Power Plants - Instrumentation Applications
Company Profile:

- International solution supplier with a wide range of process measurement instrumentation for production and logistics in the process industries
- Consultancy and service for our customers in 85 countries
- One of the largest privately owned companies in the automation industry
- Headquarter in Reinach (Switzerland)
- CEO: Klaus Endress
Our Offering: Leading Edge Field Instrumentation
Segmentation of different processes (general information)

- **Power stations**

  - **Fossil fired power plant**
    - Coal fired power plant
    - Oil fired power plant
  
  - **Gas turbine-power plant**
    - Combined cycle gas turbine (CCGT)
    - Cogeneration power plant
  
  - **Nuclear power plant**
    - Boiling water reactor
    - Pressurised water reactor
  
  - **Waste to energy power plant**
    - Incinerator plant
    - Biomass power plant
Coal Fired Power Plant

Process
Temperature Applications

- Air/Ignition System: Air pre-heater and Ignitors,

- Environmental System: Preipitator Inlet and outlet temperatures

- Steam generation/System: water flowing from hotwell condensor, feedwater heaters and lines in/out of steam drum, steam drum to superheater, main steam line to turbine, and cold and hot reheat steam lines.

- Steam Quality:
  - Feedwater Heaters
  - Turbines
  - Stuffing Box
Temperature - Conventional power plants

- Thermocouples and transmitters in use throughout the plant
- Electric fuel gas preheaters
- Electric fuel oil heaters and forwarding systems
- Lube oil heaters and systems
- Turbine water wash systems
- Turbine inlet and exhaust flow heating systems
- Water storage tank heating systems
- Steam superheaters
Temperature measurement: cooling systems

Monitoring of the lube oil circuit at the cooling water pump to avoid damages to the pumps
Temperature measurement: oil lines

Temperature monitoring in the oil lines to the main combustion

Thermocouple TC15 + weld in thermowell (bar stock) for high temperature and high pressure applications
Flue Gas temperatures

Temperature Measurement up to 1600 °C

TAF16
in different steel grades (INCONEL, SS446,...)

TAF12
with ceramic thermowell for high temperature applications

EEx-d loop powered field display
RIA141
Heavy duty multipoint

18 inserts, 900 °F, 3000 psi Application
Flow Measuring Principles Segmentation

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<th>Non conductive liquids</th>
<th>Gas</th>
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- Conductive liquids: Proline, Prosonic Flow
- Non conductive liquids: Promag, Promass, Prowirl, Deltatop, Deltaset, T-mass
- Gas: Deltatop, Deltaset
- Steam: PROline, Prosonic Flow
Raw Water Flow Metering

Measurement technology
- Electromagnetic flowmeter
  - Promag
    - (DN80, hard rubber)

Process
- Measurement of the raw water volume, which is supplied to the water desalination system
- Material: raw water
- Operation: max. 4 bar, max. 25 °C
  - Meas. range: to 160 m³/h

Characteristics
- Promag is well suited for standard applications in the water and wastewater sector
- Simple and straightforward commissioning with Quick Setup saves time
- The flange instrument Promag requires no additional instrumentation
Electromagnetic flow meter

- No pressure loss
- Unobstructed sensor tube (piggable)
- Wide diameter range (+ wid measuring range)
- High measuring accuracy
- Largely independent of flow profile
Flow: Cooling Water

Vortex Flow meter
Type: Prowirl 72F DN40/1.5"
Media: Cooling Water
Temp: +55-100°C/130F-212F
Pressure: 150 PSI

Other info:
Process required a minimum D/P to be present.
Vortex flow allows for higher efficiency and
Higher accuracy over a wider flow range than
DP flow with a primary element.
Flow: Boiler feed water supply

Other info:
Flow measurement of demineralised water, steam and vapors using vortex principle gives wider range and no long term wear influence like DP flow and orifice plate elements.
Flow: compressed air supply

Other info:
True mass flow with thermal principle. Low pressure loss and wide turn down. No added expense of temperature, primary element, error in calculations like DP flow.
Monitoring the start-up/support burner

- To initiate combustion and/or support coal firing of the boiler, oil is used for the booster and supporting burner.

- A precise mass measurement installed in the oil flow line is required for the exact batching and control of the combustion process.
Coriolis mass flow meter

- **Promass**
  - Compact device for direct, precise mass measurement (kg/h) – no additional instruments required
  - Replaces mechanical systems that can obstruct and block the furnace oil flow line
  - No moving parts for unimpeded flow and operation of the furnace
  - Safe measurement, even with poor quality oil
Flow: Burning Oil in and outlet

Massflow meter
Type: Promass 83F
Media: Burning Oil
Range: 0-2 kg/s/ 4lbs/s
Temp: +95-200 C/200-390F
Pressure: 10-25 BAR/ 150-350PSI

Other info:
Promass Mass Flow meters allow the flow rate to the recovery boilers to be measured in mass units to account for changes in the volume due to integrated temperature and density measurement. Proper density ensures less water content and a higher burn rate with less unwanted condensation/steam.
Flow: Burning Oil to burner

Massflow measurement

Type: Promass 83 F DN40/1.5”
Range: 0-2.5 kg/s / 0-5.5 lbs/s
Media: Burning Oil
Temp: +60 C / 140 F
Pressure: 200-300 kPa / 30-45 PSI

Other info:
Promass provides precision mass and density measurement of bunker C fuel Oil to the boilers without the need for long straight run piping or interference from 90 degree elbows and valves due to its compact size.
Flow: Natural Gas

Vortex Flow meter measurement

Type: Prowirl 73 F DN 150/6”
Range: 0-3 Nm3/s / 0-105 ft3/s
Media: Natural Gas
Temp: +25 C/77F
Pressure: 200 kPa/30 PSI

Other info:
Prowirl 73 with integrated temperature measurement allowed for a real time calculated volume flow without the need of an external flow computer. In addition, the device accommodated a larger operating flow range than DP.
Water volumes in the main cooling water system

- Large volumes of cooling water flow through the main condenser, helping to create a high degree of efficiency in the power plant.

- In order to measure cooling water volumes, a measuring device is required which supplies reliable values even with large pipe diameters.
Ultrasonic flow meter

- **Prosonic Flow**
  - Installed directly on pipelines via detecting sensors with transmitter mounted separately
  - External installation allowing easy retrofit with no intrusion into the pipe
  - Maintenance free with no moving parts
  - No obstructions in the pipeline and no pressure loss
  - Economical alternative for large diameters up to 4000 mm
Ultrasonic inline flow meter

- **Prosonic Flow inline**
  - Ideally suited for applications in process control and utility measurement in energy production
  - Short inlet and outlet length reducing the space required for installation in comparison to orifice plates and Vortex meters
  - Loop powered transmitter with accuracy up to ±0.3%
  - Measures the flow of conductive and especially non-conductive liquids
Volume measurement in desalination

- Full desalination requires the production of pure water necessary for the operation of steam boilers.

- Volumetric flow meters are required for the measuring of deionized water in the water/steam circuit.
Vortex flow meter

- **Prowirl**
  - Alternative to dp-flow with orifice plates
  - Compact device for volume measurement in deionized water
  - Reliable measurement independent of deionate conductivity
  - Large measuring dynamics, i.e. high turndown
  - Little Pressure loss
Ultrasonic: outlet water

Other info:
Traditionally, a large diameter magnetic Flow meter was used in this application. During a failure, it was not accessible for Replace or repair. A non-intrusive Prosonic 93 W unit was used temporarily. It became A permanent meter with more than $10K Price difference between magnetic flow and Ultrasonic.
Level Applications - Capacitance /Radar

- Air/Ignition System
  - Fuel Oil Storage Level

- Environmental System: Ash levels inside precipitator

- Steam Generation: Dearator water storage level

- Steam System: Hotwell Condenser level

- Water System: Makeup water system supply
Level Applications

- Coal System: Storage pile, Conveyor control, coal silos
- Environmental System: Scrubber lime slurry, fly ash storage
- Water System: Pond/River level treatment plant cooling tower

All rotating equipment needs lubrication to avoid excess friction and damage. Lubrication systems typically include a reservoir which must be monitored for loss of lubrication and lube oil pressure. (Point Level Switch i.e., Liquiphant)
RIA452 – Level/Pump control

Pump control
“Start/stop” using alarm
Set point relays

Level measurement

- Up to 8 relays (alarm set points) possible
- Pump failure is recognized
- Replacement pump can be controlled
- Up to four pumps can be monitored
- Running times for each pump can be monitored
- Dry run protection
- Cyclic pump start on long down times
- Fault conditioning (e.g. cable open circuit) in accordance to NAMUR NE43 or freely definable.

Feed back pump is “running/not running” using a digital signal
Level: Hydraulic oil tank

Other info:
Deltapilot S is used to measure hydraulic oil in utility storage tanks. Deltapilot uses a flush mount weld socket and Hastelloy diaphragm.
Controlling the level in the ammonia storage tank

**Measuring technology**
- Level transmitter **Levelflex**

**Process**
- Controlling the level of the ammonia storage tank to guarantee the operation of the DeNOx-Catalysator
- Medium: Ammoniac (100%)  
- Operation: app. 6 bar, app. 15 oC  
- M-range: up to 2m

**Features**
- Device works without moving parts. A better solution than displacers or floating assembly.
Level measurement with radar technology
Application in power plant => example High Pressure preheater

- Power station Anhui Datang Huaibei in China
- Level transmitter **LEVELFLEX FMP45** – Installation bypass at HP Preheater

**Measuring technology**
- Level transmitter **LEVELFLEX FMP45**
- Installation bypass at HP Preheater

**Process**
- Level measurement of the condensed extraction steam (auxiliary condensate) in the High Pressure preheater.

- Medium: Condensate (Demi-Water)
- Operation: 42.4 bar / 300 °C
- Measuring range: app. 1100 mm

**Features**
- **LEVELFLEX** is suited very well for high pressure and temperature parameters in High Pressure preheaters.
- Analysis of the signal via the envelope curve of the transmitter, that can be viewed on the display or with a laptop.
- The measurement is not influenced by fluctuations in the process or fluctuations in density. (pressure, temp.)
Level measurement with radar technology
Applications in the power plant => example Low Pressure preheater

Level-transmitter (radar instrument)
LEVELFLEX FMP40

Features

- LEVELFLEX is installed in a redundant installation with three bypasses (2 of 3 selection) to realize the safety concept of the power station.
- The measurement is not influenced by fluctuations in the process or fluctuations in density. (pressure, temp.)

Process

- Power station Jiangsu Guohua Taichang in China
- 3 bypasses (2 of 3 selection)
- Levelflex FMP40
- LP-Preheater

Envelop curve

Control the level of the condensed extraction steam to safe the steam turbine for damaging.

- Medium: Condensate (Demi-Water)
- Operation: 7 bar, 180 °C
- Measuring range: 2100 mm
Level measurement with radar technology
Applications in the power plant => example Low Pressure preheater

Level-transmitter (radar instrument)
LEVELFLEX FMP45

Features
- For safety reasons the LEVELFEX is installed in a redundant installation.
- The measurement is not influenced by fluctuations in the process or fluctuations in density. (pressure, temp.).
- For operating the application with the envelope curve you can use the display or the E+H software TOF-Tool together with a laptop.

Measuring technology
- Level-transmitter (radar instrument)
- LEVELFLEX FMP45

Process
- Control the level of the condensed extraction steam to safe the steam turbine for damaging.
- Medium: Condensate (Demi-Water)
- Operation: 1 bar, 170 °C
- Measuring range: 600 mm

Power station Guizhou Qianxi in China

LP-Preheater
Levelflex FMP45
Redundant installation
Signal of condensate level
Envelope curve
Levelflex - Fly Ash Measurement

Levelflex on Fly Ash Bins

Replacement of a plum-bob (mechanical) device

- Fly Ash silo
- Measurement range: approx. 100ft
- Fly Ash build up does not disturb the measurement
- Previously used mechanical Plum-bob instrument failed due to cable breaking
Soliphant - Solid/Liquid Interface Module

Soliphant Interface Module in a Fly Ash De-Watering Bin

Replacement of a mechanical rotating paddle switches

- Coal fired power plant.

- Soliphant detects the rising level of fly ash under water

- Soliphant II FTM30/31 solids / liquids interface module (#TSP9266)
Level: Water level in the boiler (safety circuit)

Other info:
Standard and simple DP level measurement integrated into the boiler for level /pressure measurement to ensure safety. 2000PSI overpressure rating standard with HISTOROM event recording capability.

Pressure/Level measurement
Type: PMD75 with 3-valve manifolds
Media: Water level
Pressure: 0-509.5 kPa/ 0-75 PSI
Ultrasonic – Pond Level Measurement

Potable water level measurement in large ponds

Solar charged battery powered instruments

- FMU41 (battery powered)
- installed in 4” PVC stilling well
- Pond size: 40 – 500 Acres
- Measurement cycle
  - FMU41 is powered up for 2 min. 4 x per hour
  - the reading is taken into SCADA system
  - the unit is powered back off
Levelflex Remote Housing – Displacer Replacer

FMP40 for High Temperature Application
Replacement of Displacer Level Instrument

- FMP40 + remote housing
- Temperature
  - 167°C (333°F) operating temp
  - 249°C (480°F) max temp
- Pressure: Ambient to 1 bar
- Measuring range: 76”
Liquiphant – PD Pump Protection

Liquiphant for empty pipe detection

PD pump protection from running dry

- Empty pipe detection
- Prevents PD pumps (Positive Displacement Pump) from running dry
- Saves repair costs ($1,500 - $2,000) and prevents from purchase of new pump ($4,500)
Float Chambers in Power Plants

Float switches + Chambers

- corrode + sink or stick
- need maintenance
- do not fit to any installation position
- need more space
- are expensive
- ...

...
Replacement of high temperature float switches with Liquiphant

- 23 Liquiphant M + Liquiphant (HT) in an old power plant
- Bypass provided to get rid of expensive float chambers
WATER TREATMENT CONTROL ROOM WITH REMOTE DISPLAYS INSTALLED
Microwave Energy

Effects on humans?

Inside:
appr. 1 W/cm²

Leakage with door closed:
appr. 0.005 W/cm²

Pulse:
appr. 0.000'15 W/cm²

With transmitting power of 2 W:
ca. 0.000'1 W/cm²

Average:
appr. 0.000'000'21 W/cm²
Electromagnetic Waves

- Telephone
  - AC current
- Radio waves
- TV
- Microwaves
- Heat radiation
- Visible light
- Ultra violet
- X-rays
- Gamma waves
- Cosmic radiation

**Frequency**
- 1 Hz
- 10 Hz
- 100 Hz
- 1 kHz
- 10 kHz
- 100 kHz
- 1 MHz
- 10 MHz
- 1 GHz
- 10 GHz
- 100 GHz

**Wave length**
- 1 GHz
  - Decimeter
- 10 GHz
  - Centimeter
- 100 GHz
  - Millimeter

- 1.5 GHz (TDR)
- 6 GHz (radar)
- 26 GHz

- Kilometer
- Meter
- Micrometer
- Nanometer

- 500
- 1000
- 1500
- 2000
- 2500
- 3000
- 3500
Power plant in the USA

Free space radar shooting through a grid on coal in a bunker
Distance is 62 ft.
DP or Vortex?

- Cheaper for smaller line sizes
- Better long-term stability (less subject to wear) than orifice
- Calibrated, not only calculated
- Low installation costs
- Low maintenance requirements
- Higher turndown
- Lower pressure drop
- Fewer emission points
- Primarily linear signal
- Direct measurement
- Robust against changing T and p
- Non-clogging (E+H)

- Installed base, widely accepted
- Standardized since 1929
- More DN/PN available
- Available for T>450°C
- More special materials
- Measures down to 0 (however with 0 accuracy...)
- Works at lower Reynolds #
- Attractive Pricing for bigger DN
- Faster Response Time
Pressure: Gas pressure in burning process

Pressure measurement
Type: PMP 631 with 2-valve manifolds
Media: Propane, Air
Temp: +200-250 C/390-480F
Pressure: 10-12 bar/145-175 PSI

Other info: Direct Measurement of gases at the boiler reduces error with capillary tubes, leak points with “plugged” ports, and minimize error with density factor adjustment for individual gases.
Pressure Applications

- **Air /Ignition System**: Fuel Cutoff (shutdown), Fan Performance, Fuel flow between pulverizers and burners, air pre-heater and ignitors

- **Steam Generation**: Boiler Alarm, Water flowing from hotwell condensor, supply pump performance and steam lines in and out of drum, feedwater heaters and steam drum

- **Steam System**: Steam drum to superheaters, main steam line to turbine, cold and hot reheat steam lines, steam turbine throttle valve position

- **Water System**: Pump Monitoring
- Application examples

Power plant
Pressure measurement in de-sulphurization process

Utilities
Level measurement in the gear box of a cooling tower fan
Level Applications

With impulse piping and condensate chamber for liquids with condensing vapours

\[ Dp = (\rho \cdot g \cdot (h + h_b) + p_{head}) - (\rho_c \cdot g \cdot h_c - p_{head}) \]
## Product matrix

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- **coal supply**
- **oil supply**
- **ash removal/slag removal**
- **gypsum processing**
- **raw water supply**
- **full desalination**
- **waste water treatment**
- **steam generator (main firing)**
- **detoxification (DeNOx)**
- **dust removal (electrofilter)**
- **fluegas desulpherisation**
- **water/steam-circuit**
- **steam turbine**
- **generator**
- **main cooling water system**
## Product Matrix

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Any questions?

Thank you!