FLEXIM Flexible Industriemesstechnik GmbH

Non intrusive flow measurement at high temperature applications

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Flexim Instruments Asia Ltd
Singapore







Meters from Berlin for the World

FLEXIM provides process instrumentation solutions for all branches of industry. The main field of activities of the company are non-intrusive flow measurement and inline process analysis. The headquarters and the works are located in Berlin, Germany.





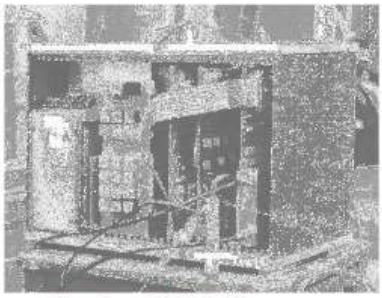
Prototype ultrasonic flowmeter 1986

Landmarks

- 1972 Fundamental research in ultrasonic flow measurement at the Institute for Automation Systems of the University of Rostock
- 1979 Ultrasonic flowmeter
- 1982 Research on the field of pipe bounded flow
- 1985 Prototype of the first ultrasonic transit time difference flowmeter
- 1990 Formation of FLEXIM GmbH
- >10.000 instruments in operation
- >25% of turnover invested in Research & Development



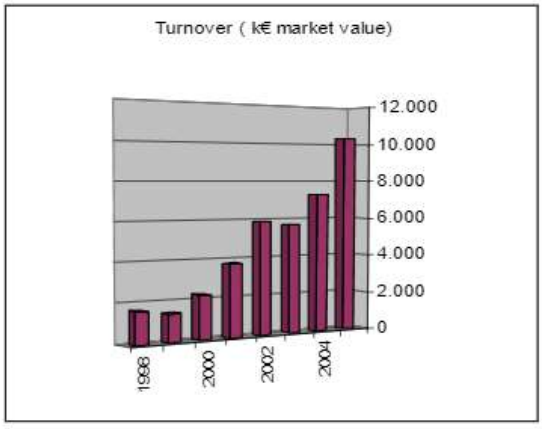
Ultrasonic flow meter with electronics



The first FLEXIM flow meter

Milestone 2006



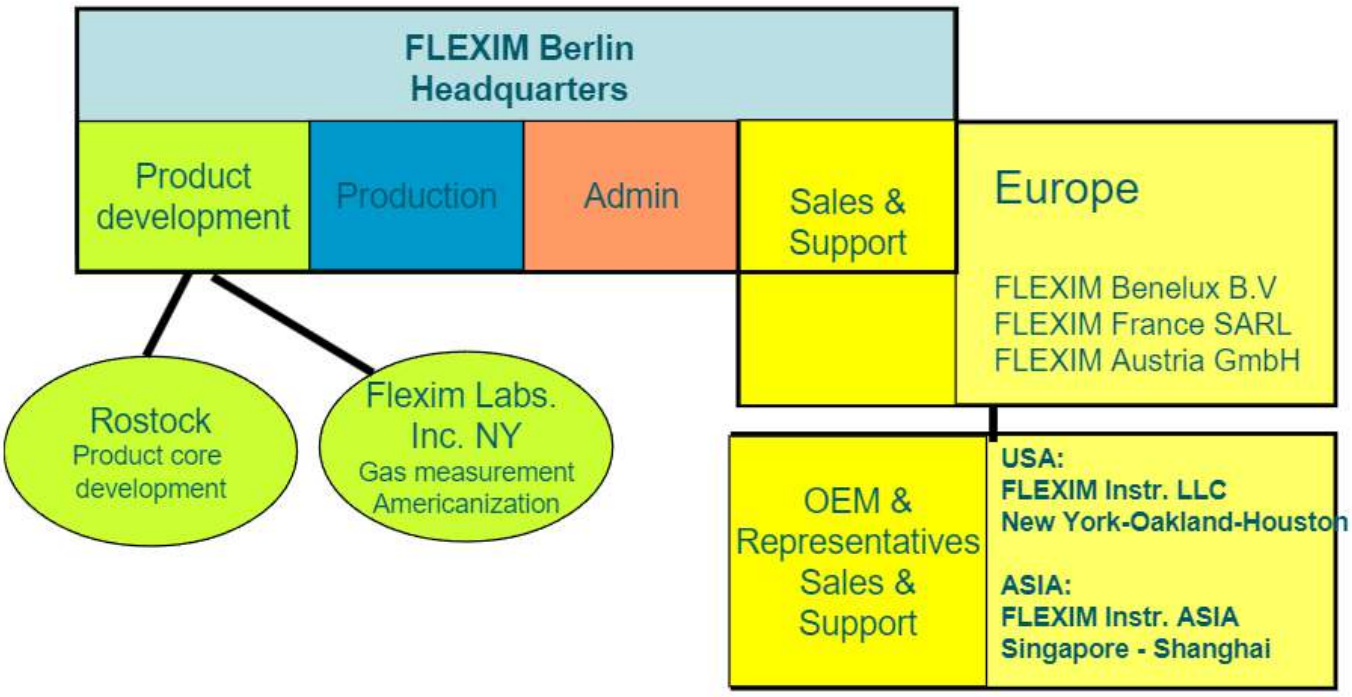


2005 / 2006 Milestone

- Nearly 40% Increase of total turnover
- FLEXIM staff now >90 people
- approximately 60% have an University degree
- Berlin Site now > 2000 m²
- Increased Production capacity (ready for 4000 pc. p. year)

- Foundation of FLEXIM Labs. New York
- Foundation of FLEXIM ASIA Singapore
- Foundation of FLEXIM China Shanghai

Organization



Shareholder and Employees

FLEXIM is owned by 4 shareholders who founded the company in 1990

- Managing Director: Dipl. Ing. Jens Hilpert
- Head of R+D: Dr.Ing. Andreas Mitzkus
- Head of Research Laboratory at Technical University Rostock: Dr.Ing.Funck,
- Electronic Hard-. and Software: Dipl. Ing.David Ulbrich

currently 90 employees worldwide, among them 17 in R+D.

Employees in FLEXIM branche offices:
Singapore: 2, planned 4 China: 4, planned 5

Turnover

Year 2004: 7,7 Million €
Year 2005: 10,3 Million €
Year 2006: 12,5 Million € → >16 Million US$

Export out of Germany: apr. 75%

Customers

Hydrocarbon process Industries.
Flexim is approved supplier for:
ExxonMobil, Shell, BP, TOTAL, Wintershall, DEA, AGIP, Enichem,
Technip, Statoil, Norsk Hydro, Maersk

Power, Installations in combustion and nuclear power station.
E.ON Germany, RWE Power, Vattenfall Europe, Electricite de France, KOPEC Korea….

Chemical, Pharmaceutical + Semiconductor
Bayer, Aventis, BASF, Degussa, DOW, Schering, Glaxo, AMD, Infinion, Phillips,
Wacker

Total number of customers is > 2000

Clamp On Ultrasonic flow meter!
Typical applications?



Large pipe diameters



Check metering with portable type

Retrofit on existing pipes



Non typical applications

FLEXIM



High temperature

Small diameter / ultrapure





High pressure, small pipes



Aircraft leak detectio

Clamp On Ultrasonic flow meter!
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Retrofit on existing pipes



Non typical applications

FLEXIM



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Aircraft leak detectio

Non Typical Applications
Clamp On Natural Gas Measurement

42" High pressure Natural Gas transport line (100 bar)
from Norway to Germany.
Check metering at STATOIL Karsto Gas Treatment plant



Nat. Gas Regulation Station Egtved, Denmark



Natural Gas Measurement at ExxonMobil, Shell, RWE, BP, STATOIL, MAERSK

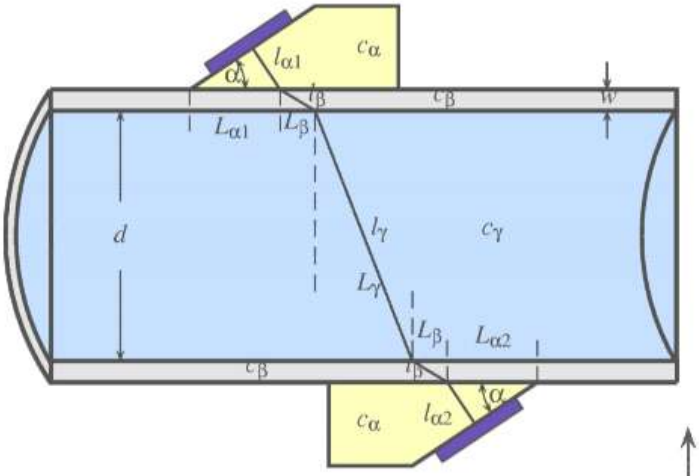
For Nat. Gas at pressures > 35 bar !!

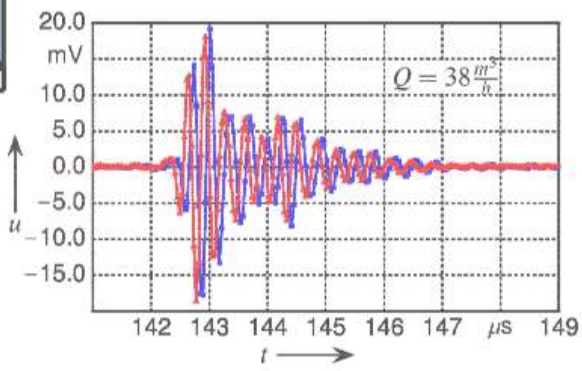
Transient time principle

ISA Hamilton\Page12 ISA Hamilton.pdf trans. time

ISA Hamilton\Page15 ISA Hamilton.pdf signal high flow

ISA Hamilton\Page14 ISA Hamilton.pdf signal no flow





$$v = k_a \frac{\Delta t}{\Sigma t - \Sigma \tau} = k_a \frac{\Delta t}{2t_{F0}}$$

$$k_a = \frac{c_a}{\sin \alpha}$$

FLEXIM Products ADM Series

FLUXUS ADM 6725 ▶ Quick Start Guide

The Portable Flowmeter

Portable flow measurement in clamp-on technique, ideal for service



FLUXUS ADM 7404 ▶ Quick Start Guide

The Multi-Talented

Ultrasonic flowmeter for permanent installation, flexible configuration with various inputs and outputs



FLUXUS ADM 7907 ▶ Quick Start Guide

The Control Cabinet Pro

Ultrasonic flowmeter for permanent installation in 19" rack systems



FLUXUS ADM 8027 ▶ Quick Start Guide

The EEx-pert

Ultrasonic flowmeter for permanent installation in explosive atmosphere, ATEX-certified for zone 1 and 2



FLUXUS ADM 5107 ▶ Quick Start Guide

The Water FLUXUS®

Economy ultrasonic flowmeter for the water and wastewater industry



FLUXUS ADM 8127 ▶ Quick Start Guide

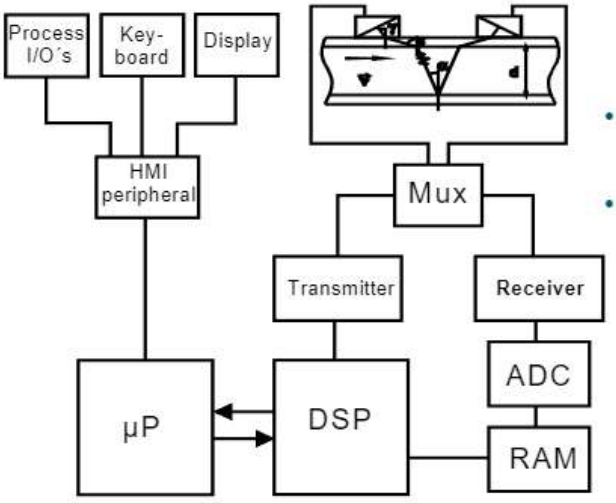
The Offshore FLUXUS®

Seawater-proof ultrasonic flowmeter for offshore applications, ATEX-certified for zone 1 and 2



Electronic design

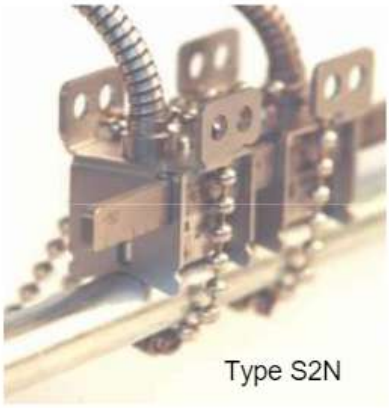




Digital Signal Processing Technology

- The FlexTecht uses two parallel µP´s for signal processing. Allowing for reliable measurement under extreme conditions
- The primary DSP continuously measures with a very high sample rate of 1000Hz and writes the sample data in the RAM
- A second µP configures the measuring process and statistically evaluates the stored raw data.
- Corrupt or invalid raw data and runaways are sorted out, providing stable performance under the most demanding conditions

Transducers for liquid applications



Type S2N



Type M2N
Type Q3N

- stainless steel housing
- watertight transducers
- wet calibration on the FLEXIM flow rig
- automatic recognition of the transducers and transmission of the calibration data upon connection

Transducer design

Unique transducer design

- robust stainless steel construction
- no BNC connector→ water tight
- paired transducers → precision, typical zero point error < 0,005m/s
- calibration can be traced back to national standard; calibration certificate acc. to ISO 9001
- transducer data in EPROM
  - →precise measurement
  - →avoids input errors
  - →accelerates start-up
  - →traceable documentation



Factory calibration

Flow calibration

- flow calibration of all standard transducers
- calibrated precision pipe for clamp-on transducers
- DN25 to DN200
- Q up to 400 m³/h
- can be traced back to national standards (DKD)



Factory calibration



calibration data

Applications in Petrochemical Industry

DEGUSSA Marl

EXXON Mobil

EXXON Mobil gas production

BP Chemical

DSM

STATOIL ASA

VALERO

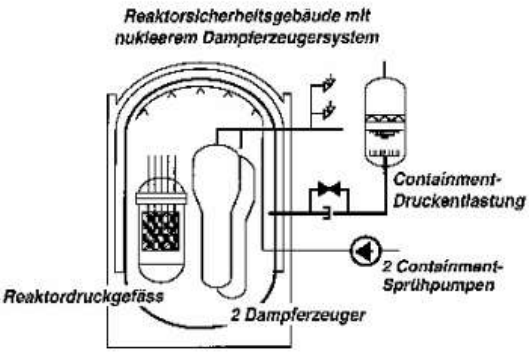
HT application in Nuclear Power Station

Customer: nuclear power plant Beznau
(through SIEMENS Nuclear Power)

REQUEST:
Masurement in the primary coolant circuit at 300℃

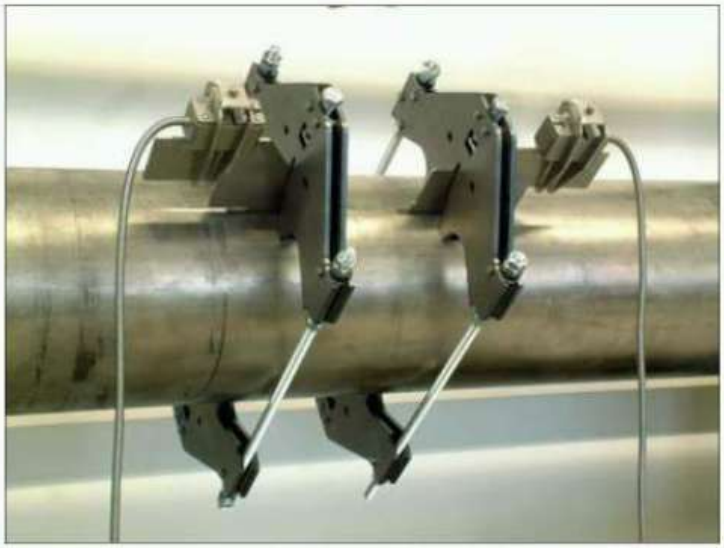
→ no intrusion in the pipe system
→ large temperature range
→ no active electronic components in the "hot" zone





Wave Injector

Flow measurement at high temperatures



WaveInjector WI-300

WaveInjector

- Patented system
- Can be used up to 450°C
- Each system is designed for a specific pipe diameter range, not for a single diameter
- Standard flow transducers can be used
- Metallic silver coupling to the pipe surface

Background of WI Development

3 Requests had driven the development in the years 2002/2003

1) High Temperature (HT) solutions for the Hydrocarbon Petrochemical Industry (HPI) Measurement of quench oils, heat transfer oils, heavy residue, pitch, bitumen ….
2) HT measurements in Power Stations for check metering.
3) HT long term feed water monitoring for determination of secondary circuit energy balance.

In HPI the sensors need to be EX approved (ATEX / FM conformity)
The sensors consist out of the stainless steel housing, a PEEK wedge, the piezzo element and molding material.

→ The sensor wedge, piezzo and molding do not stand temperatures>200℃ everlasting.
→ The sensor coupling done with Silicon or Teflon need to be re-done quite regularly.

Solution:

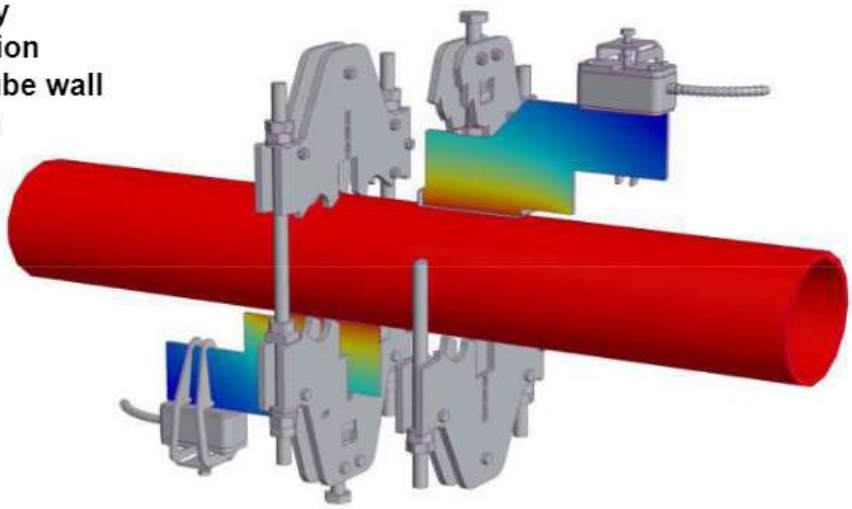
Use of standard sensors. Remove the sensors away from hot pipe surface via Wave Injector plates.
Coupling of the plates done with metal foils out of lead or silver.

Temperature profile in coupling plates

Development of the coupling plate geometry
by “Finite Element Simulation” and model verification

Huge temperature gradient between pipe surface
(400℃) and upper plate end (90℃)

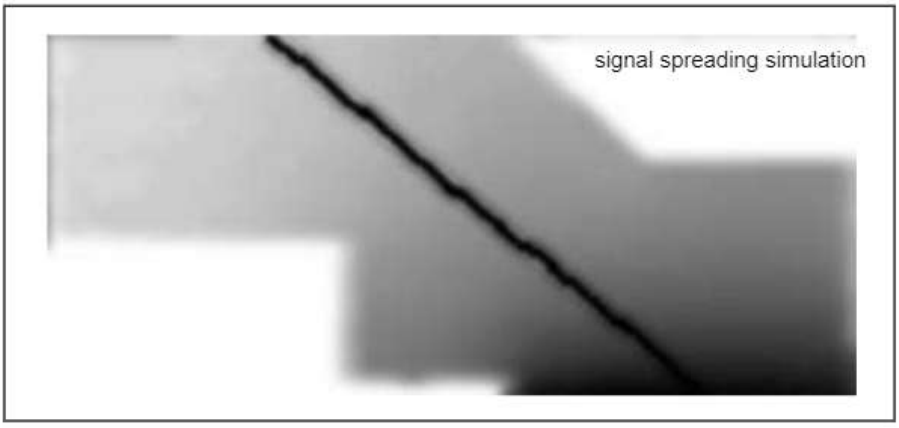
Patent on rhombus geometry
to achieve isotherms extension
in a parallel manner to the tube wall
and perpendicular extension
to the path length
of the sound waves



Acoustic sound path in coupling plate

The coupling plate is considered as a part of the sensor

Sensor coefficient K= c / sin alpha. → c is temperature compensated.



The signal path of the sound waves is liniar due to perpendicular extension of the isothermes

Signal is not refracted by the temperature profile

→ Alpha is constant, therefore no impact on sensor accuracy by changing temperatures

On side test at YONGGWANG UNIT 5, Korea

Installation of Wave Injector brackets
Preparation of pipe wall contact area





Installation of Wave Injector coupling
Plate and ultrasonic sensor

3 party calibration results

Third party flow laboratory calibration runs:

1) "Landesbetrieb Mess- und Eichwesen Nordrhein Westfalen"
   Metrology Laboratory of state NRW (PTB)
   Düsseldorf Mai 2004
   Waveinjector, volumetric test
   Anlagen zur präsentation\Eichamt_Kalibrierschein.pdf

2) ALDEN Research Laboratory, Holden Massachuchets April 2005
   First without WI, then with WI. Volumetric test
   Anlagen zur präsentation\AldenCalibrationReport 2006 essence.pdf

3) DELFT Hydraulics NL (Dutch standard)
   Calibration against Massflowmeter
   Anlagen zur präsentation\Delft Hydraulics 2006.pdf
   ISA Hamilton\page29 ISA Hamilton.pdf
   ISA Hamilton\page30 ISA Hamilton.pdf

4) EVALUATION International - WIB – EXERA at TÜV NEL Glasgow during 2005
   Evaluation Report E 1847 X 05
   ..\..\Schreibtisch\Informations for Partners\Accuracy reports\TÜV-NEL Evaluation International\Report NEL E 1847 X 05.pdf

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Ruetgers Tar Refinery

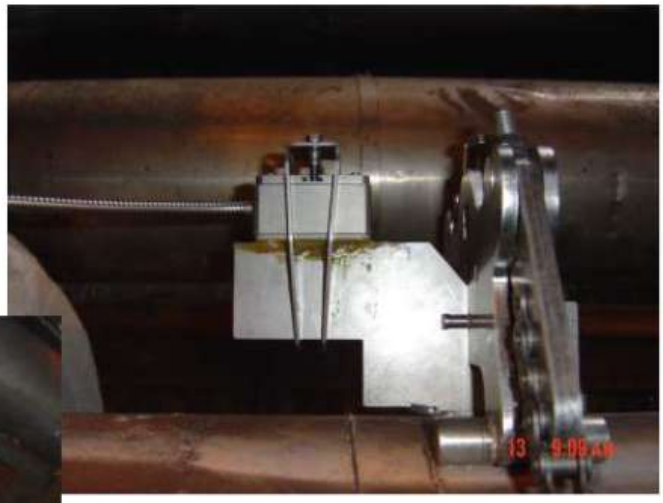
SUNCOR is producing oily sands in sand mines in Alberta Canada. The sand is transported to the processing plant, where a heavy crude is extracted and refined. Exploring oil sand started to be Lucrative at crude oil prices >30 USD. SUNCOR is the fastest growing oil producer in north America.



Bitumen measurement at 350°C
flowing out of vacuum tower bottom

400mm diameter, 9.5mm wall thickness

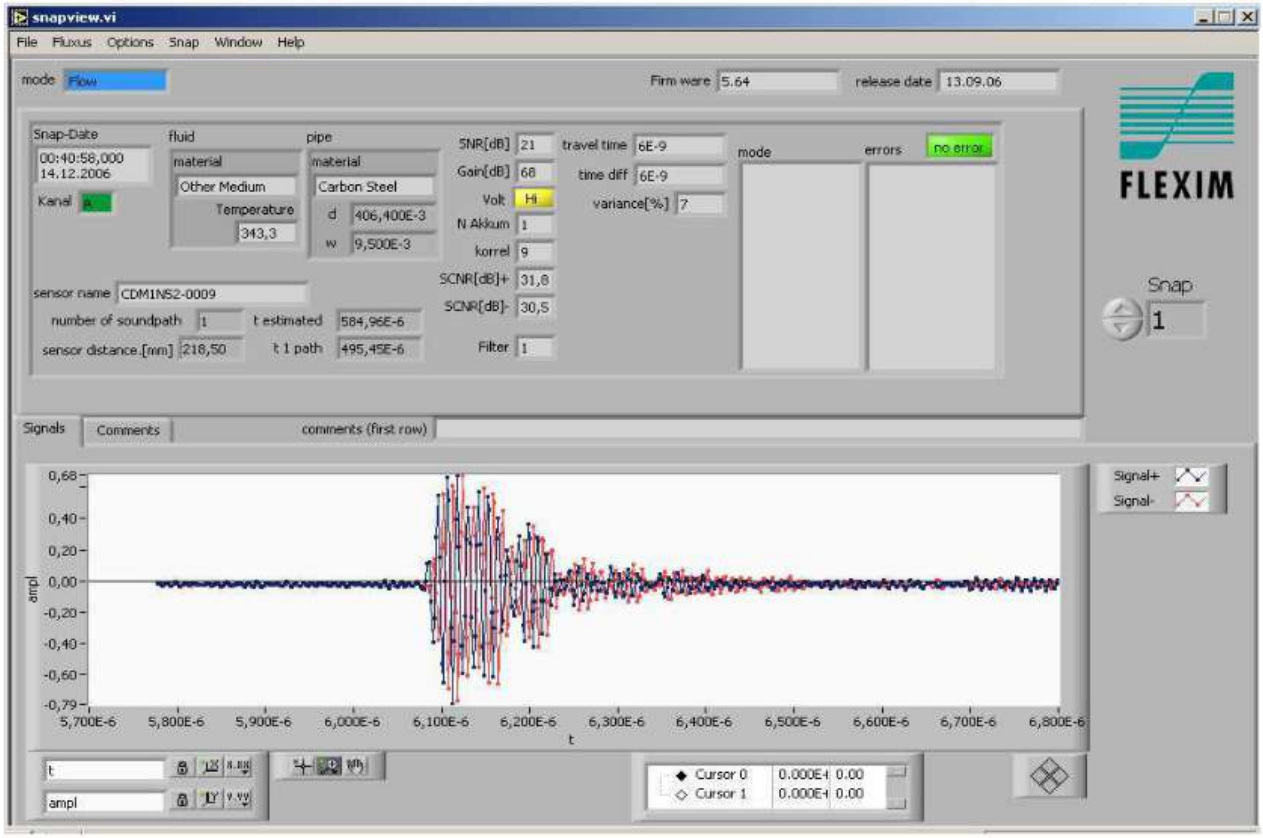
The Bitumen contains sand particles





WI bracket mounted with stainless steel chains
For diameters >350mm

Signal snap shoot



BP Refinery Lingen Germany

Application 1:

Atmospheric distillation, heavy product.
Temperature 280-300℃
Carbon steel pipe 168,3 x 7,1mm
Flow range 0-100t/h → standard application

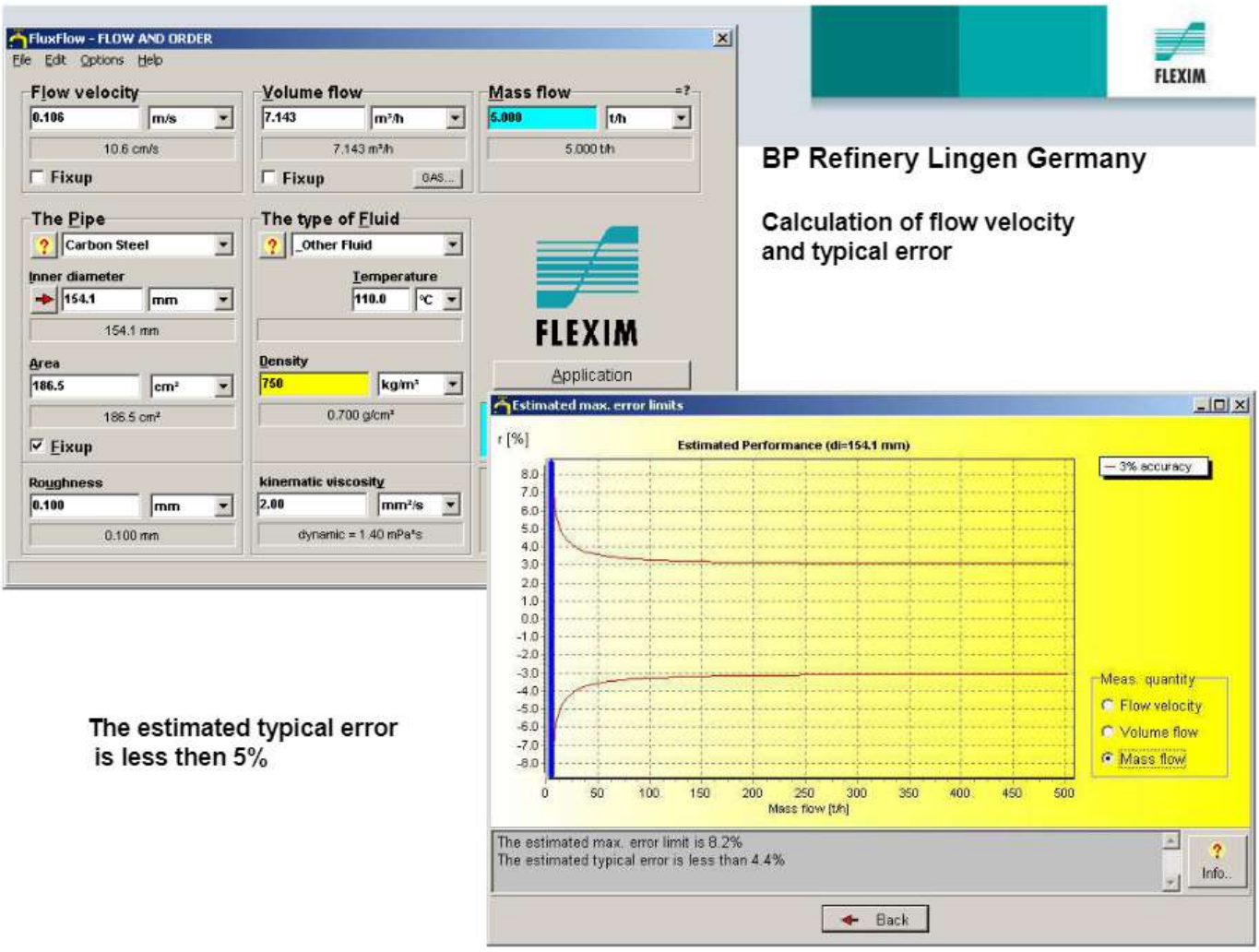
Application 2:

Atm. destillation bottom product.

Temperature 350-360℃
→ Flow range apr. 5 t/h → velocity of 0,08m/s
→ Replacement of old orifice, which was out of specification since crude got lighter and less heavy residue is produced.

Ultrasonic flow meter are known for their high dynamic range. Flexim is measuring from 0,03m/s. Zero point offset is apr. 0,003m/s

→ Calculation of flow velocity and typical error



FLEXIM

BP Refinery Lingen Germany

Calculation of flow velocity and typical error

The estimated typical error is less then 5%

ConocoPhillips Refinery, Wilhelmshaven Germany

Medium: side stream of vacuum distillation
Hastelloy pipe 56,8mm x 4,1mm, Temperature 250-270℃

The CONOCO Engineers usually decide for Vortex flow meters as standard solution for high temperature flow tasks <3". In this case a special material request had lead into extra long delivery times for the Vortex meter.
After conducting on site presentation they decided for the first FLEXIM installation.

Pipe Interface Detection:

To avoid unnecessary losses in the pump field, a clamp on product determination was requested.
Piping 20" and 10", multi product lines.
To separate light from heavy products a ball pig is send with. The pig is released and removed in pig sluices. To control the pig removal, the flow velocity and the position of the medium interface is necessary to know. Both information can be obtained from the USCO flow meter. Two different medias will have different physical properties (Speed of Sound). The SS is measured online.
SS is temperature dependant similar to density.

→ Hence the temperature / sound speed relation fo each medium need to be determined

SOUND SPEED versus temperature for VGO

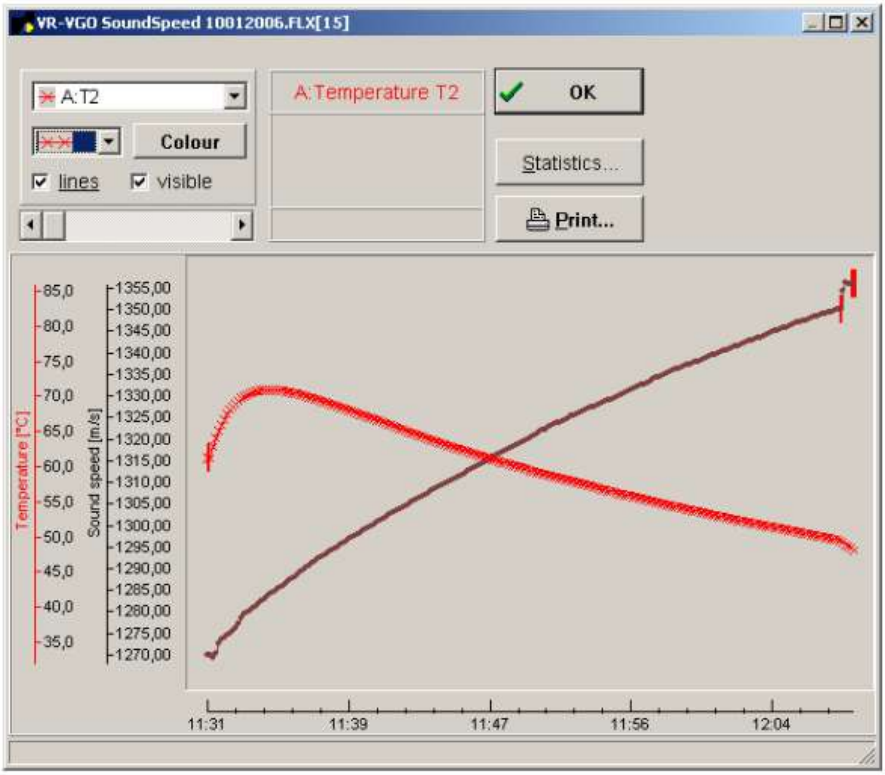
Plox-S

Speed of sound and
temperature for
vacuum residue

Temperatures between 50-70℃
Speed of Sound
1285 to 1345 m/s

The difference between
Light Gas Oil (LGO)
and Heavy Gas Oil (SGO) was
1290 – 1350 m/s -> delta 60m/s

Resolution of sound speed
measurement better then 0,5 m/s



Pipe Interface Detection

Signal outputs:

First 4-20mA
→ volume flow
Second 4-20mA
–> flow velocity
Third 4-20mA
→Sound speed

Sound speed measurement
behaves similar to density measurement



Dow Chemical Germany

DOW Böhlen Germany, 8 Set WaveInjector

Carbon steel pipe DN80
Temperature medium 200℃, Quench oil. → not so hot at all….
Piping is cleaned and flushed with superheated steam from time to time
at 320℃ to prevent fouling

DOW Stade,

12" Hastelloy pipe
chemical product (MDI)
with chlorine contend at 250°C.
A heat exchanger is effected by fouling,
the flow rate increase and the
HE gets cleaning.
→ safety related



PREEM Refinery Gothenburg Lysekil

Heat transfer oil @ 350℃. 4" pipe, partly isolated.



PREEM Refinery Gothenburg Lysekil

Replacement of 10 year old orifice system. Enduring problems with fouling in dP Emeto piping.

Fast decision by the Customer had lead into urgent delivery and installation in between 8 days.

Coupling with silver
Installation in Ex Zone 1
Transducer
EEx m II T6
Transmitter
EEx de IIC T6



SHELL Refinery Moerdijk NL

Installation Challenge!

20” pipe with 350℃ hot oil

To be installed on a scaffold at 12m height.



SHELL Refinery Moerdijk NL

Medium: SHELL Thermia HT Oil @ 350-400℃



Supply of hot oil from the central power station to the process plants and tank farm

The minimum flow information is safety critical to protect the boiler system. The authorities requested a second flow measurement since they expected the installed orifice to be out of spec.

SHELL Global Solution Den Haag Had made a recommendation to the plant.

→ SHELL decided to install this redundant system permanently

→Largest diameter for Flexim WI so far!