different antennas for measuring ranges up to 80 m
- Maintenance-free



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## APPLICATION NOTE Chemical

### Level measurement of ferrous chloride and hydrochloric acid

- Automated inventory management of highly corrosive liquids
- Remote control of cylindrical tanks using TDR technology
- Application parameters requiring wetted parts made of Hastelloy and PVDF

#### 1. Background

A chemical company operates a production site for ferrous chloride ( $\text{FeCl}_2$ ) and hydrochloric acid (HCl). These derivatives are mainly produced through electrolysis and are then delivered to the paper, mining or waste water industry. Hydrochloric acid, a clear, colorless and highly pungent solution, and ferrous chloride, a yellow-brown liquid, are both very corrosive. In order to store them, the chemical company uses cylindrical tanks (approx. 1700 mm / 5.5 ft in height) made of acid- and chloride-resistant materials.

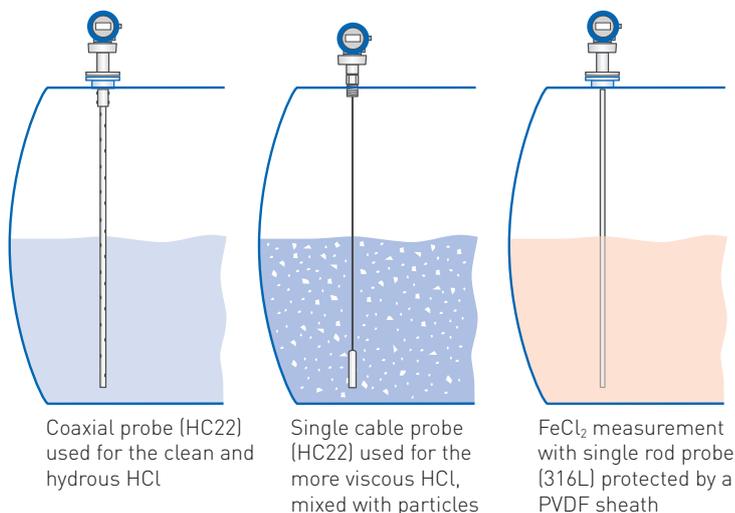
#### 2. Measurement requirements

The company recently started implementing an automated inventory system. Hence, the customer was aiming for remote monitoring in order to replace the manual stock control. Being highly corrosive substances, HCl and  $\text{FeCl}_2$  must be handled with great care. Overfill protection is therefore a safety issue for the customer.

Depending on the ultimate use for these chemicals, the product quality can vary significantly with some of them being clean and hydrous whilst others are more viscous and contain particles. These parameters had to be taken into account when the company started searching for a technical solution to measure the level in the tanks.

## 3. KROHNE solution

The chemical company found the OPTIFLEX 2200 C to be the right meter to master level measurement of HCl and FeCl<sub>2</sub>. KROHNE supplied 3 units of the 2-wire guided radar (TDR) level meter which were installed with horizontal housing position on top of the cylindrical tanks. For the first tank containing hydrous and clean HCl, an OPTIFLEX 2200 C with a 1600 mm / 5.25 ft coaxial probe made of resistant Hastelloy C22 was used. This probe fits well with the parameters of the medium and allows for level measurement with close to no dead zone. For the process connection a DN 50 / 2" flange made of Hastelloy C22 was selected. The tank holding the more viscous HCl, a comparatively unclean and thick liquid, required a single cable probe (1600 mm / 5.25 ft) also made of Hastelloy C22. Unlike coaxial probes that would face issues with the particles in the HCl, the single cable probe ensures stable level measurement in this application. It was chosen with a G½ threaded connection made of Hastelloy C22. The FeCl<sub>2</sub> tank was equipped with a 316L single rod probe protected by a PVDF (Polyvinylidene fluoride) sheath which also covers the DN 50 / 2" flange connection. All devices were fitted with Kalrez gaskets to withstand the aggressive liquids. The readings of the OPTIFLEX 2200 C are transferred to a control room.



## 4. Customer benefits

The customer is now able to remotely monitor the liquids stored in the 3 tanks. The OPTIFLEX 2200 C provide all necessary data for reliable stock inventory of the chemicals. They ensure the tanks never run dry, preventing process interruptions due to uncoordinated stocking procedures. The KROHNE device also helps the company keep filling processes under control. Overfilling is no longer an issue as the OPTIFLEX 2200 C triggers an alarm when a certain limit is exceeded. This way, the customer not only improves its processes but also makes sure that the safety of the plant and its employees is sustained. The chemical company also benefitted from the experience KROHNE offers in level measurement. By advising the customer on the best adapted construction material and probes, the requirements of this application were met fully.

## 5. Product used

### OPTIFLEX 2200 C/F

- 2-wire loop-powered HART® TDR level meter for liquids and solids
- Horizontal and vertical housing position to suit every installation
- The remote converter can be installed up to 100 m / 328 ft from the probe
- Measuring range up to 40 m / 131 ft
- SIL2-compliant according to IEC 61508 for safety-related systems
- ±3 mm / ±0.12" standard accuracy
- Up to a flange temperature of 200 °C / 390 °F and 40 bar / 580 psig



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## APPLICATION NOTE Oil & Gas

### Interface measurement on a crude oil separator

- Oil recovery from water and other components
- Measurement of the water interface level during separation process
- Continuous measuring results for the stock management

#### 1. Background

Crude oil (petroleum) is a naturally occurring, flammable mixture of hydrocarbons and other liquid organic compounds. It is recovered mostly through oil drilling, before being refined. One of the first steps is to separate the hydrocarbons from the water and other unwanted components coproduced during the oil recovery. This is done by separating vessels (separators).

#### 2. Measurement requirements

A European refinery offering storage and handling of petroleum products has a separator, 4.6 m high. Its water interface level needs to be continuously regulated to avoid water entering the oil skimmer or oil entering the water evacuation. Previously, this level was calculated approximately, based on the difference between the quantity of crude injected and the quantity of water extracted. From time to time, this calculation was checked manually using a gauge rod partly covered in “water finding paste”. In order to optimize their process and stock management, the refinery was looking for a level meter, able to deliver reliable and accurate measurements directly to the control room. The device was to be easy to install and use so as to keep service low. It was an essential requirement of the technical solution to be ATEX approved.

## 3. KROHNE solution

KROHNE delivered an OPTIFLEX 1300 C TDR guided radar level meter with ATEX Ex ia approval, a Ø 2 mm single cable probe and a G½ process connection to which the customer added his own flange.

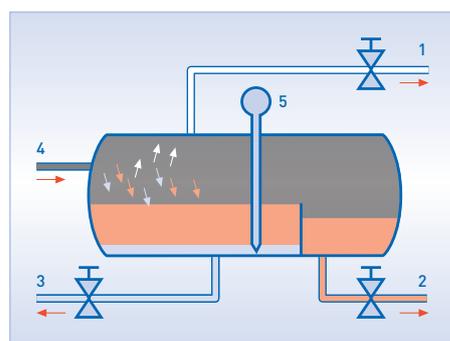
Installed on the roof of the separator, the device is capable of detecting the water interface below the oil layer. It continuously measures the water interface level and automatically transmits the data to the control room.



The OPTIFLEX 1300 C measuring on top of the separator

## 4. Customer benefits

The demanding measurement requirements of this application were fully met with only one TDR level meter. The device is capable of detecting the water interface below the oil layer with great accuracy and reliability. This enables the customer to maintain the water level as low as possible. The measured data are automatically and continuously transmitted to the control room via HART communication, enabling for optimized process and stock inventory. Manual checks become obsolete. Being a 2-wire device, the OPTIFLEX 1300 C needs less wiring than 4-wire transmitters. It is easy to install and operate, and requires only little maintenance. All this makes it a money saving solution for the customer.



1 Gas, 2 Oil, 3 Water, 4 Crude (Oil/Gas/Water/Sediments), 5 OPTIFLEX 1300 C

## 5. Product used

### OPTIFLEX 1300 C

- Universal level meter, 2-wire guided radar for liquids, pastes, granulates, powder and liquid interface
- High signal dynamics and sharper pulses for improved accuracy
- Displays level and interface
- Touch screen for simple operation without opening the housing
- Simple installation, no on-site calibration required
- Probes available in stainless steel and Hastelloy C-22, other materials on request
- PACTware and DTMs available fully functional and free of charge
- Optional process safety (with Metaglas dual process sealing system for dangerous products)



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# APPLICATION REPORT

Chemical

## Level measurement of DOP plasticizer in a tank

- Storing organic raw material for delivery purposes in supply tanks
- Monitoring the volume of an agitated medium with Guided Radar (TDR) technology
- Installation in a high temperature (HT) environment of an ATEX Zone 2



### 1. Background

The Czech chemical company DEZA a. s. produces various raw materials for the construction and automotive industry. One of these organic compounds is dioctyl phthalate (DOP), a softening agent (plasticizer) widely used in the production of imitation leather or mould plastic.

In order to ensure the highest possible quality of the plasticizer, the raw material is always separated from its secondary components first and then filled into a tank for delivery purposes. As a back-up for that tank, DEZA uses various supply tanks. If these tanks run empty, the whole delivery process comes to a standstill. Therefore, it is important for DEZA to monitor the volume in the tanks.

### 2. Measurement requirements

Over the past three years DEZA has tried to master this application using a radar sensor from a competitor. However, this level meter was unable to produce stable and reliable measuring values. It was particularly sensitive to disturbances in the pre-installed stilling well. For this reason the customer decided to test an alternative measuring principle in one of its supply tanks. This instrument was to fit well into the existing infrastructure of the stilling well and had to be able to meet the challenging measurement environment of the application, particularly the agitator at the bottom of the supply tank.

Given that the DOP plasticizer is easily flammable, DEZA also required the level meter to be ATEX Ex d-approved.

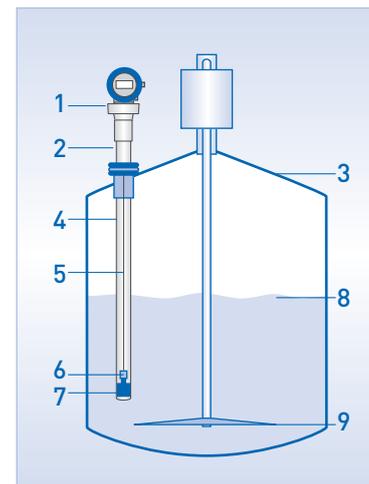
<b>Medium:</b>	Dioctyl phthalate (DOP)
<b>Range:</b>	
(Level)	0.8...3.8 m / 2.6...12.5 ft
(Volume)	0...23 m <sup>3</sup> / 0...812 ft <sup>3</sup>
<b>Temperature:</b>	160...180°C / 320...356°F
<b>Tmax:</b>	200°C / 392°F
<b>Pressure:</b>	0.5 barg / 7.2 psig



## 3. KROHNE solution

All requirements of this application were met by the Guided Radar (TDR) level meter OPTIFLEX 2200. The device was delivered as a high temperature (HT) version and fitted on the tank roof with a flange connection. The housing of the OPTIFLEX 2200 was mounted horizontally to make the display screen easier to read. The Ø2 mm / 0.08" single cable probe of the level meter was installed into the existing 4.05 m / 13.3 ft long stilling well (Ø 36 mm / 1.4"). The cable probe of the OPTIFLEX 2200 has a counterweight with a stainless steel centering piece screwed into it. There was approx. 0.5 m / 1.6 ft of space underneath the stilling well leaving some clearance for the agitator.

The TDR (Time Domain Reflectometry) technology of the OPTIFLEX 2200 allows the device to measure level independently of physical property variations such as pressure changes. The measuring values are transmitted via a current output (4...20 mA) to a control room, where the DOP stored in the tank is permanently monitored.



1. OPTIFLEX 2200 C 2. HT extension  
3. Tank 4. Stilling well 5. Cable probe  
6. Counterweight 7. Centering piece  
8. Level of medium 9. Agitator

## 4. Customer benefits

With the help of the OPTIFLEX 2200 DEZA can continuously monitor the level and volume in the supply tank. The stable and relevant values provided by the level meter ensure the customer is always aware of the amount of DOP that can still be filled into the final tank. This enables the company to avoid delivery issues.

Unlike the competitor devices, the KROHNE level meter with its integrated DPR algorithm is able to eliminate dynamically false reflections caused by environmental disturbances. Therefore, it was not needed to rebuild the tank, despite obstacles such as the agitator. The Guided Radar (TDR) fits best with the pre-installed stilling well environment. Commissioning and installing the device was a simple process. It was not necessary to empty the tank. Only the length of the probe had to be adapted and a quick configuration was carried out using PACTware™.

DEZA is very satisfied with the performance of the OPTIFLEX 2200. Having already had positive experiences with other KROHNE meters, the customer once again benefitted from the technical support of the local KROHNE sales engineers.

## 5. Product used

### OPTIFLEX 2200 C

- 2-wire loop-powered HART® TDR level meter for liquids and solids
- Horizontal and vertical housing position to suit every installation
- The remote converter can be installed up to 100 m / 328 ft from the probe
- DPR (Dynamic Parasite Rejection) to eliminate false reflections caused by environmental disturbances and product build-up
- Measuring range up to 40 m / 131 ft
- SIL2-compliant according to IEC 61508 for safety-related systems



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## APPLICATION REPORT Chemical

### Level measurement of hydrofluoric acid in a receiver tank

- Storage of extremely caustic medium for manufacturing CFC substitutes
- Simple mechanical level monitoring to protect against emptying and overflowing
- High process stability thanks to closed, seal-free design of measuring device



#### 1. Background

Solvay Fluor GmbH, a subsidiary of the international chemical manufacturer Solvay, produces specialist fluorine products at its site in Frankfurt. Fluorine compounds are used in refrigeration technology in particular, where they are replacing chlorofluorocarbons (CFCs). Hydrofluoric acid is a major raw material used in the manufacture of refrigerants.

#### 2. Measurement requirements

The toxic and highly caustic acid is pumped from a receiver tank to the refrigerant production plant. The receiver is fitted with a level control to ensure a continuous feed of hydrofluoric acid to the production plant.

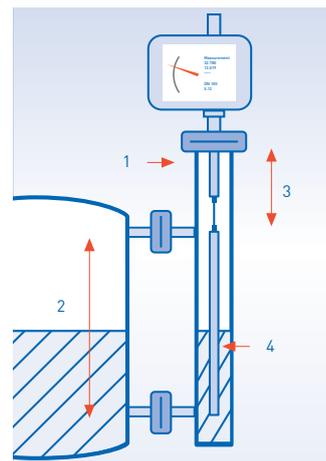
Medium:	Hydrofluoric acid
Density:	970 kg/m <sup>3</sup> / 8.09 lb/gal (US)
Temperature:	+20...+25 °C / +68...+77°F
Pressure:	0.6 barg / 8.7 psig

In the past Solvay used a displacer level transmitter at this measuring point, however, this was replaced a few years ago by level transmitters with guided radar. But these competitor devices were unable to withstand the aggressiveness of the hydrofluoric acid, which kept diffusing through the gasket of the measuring devices. The failure of the measurement constituted a significant safety risk for the customer. Furthermore, the production process had to be repeatedly interrupted to replace the faulty measuring devices. The recurrent plant downtime incurred high costs on every occasion. Solvay, therefore, decided to revert back to a level transmitter with a closed design.

## 3. KROHNE solution

KROHNE recommended the BW 25, a level transmitter that works according to the mechanical displacement principle. The measuring device was fitted to the receiver tank in a bypass using a flange connection (DN 80) for the measurement. Because of the dissociation behaviour of the hydrofluoric acid and the concentration of the medium, it was decided to use a displacement rod and measuring device spring made of stainless steel (1.4404 / 316L).

The measurement involves immersing the displacement rod (1000 mm / 3.28 ft) attached to a measuring spring in the hydrofluoric acid. It experiences a lift proportional to the mass of the displaced liquid. Every time the weight of the rod changes, the length of the spring also changes. This can then be used to determine the fill level. The linear expansion of the spring is sent to the display via a magnetic coupling. The measured values are then sent to the customer's PMS via the integrated two-wire current output (4...20 mA / HART®).



1 Measuring spring;  
2 Measuring range;  
3 Non-measurement range;  
4 Displacement rod  
(1000 mm / 3.28 ft)

## 4. Customer benefits

The BW 25 level transmitter proved to be the most suitable measuring device for Solvay in this application. As the displacer is a closed measuring solution, featuring a design that does not require any gaskets, the known isolation problems do not occur. It is not technically possible for the hydrofluoric acid to diffuse into the housing. The display housing is separated from the pressurized parts. Cost-intensive plant downtimes caused by faulty measuring devices and repeated installation and removal operations are a thing of the past.

Thanks to the electronic transmission of the measured values, Solvay can reliably monitor the set limit values via a PMS. This prevents the tank from running empty or overflowing and ensures a high level of plant safety. The chemical manufacturer is benefiting from a tried and tested measuring device that KROHNE has continuously developed over decades to the present standard. As the BW 25 is still a suitable device for applications with very aggressive media in particular, it will remain a firm part of the KROHNE product portfolio for level measurement, alongside the non-mechanical measuring devices.

## 5. Product used

### BW 25

- Displacer level transmitter for liquids
- Rugged design for extreme operating conditions
- High resistance to pressure and temperature (up to 400 bar / 5800 psi and +400°C / +752°F)
- Pressure-proof isolation of the measuring and display room
- Possible to measure interfaces
- Displacement rods from 0.3...6 m / 0.98...29.5 ft
- Quick retrofitting of display modules without interrupting the process
- Two-wire, 4...20 mA/HART®



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**KROHNE**

### Analytical measurement

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of a wastewater treatment plant ..... 66
- pH monitoring in alcoholic fermentation ..... 68



# APPLICATION REPORT

Water & Wastewater

## Measurement of free chlorine in a drinking water system

- Adding chlorine to disinfect drinking water from wells
- Monitoring the chlorine content prior to network supply
- Automated disinfection control using a control system

### 1. Background

The Association for Water Supply and Sewage Treatment Geiseltal (ZWAG) operates a water supply network for around 10,000 households in Mücheln, Saalekreis, Germany. The company abstracts the drinking water through regional filtration wells from a surface spring. From there it is pumped into a central high-level tank and then fed into the network as needed. Compared to groundwater from deep wells, spring water has a slightly higher, natural bacteriological makeup and must thus be disinfected. As this application requires an extended disinfecting effect (sustained efficacy) right up to the supply point into the drinking water system, free chlorine is the only permitted disinfectant. Unlike UV and ozone which according to the Drinking Water Ordinance are only permitted for spot disinfections, free chlorine ( $\text{Cl}_2$ ) can kill off the organic material contained in untreated water along the entire transportation route.

### 2. Measurement requirements

To disinfect, the company adds chlorine bleach (sodium hypochlorite) at the outlet of the well at 0.3 mg/l. The upper limit for free  $\text{Cl}_2$  prescribed in the Drinking Water Ordinance is 0.3 mg/l and is not to be exceeded at the supply point. The ZWAG thus depends on reliable chlorine content control downstream from the high-level tank. At the same time the measurement proves a sustained effect after the high-level tank ( $\text{Cl}_2$  content above the lower detection limit of 0.1 mg/l).

The operator had so far measured free chlorine photometrically by way of random checks. This process requires labourious manual sampling. To automate chlorine analysis and the transfer of measurements to a control system in the future, the ZWAG decided to retrofit the existing infrastructure using appropriate measurement technology.

**KROHNE**

## 3. KROHNE solution

The ZWAG decided on the OPTISYS CL 1100, a completely pre-installed measuring system used to determine the amount of free chlorine in the drinking water. It consists of the membrane-free OPTISENS CL 1100 sensor in combination with a MAC 100 converter, a flow controller, valves, a temperature sensor and a pH sensor.

The product to be measured is taken downstream from the high-level tank and transported to the measuring system via a copper bypass line. The OPTISYS CL 1100 takes the measurements and then makes them available via a 4...20 mA output in the ZWAG control system. As samples may not be returned to the drinking water circuit, they are disposed of in a sink behind the measuring circuit. To keep the measuring cell free of deposits such as algae, the measuring system is connected to a flushing circuit. Shock cleaning is carried out using a chlorine bleach solution. In addition, the sensor is automatically cleaned once a week thanks to the self-cleaning function. The customer can use a relay output at any time to control when the cleaning of the sensor takes place.



OPTISYS CL 1100 with measuring and flushing circuit

## 4. Customer benefits

The ZWAG is now in a position to monitor chlorine analysis fully automatically using the control system, significantly reducing manual effort. With the help of the OPTISYS CL 1100 the supplier ensures that a constant average free chlorine content of about 0.1 mg/l is maintained even at the supply point. This allows the customer to guarantee reliable and economic operation of the drinking water system. The legally prescribed limit is observed and/or not exceeded.



Automated transfer of measurements to control system

When operating the OPTISYS CL 1100, the ZWAG also benefits from the standardised user concept of the MAC 100 converter. Since the customer is already using several KROHNE measuring devices, he already knew how to operate the device. There was thus no need for staff training and he could start using the fully operational measuring system immediately.

Should future measurements be required to directly regulate the dosage of free chlorine, use of a chlorine sensor with integrated transmitter technology (SMARTSENS) is also feasible. This sensor communicates directly with the control system without a transmitter.

## 5. Product used

### OPTISYS CL 1100

- Ready-to-operate measuring system for free chlorine, chlorine dioxide and ozone in water applications
- Membrane-free sensor with 2 gold electrodes for long-term stability and easy maintenance
- Optionally available with automatic sensor cleaning (ASR) and pH compensation



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# APPLICATION REPORT

Water & Wastewater

## Measuring ORP in the aeration basin of a wastewater treatment plant

- Determination of the oxidation-reduction potential for controlling the intermittent denitrification
- Replacement of an analogue measuring system with digital 2-wire measuring technology including standardised fieldbus
- Cost reduction and increased operating safety through direct communication between sensor and control system

### 1. Background

The Association for Water Supply and Sewage Treatment Geiseltal (ZWAG), in the Saalekreis district of Saxony-Anhalt, Germany, operates a central wastewater treatment plant which receives municipal wastewater from the administrative region. After the mechanical cleaning process, the wastewater flows through two aeration basins into a combined basin with integrated final treatment. During full biological wastewater treatment, the activated sludge process is applied with simultaneous aerobic sludge stabilisation. The micro-organisms in the activated sludge are exposed to a constant "hunger state", so that almost all usable substances are processed as nourishment. Technically, this works through a discontinuous supply of oxygen in the basin – referred to as intermittent denitrification. Nitrification and denitrification are controlled throughout the lifetime of the bacteria in the activated sludge. The activity of the bacteria is therefore significantly dependent on the oxidation-reduction potential (ORP). This redox potential is one of the most important values in order to correctly adjust the aeration and depletion control of the aeration basin.

### 2. Measurement requirements

The ZWAG has been using an analogue ORP measurement for some time. The measured voltage from the sensor is converted in the transmitter and transferred as a 4...20 mA signal to the control system. Recently, there have been repeated failures at the measuring point as the transmitter was no longer fully functional, which disturbed the communication between the sensor and the transmitter. The customer was therefore faced with the decision either to invest a multi-figure euro sum into an analogue measuring system from the same manufacturer, or to replace the entire measuring point.

## 3. KROHNE solution

The ZWAG decided on the SMARTPAT ORP 1590. The digital 2-wire ORP sensor communicates directly with the control system through the 4...20 mA/HART® signal, without the need for an additional transmitter. This is already integrated in the sensor head. The measured voltage is converted into the 4...20 mA/HART® signal in the sensor and the sensor communicates directly with the SCADA system.

Although SMARTPAT allows off-line calibration in the laboratory – with direct storage of the calibration data in the sensor – the customer can also calibrate the sensor periodically on-site. Therefore, the sensor must not necessarily be removed from the assembly. Through the use of a suitable junction box (see picture right) the sensor can be accessed directly with a HART FSK modem. Thanks to the free of charge KROHNE DTM software, it is possible to communicate with the sensor on a laptop using an FDT frame application like PACTware™. The sensor remains in the current loop and after cleaning is immersed into the redox solution and calibrated. The calibration data is stored directly in the sensor, which is then reinserted into the basin.



SMARTPAT ORP 1590 with integrated transmitter technology



Junction box SJB 200 W

## 4. Customer benefits

SMARTPAT ORP 1590 offers the customer significantly higher operating safety. The compact electronics which are built into the sensor reduce the risk of a measuring point failure, largely because an additional transmitter is no longer required. The signal processing on the low-ohm 4...20 mA/HART® is carried out directly in the sensor. With this new sensor concept, the problems experienced with the classical transmitter have been solved.

The ZWAG has benefited particularly from a much cheaper solution with significantly lower costs for acquisition, installation and ongoing maintenance. On the one hand, the cable connection no longer needs to be protected by an expensive shield to prevent erroneous transmission of the weak voltage signal to the transmitter. On the other hand, the transmitter no longer has to be replaced every few years.

The standardised sensor design allows installation in virtually all assemblies available on the market. In addition, the SMARTPAT technology enables rapid on-site calibration of the sensor without transmitter. Offline calibration is also an option for the customer in the future. With the help of the appropriate SMARTPAT accessories the lifetime of the sensors can be increased under laboratory conditions through cleaning, regeneration and calibration.

## 5. Product used

### SMARTPAT ORP 1590

- Digital ORP sensor for the water and wastewater industry
- 2-wire loop powered sensor with integrated transmitter technology
- Usable for aggressive media with offline calibration function



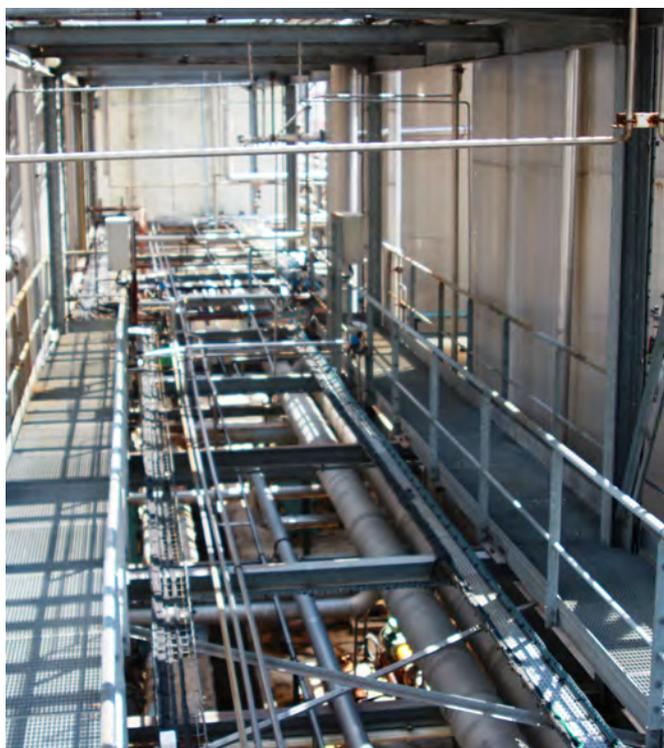
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# APPLICATION REPORT

Food & Beverage

## pH monitoring in alcoholic fermentation

- Distilling traditional alcohols from sugar beet syrups
- Inline pH measurement for process control
- Cost saving installation of sensor with integrated transmitter technology



### 1. Background

Tereos France is a world leading producer of sugar and one of Europe's main manufacturers of starch-based products and alcohols. Among others, the company operates several distilleries of which one is located in Val des Marais, in Northern France, where agricultural raw materials are turned into traditional alcohols.

Prior to the main distillery processes, low-purity syrups with a sugar content of 55...65% are extracted from sugar beet and subsequently transformed into alcohol ("wine") of 5...13 Vol.-% for further processing. The fermentation process is carried out in 7 tanks. For the desired degree of alcohol, these tanks are kept at 32...37 °C / 90...99 °F. This way, the distillery produces about 200m<sup>3</sup> of "wine" per day.

### 2. Measurement requirements

The best fermentation condition is maintained at a pH value of between 2.5 and 4. For this reason it is very important that the pH value of the low-purity syrups in the tanks is monitored on a regular basis. The customer therefore established a pH measurement cycle (7 samples, 1 cleaning; cycle time: approx. 1 hour). Samples taken manually also get checked in a lab every two hours. If the pH value rises above 4.5, sulfuric acid and phosphoric acid (nutrient) have to be added to prevent the growth of bacteria, which can contaminate the alcohol solution. Tereos previously used a pH sensor from an alternative supplier for this application, however the sensor and external transmitter were affected by hydraulic shocks caused by the medium. The liquid entered the transmitter via the cable gland and damaged the device. This interrupted process monitoring which also had an impact on the acid dosage as the dosing pump stopped working. The rise of the pH value could not be prevented effectively and the performance of the dosing pump could not be controlled. Therefore the customer looked for a new solution capable of measuring pH reliably at high pressure conditions of around 5 barg / 72.5 psig.

**KROHNE**

## 3. KROHNE solution

KROHNE offered SMARTPAT PH 2390. The pH sensor was installed directly into the pipe. The rugged sensor design makes this sensor type suitable for this application because of the high pressure resistance of up to 6.9 bar / 100 psi. It can be easily adapted to such harsh applications with alcoholic solutions.

The 2-wire loop powered SMARTPAT PH sensor features integrated transmitter technology. The entire transmitter technology is miniaturised and fits into the sensor head, eliminating the need for an external transmitter. The SMARTPAT PH sensor stores all data and sends these as bidirectional digital signals with 4...20 mA / HART® directly to a PLC that controls the dosing pump.

## 4. Customer benefits

Tereos now benefits from a stable pH value that helps them maintain the best fermentation conditions for their alcohol production. An accurate dosing of nutrients is guaranteed in case the pH value rises above 4.5. The dosing pump no longer stops due to a damaged pH sensor and its performance can now be reliably monitored. The mechanical protection of the sensor prevents product entry and guarantees operational safety.

Given that the SMARTPAT PH 2390 features integrated transmitter technology, the investment costs of the complete measuring loop is significantly reduced in comparison to the previous measuring system that needed a separate transmitter. Maintenance and costs are also reduced because the sensor can be configured and calibrated offline in the laboratory under controlled conditions. Calibration errors and cumbersome sensor handling on-site are no longer an issue. The sensor can be cleaned and regenerated to extend the lifetime.

Tereos stands to gain from the single source supplier KROHNE that does not only provide the sensors but the whole range of professional equipment (e.g. buffer solutions) as well as consulting services.



SMARTPAT PH 2390 installed between a hydrometer (left) and a redundant probe (right)

## 5. Product used

### SMARTPAT PH 2390

- 2-wire loop powered sensor with integrated transmitter technology
- Special sensor design for harsh applications
- Low maintenance cost and long service cycle
- Large PTFE diaphragm for reliable pH measurement
- Double junction for extended life time and a wide application range
- With integrated Pt1000 and standard VP2 connector



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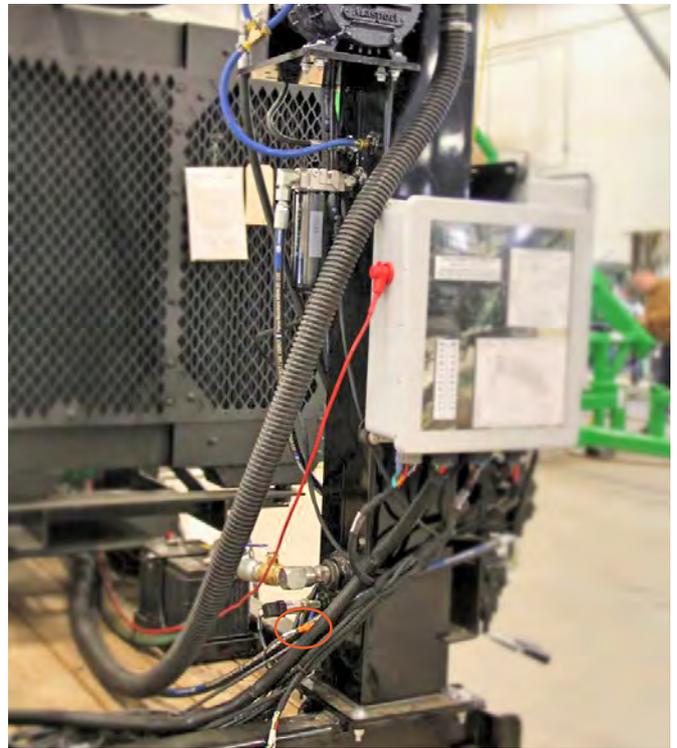
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**Temperature measurement**

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- Measuring the temperature in steam pipelines  
in a chemical plant ..... 76



## APPLICATION REPORT Machinery & Apparatus

### Temperature control of a hydraulic oil reservoir

- Monitoring temperature to maintain smooth operation of a pump cart
- Installation in a tight space using technology with a built-in signal transmitter
- Disturbance-free transmission of output signal to a wireless control system



#### 1. Background

Puck Custom Enterprises, Inc. (PCE), is a leading supplier of nutrient handling solutions. Based in Manning (IA), USA, the family-owned OEM manufactures a full line of drag hose manure application equipment such as pump carts for the farming industry.

These pump skids are used for a variety of processing and cleaning operations in land applications where stationary units cannot be used. The pump units have a capacity of more than 3000 gal (US) per minute (approx. 11,350 l/min) and are equipped with a great deal of measuring instrumentation that helps maintain smooth operation.

#### 2. Measurement requirements

One measuring parameter to be monitored is the temperature in the cart's hydraulic oil reservoir. The reservoir holds all the hydraulic oil for the pump units. If the fluid heats up under constant operation, it starts to become too thin to operate the system. To ensure that the physical properties of the oil are maintained and that the system continues to function properly, it is important that a specified temperature range is not exceeded.

With this in mind, PCE was searching for a new cost-effective way to equip their carts' hydraulic oil reservoirs with temperature instrumentation. As the temperature has to be controlled by the pump operator at all times, the measured value was to be transmitted to PCE's custom wireless pump control system MobileStar.



PCE pump cart



## 3. KROHNE solution

As an existing customer of flow and level technologies, PCE provided KROHNE the opportunity to also advise on temperature assemblies. KROHNE recommended using the OPTITEMP TRA-C30 compact sensor. The sensor features a built-in signal transmitter preconfigured to the desired fixed temperature range in the oil reservoir. Thanks to its customized process connection and compact design it fits easily into the tight space of the reservoir.

The 4...20 mA output of the OPTITEMP TRA-C30 ties directly into PCE's MobileStar control system. Whenever the temperature in the reservoirs exceed a defined temperature threshold, the pump control system instantly issues an alarm so that the operator can take counter steps.



Display of pump control system

## 4. Customer benefits

PCE stands to gain from a reliable compact sensor that ensures smooth operation and integrity of all the pump equipment. As the transmitter of the OPTITEMP TRA-C30 is integrated into the sensor, the sensor's small signal is converted into a standardized output signal which makes it immune to interference. External transmitters or connection heads are eliminated, allowing the sensor to speak with the Mobile-Star system without any wiring. The robust design and reduced housing make the OPTITEMP TRA-C30 also less susceptible to mechanical stress and less prone to accidental damage in the demanding environment of the pump cart's oil reservoir.

With preconfigured temperature ranges, no extra configuration is needed. This way it provides the customer with a ready to use solution. In case the compact sensor has to be replaced one day, maintenance work requires minimal time. The reduced number of parts and compact design cuts installation time significantly.

PCE is very satisfied with the OPTITEMP TRA-C30. The company now considers KROHNE its' main instrument vendor. Given PCE's recent rapid growth, this opens up an opportunity of up to 200 sensors per year.

## 5. Product used

### OPTITEMP TRA-C30

- Compact sensor for measuring gases, liquids and solid matter
- Designed for general applications such as: machine builders, OEM manufacturers, plant engineering
- Operating flawlessly in temperatures from -40 to +85 °C / -40 to +185 °F
- Classed IP67, the sensors are dust tight and can be used in wet outdoor environments
- Short response times (for water  $t_{0,5} = 3.2$  s,  $t_{0,9} = 9.0$  s)
- Accuracy  $\pm 0.15\%$  of the measuring span
- Long-term stability  $\pm 0.1\%$  of span per year



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# APPLICATION REPORT Iron, Steel & Metal

## Temperature monitoring in a continuous casting plant

- Continuous casting guide system with high ambient temperatures
- Continuous control of temperature development of driver motor gear mechanism
- Thermally resistant and stable measuring insert



### 1. Background

The Krupp Mannesmann GmbH (HKM) smeltery operates two continuous casting lines at their Duisburg location for the production of round bar steel to manufacture alloyed boiler tubes, ball bearing steel and other forging goods. The liquid steel is poured from the pan into a distributor and then flows through five or six water-cooled casting dies that form the continuously cast rounds (180 to 406 mm / 7 to 16 in). The steel is conveyed through the casting machine via four or five driver machines per strand.



Cast round steel

### 2. Measurement requirements

Due to the continuously cast rounds, the area surrounding the first three driver machine rows behind the ingot mould in particular is heated up to several hundred degrees Celsius. The motors that power the driver machines must therefore be permanently cooled using fans and a cooling water circuit. It is also necessary to monitor the operating temperature of the expensive gear mechanism to prevent constant overheating (>50-60°C / 122-140° F).

New temperature meters were installed on one of the two casting lines. However, they could not withstand the extreme requirements and had to be replaced several times after only a few short weeks. HKM thus started looking for a stable, reliable temperature measuring solution for the 15 gear mechanisms in the first three motor series.

## 3. KROHNE solution

HKM made the decision to use 15 OPTITEMP TRA-P14 resistance thermometers to monitor the temperature of the gear mechanisms. When it came to contact temperature measurement, Pt100 temperature sensors were inserted approx. 100 mm / 4 in into the gear box via a clamp-compression fitting. The thermometer connection heads are mounted directly on the water-cooled cladding of the motor.

OPTITEMP TRA-P14 connection heads are made of stainless steel. In addition, special heat-resistant gaskets as well as a suitable cable gland were used. The resistance signal is applied in the connection head to a temperature-resistant ceramic clamping socket. A thermal jacket then provides protective insulation for the cable and it is through this that the 4-wire resistance signal is forwarded to a central control room.



OPTITEMP TRA-P14 connection head mounted on water-cooled motor cladding

## 4. Customer benefits

With the KROHNE OPTITEMP units, HKM once again has thermally-resistant thermometers that are constantly stable. They are capable of reliably monitoring the temperature development of the gears, even at high ambient temperatures. This way, the thermometers make a valuable contribution for steel specialists to the timely detection and avoidance of constant overheating and thus destruction of the expensive gearing mechanism on continuous casting. Using the Pt100 sensors prevents prolonged interruption of the production process.



Measuring insert of a Pt100 sensor in the gear mechanism of the drive motor

## 5. Product used

### OPTITEMP TRA-P14

- Insertion-type thermometer with maximum thermal resistance
- Measuring the temperature of gases, liquids, vapours and solid bodies in industrial processes with advanced requirements
- Long-term stable Pt100 RTD in wire-wound or thin film version
- Maximum measuring range: -200...+600°C / -328...1112°F
- Temperature transmitter with analogue and digital output signals



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## APPLICATION NOTE Chemical

### Measuring the temperature in steam pipelines in a chemical plant

- Secure supply using steam as a heating medium
- Continuous monitoring of steam temperature
- Reliable measurement despite high mechanical loads

#### 1. Background

In a chemical plant, process steam is used both to heat processes and as a heat transfer medium. The steam is generated centrally and transported and further distributed to various parts of the plant via large pipelines. To safeguard the processes and productions which depend on the steam, the steam temperature is measured at several points in the network. By measuring the temperature of the steam in the feed and return lines in combination with a flow measurement and a calculator, the energy consumption of a plant component or process can be calculated.

#### 2. Measurement requirements

It is necessary to measure the temperature of the steam in DN 200 pipelines serving as transport lines to plant components. They carry medium pressure steam at 26 bar and 226 °C. The thermometers used must enable quick and accurate temperature measurement at a flow velocity up to 30 m/s in the 100 ... 300 °C range. The pipelines are for the most part completely insulated. At the measuring points, the thermometer neck pipe must be guided through the insulation to the outside. To minimise ongoing costs, the goal is maintenance and fault-free operation.

#### 3. KROHNE solution

In the plant, a total of over 50 weld-in OPTITEMP TRA T30 (Form F) resistance thermometers with OPTITEMP TT 50 C temperature transmitters are used. The transmitter is integrated into the head of the thermometer (head-mount transmitter).

### 4. Customer benefits

Process conditions place high demands on the mechanical strength of the thermometer. OPTITEMP TRA T30 devices guarantee safe and reliable measurement of the steam temperature at the measuring points. To meet accuracy requirements, resistance thermometers were selected instead of thermocouples. Due to the high pressure and the flow velocity, Form F weld-in thermometers were used. This design keeps the risk of thermowell breakage as a result of vibration induced by vortex shedding to a minimum. The steel 1.4571 thermowell material is resistant up to 400 °C under the given conditions of use and welding sleeves for installation in pipelines were included in delivery. The thermometers are particularly sturdy to ensure fault-free operation. Maintenance is not required.



### 5. Product used

**OPTITEMP TRA T30 weld-in thermometer  
with OPTITEMP TT 50 C head-mounted temperature transmitter**

- Specially designed for steam measurements
- Withstands high flow velocities
- Welding covers with particular strength in a variety of materials
- Optionally available with a HART compatible temperature signal converter



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### Pressure measurement

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## APPLICATION REPORT Food & Beverage

### Differential pressure measurement to regulate a vapour compressor

- Heat recovery for the thermal treatment of wort
- Measuring the differential pressure between the vapour chamber and the atmosphere
- Long-term reduction in costs and CO<sub>2</sub> emissions thanks to better automated process steps



#### 1. Background

The König Brewery in Duisburg, Germany, produces the alcohol-free beer König Pilsener Alkoholfrei and the beer-lemonade mix König Pilsener Radler in addition to its namesake, the premium beer König Pilsener. The long-established company stands for both high standards when it comes to product quality as well as the sustainable and cost-saving use of energy sources. To achieve this, the production facilities need to be appropriately designed. The need for heat energy is particularly great when it comes to wort boiling. Generating steam to thermally treat the wort is extremely energy-intensive. In order to sustainably reduce energy costs, the brewery relies on the heat recovery process when boiling wort.

#### 2. Measurement requirements

The vapours generated when boiling wort are collected and compressed. When compressed, the temperature of the vapour increases from 100 °C / 212 °F to about 120 °C / 248 °F, which means that it can then be used again immediately to boil wort.

The König Brewery uses a mechanical vapour compressor to compress the steam. It is only activated when the vapour pressure above the wort reaches a minimum gauge pressure of 25 mbar / 0.36 psi. Until now the company has been using a U-tube manometer to determine the differential pressure. However, as part of the continued modernisation and automation of the plant, this device had to be replaced. A state-of-the-art differential pressure transmitter that could directly transfer its measuring signal to the central control room was required.



A look at the compressor unit

**KROHNE**

## 3. KROHNE solution

The OPTIBAR DP 7060 C differential pressure transmitter was chosen. The KROHNE device measures the vapour pressure above the wort compared to the atmospheric pressure outside of the tank. The extremely compact measuring cell provides the measurements with step response times of just 125 ms to the programmable logic controller (PLC). This guarantees reliable and stable process control. Once the predetermined minimum differential pressure has been reached, the control system activates the vapour compressor.



Differential pressure measurement in the wort kettle

## 4. Customer benefits

Thanks to the use of the OPTIBAR DP 7060 C, the heat recovery works smoothly via the PLC. The brewery has been able to considerably reduce the energy requirements for this energy intensive process step. Now, considerably less primary energy is required to produce steam for the boiling process. That means that in the long term König reduces both energy costs and CO<sub>2</sub> emissions in beer production. König also benefits from the long service life of the OPTIBAR DP 7060. The sturdy design of the measuring device ensures a reduction in the cost of maintenance and replacement parts.

## 5. Product used

### OPTIBAR DP 7060 C

- Differential pressure transmitter for the measurement of flow, level, differential pressure, density and interface
- Very good repeatability and long-term stability of the measuring signal
- Extremely quick step response times <125 ms
- Measuring ranges up to 30 mbar / 0.44 psi even without electronic spreading
- Turn down up to 100:1, higher on request
- Universal modularity of the entire OPTIBAR process series
- Comprehensive diagnostics and configuration



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# APPLICATION REPORT Chemical

## Gauge pressure measurement for inerting storage tanks

- Maintaining a protective layer of nitrogen
- Reliable prevention of oxidation of stored ester
- Increased product yield
- Use of pressure transmitter with ceramic measuring cell

**oleon**  
A NATURAL CHEMISTRY

### 1. Background

Oleon is part of the Avril Group, a manufacturer in the oil and protein sectors. Established in 1950, the company is now one of the biggest manufacturers of oleochemical products based on renewable raw materials such as natural fats and oils. The company offers a wide range of products including fatty acids, glycerin, esters, dimers, technical oils, speciality oleochemicals and biodiesel. Headquartered in Ertvelde, Belgium, the company runs several production sites in Belgium, Germany, France and Malaysia.

### 2. Measurement requirements

The customer stores ester in several tanks at its European sites. The ester is covered with a layer of inert gas (nitrogen) to protect it against oxidation. There is a slight gauge pressure in the tank (between 0...25 mbarg / 0...0.36 psig), which the customer must continuously monitor by way of relative pressure measurement at the top of the tank.

If the gauge pressure cannot be measured, there is a risk of air intake. If oxygen gets into the tank, it can cause the ester to oxidise. This is a new application for the customer, there was no previous measuring point for this parameter. The temperature in the tank is +80°C / +176°F. ATEX-approved measuring devices were required for this application.



Measuring gauge pressure of the nitrogen layer

**KROHNE**

## 3. KROHNE solution

KROHNE suggested 4 OPTIBAR PC 5060 C pressure transmitters. They were installed in the top portion of the steel storage tanks.

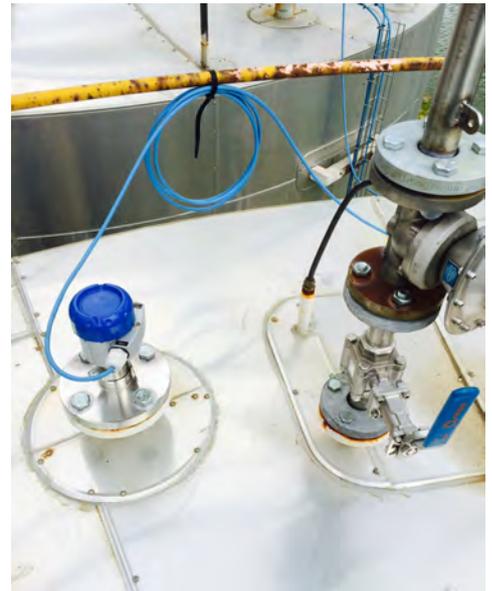
The numerous available mechanical screw or flange connections allowed the customer to keep the existing thread and thus avoid having the tank re-certified.

The OPTIBAR PC 5060 C pressure transmitter is made up of a sturdy ceramic diaphragm that is resistant to oxidization and corrosion in chemical surroundings. This ceramic protects the device from product vapours while ensuring reliable and accurate measurement.

Furthermore, the OPTIBAR's pressure measuring range allows it to cover extended ranges while remaining immune to overload of 5 times the measuring range.

From the range of housing available, a version made of powder-coated aluminium was selected to meet the customer's requirements and suit the surrounding conditions.

The device comes with 4...20 mA signal output (incl. HART®). It was decided not to use the "SIL 2/3" device option as the device is only used for a process measurement and not in PCT safety equipment.



OPTIBAR PC 5060 C pressure transmitter at top of tank

## 4. Customer benefits

The nitrogen layer is maintained by measuring a constant gauge pressure. The ester does not oxidise, which allows the customer to effectively limit product loss and increase his yield.

The customer values the good business relationship and the technical support provided by KROHNE. As a result, Oleon has meanwhile acquired additional pressure and level transmitters as well as temperature sensors.

## 5. Product used

### OPTIBAR PC 5060 C

- Pressure transmitter for the measurement of process pressure and level
- For applications with gases, liquids and steam
- High plant availability thanks to maximum overload and vacuum resistance in the ceramic measuring cell
- Extremely quick step response times <85 ms
- 2-wire, 4...20 mA/HART®, FOUNDATION™ fieldbus, PROFIBUS PA
- Also with option for Safety Instrumented Systems (SIL2/3)
- Optional display and adjustment module
- Factory parameters set via display module or PACTware



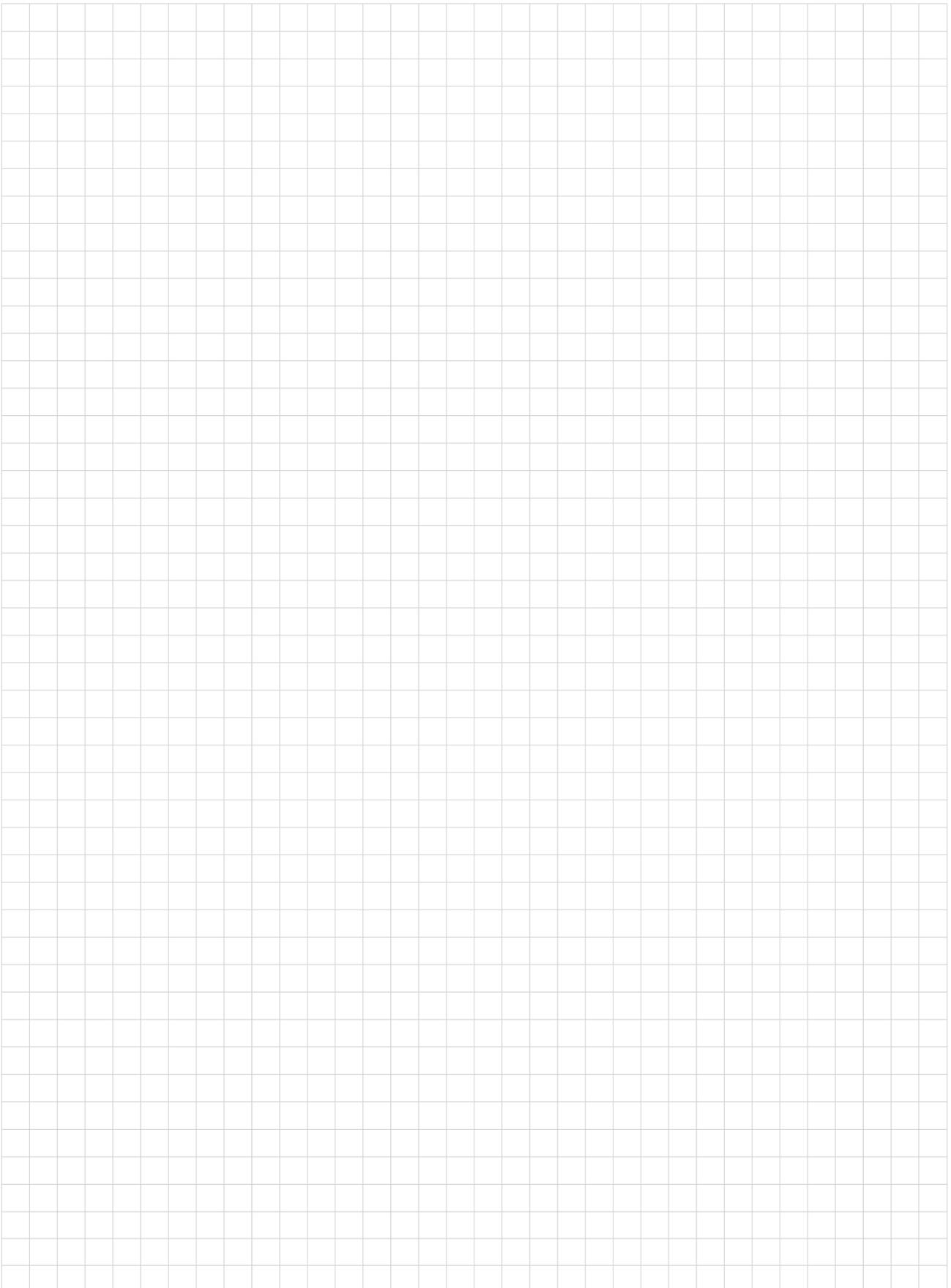
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## KROHNE – Process instrumentation and Measurement solutions

- Flow
- Level
- Temperature
- Pressure
- Process analysis
- Services

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