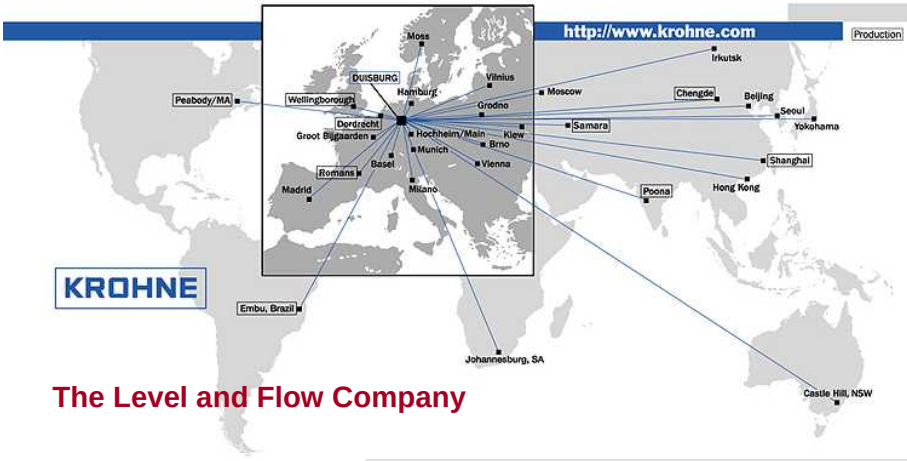
KROHNE Worldwide

- 13 Production facilities in 9 countries
- 29 KROHNE offices
- 59 KROHNE representatives



The Level and Flow Company

The Netherlands

KROHNE in Dordrecht

KROHNE Altometer
Production of EMF & UFM

KROHNE Nederland B.V.
Dutch sales organisation

KROHNE Oil & Gas B.V.
KROHNE system provider

KROHNE Flow & Level Company

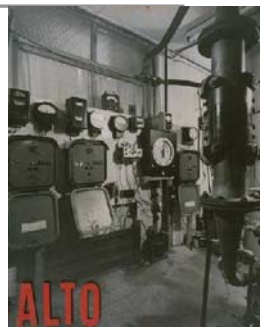
Flow

- Variable Area
- Vortex
- Coriolis Mass
- **Electromagnetic**
- **Ultrasonic**
- Flow Controllers

Level products

- Level switches
- Radar
- Ultrasonic
- TDR Time Domain Reflectometry

KROHNE Altometer: More than 50 years experience



1953 TOBI - later ALTO - produces world's first electromagnetic flowmeter for industrial applications
1962 ALTO, later Altometer, joins the KROHNE family
1966 Construction of the world's largest calibration rig in Sliedrecht, The Netherlands, for calibrating flowmeters up to diameter DN 120"

KROHNE Altometer - History

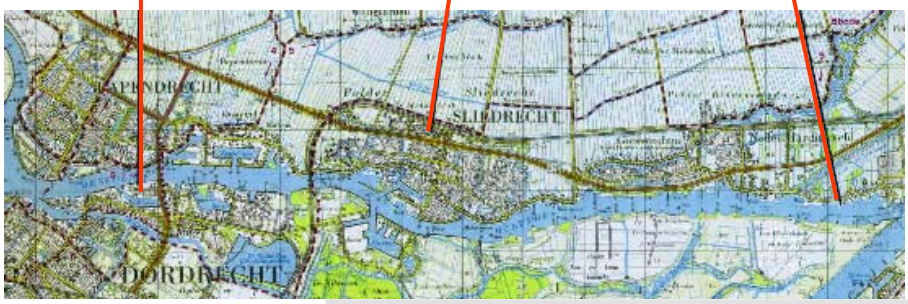
Dredging industry

KROHNE Altometer - History

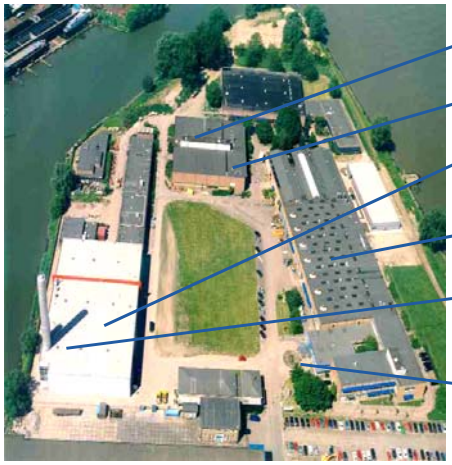
Dordrecht

Sliedrecht

Hardinxveld



KROHNE Altometer: Overview Production Facilities



Production UFM

KROHNE Oil & Gas Division

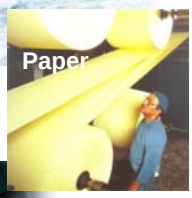
Production EMF
DN > 150

Production
EMF

Calibration
Facility

Main entrance
& Offices

KROHNE Customers



KROHNE is Innovation

There is always an OPTIFLUX for your application

OPTIFLUX: diagnostics

IFC 300
online diagnostics

- ✓ standard integrated
- ✓ continuous online checking of flow converter, flow sensor, process conditions
- ✓ improves availability

IFC 300 vitality check for reliability and cost reductions

KROHNE UFM is Innovation

KROHNE offers a complete range of liquid ultrasonic flowmeters

KROHNE UFM

KROHNE has an ultrasonic solution for all applications

Custody transfer

- World-famous ALTOSONIC V custody-transfer meter
- Dedicated ALTOSONIC III for light oil products

Process & Control

- UFM 3030 inline liquid ultrasonic flow meter
- Weld-on sensors with hot-tapping
- Channel mounted sensors
- Gas flow meters

Temporary & Portable measurements

- Clamp-on meters for portable measurement

UFM 3030
inline ultrasonic process flow meter for liquids

- Universal
- Easy to engineer
- Easy to install
- Easy to operate & maintain
- For a very attractive price

ALTOSONIC III
Dedicated Ultrasonic Flowmeter
for **Custody Transfer** of
light crudes & refined products

- Cost effective
- Eliminates maintenance
- Long term stability; high reliability

ALTOSONIC V

- first ultrasonic flowmeter for:

- **Custody Transfer of multiple liquid hydrocarbons**
- **Fiscal metering**
- **Master metering**

- **Top of the line performance**
- **A complete & Customized solution**

KROHNE: A Symbol for Quality

ISO 9001

ATEX

Pressure Directive (PED)

RVA accreditation

KWU
KTA 1401

CE

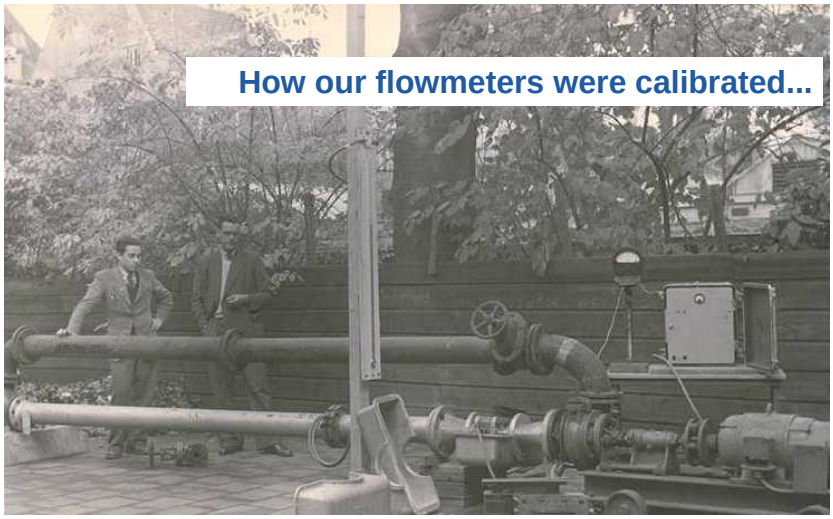
Factory Mutual System Approved

KROHNE Calibration Facilities

the largest
the highest
the most accurate!

- Standard wet flow calibrations for each flowmeter leaving the factory
- Flow meter sizes from 2.5 mm to 3000 mm
- 8 piston provers and 2 calibration towers
- RVA accreditation by NMi traceable to (inter)national standards
- Max. flow rate: 30.000 m^3/hr
- Uncertainty down to 0.02%

Long History of Calibration



Piston Prover Test rig 3

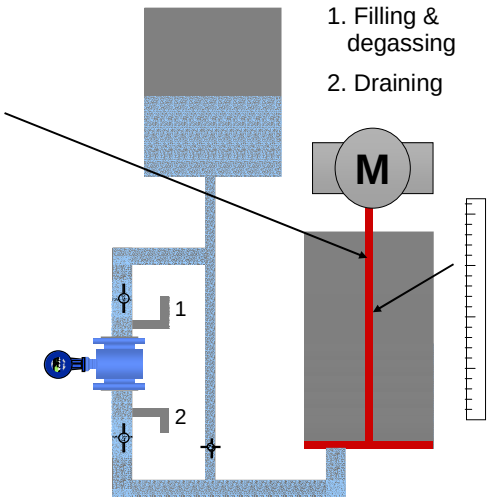
RvA accreditation

RAAD VOOR ACCREDITATIE

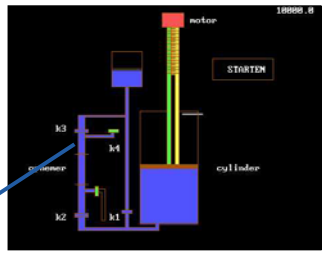
Calibration meter sizes: DN 25 - 150 (1” - 6”)
with RvA flow range: 0,0001 - 0,03 m^3/s

Calibration: Piston prover

- The movement of the piston is determined with a ruler mounted on the piston rod
- The displaced volume is calculated from the internal diameter of the cylinder and the measured displacement
- This volume is compared to the volume indicated by the flowmeter under test



Calibration: Piston prover



- Proving process is guided by a computer
- When carried out successfully, a calibration certificate is printed

Calibration: Piston Provers

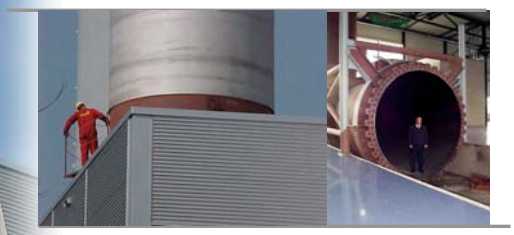
Overview Piston Provers

Name	Flow range [m³/hr]	Diameter range [mm]	[inches]	Uncertainty
Test rig 3 (*)	0.2 - 127	25 – 150	1.5 – 6	0.02%
Test rig 7	0.002 - 7.5	2.5 – 40	0.1 – 1.5	0.02%
Test rig 8	0.002 - 7.5	2.5 – 40	0.1 – 1.5	0.02%
Test rig 9	0.002 - 7.5	2.5 – 40	0.1 – 1.5	0.02%
Test rig 10	0.2 - 127	40 – 150	1.5 – 6	0.02%
Test rig 11	0.02 - 30	15 – 80	0.5 – 3	0.02%
Test rig 12	0.2 - 127	15 – 150	0.5 – 6	0.02%
Test rig 15	0.2 - 127	25 – 150	1.5 – 6	0.02%

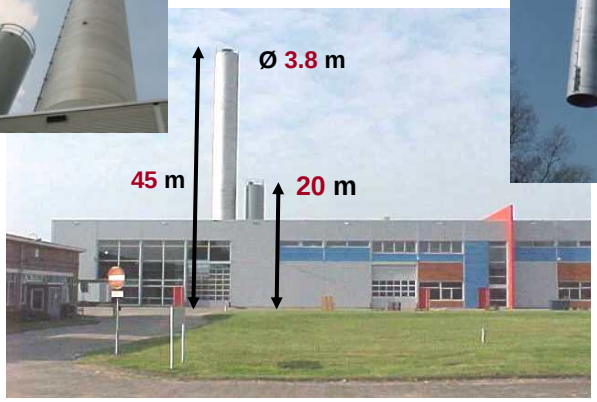
(*) RvA accreditation

Calibration Facilities

KROHNE's Dordrecht site houses the most accurate flow calibration rig in the world for high flow rates up to 10 m^3/s



Calibration: Towers



Calibration Facilities

… and how we calibrate them now

- Our calibration procedures guarantee flow measurements of the highest accuracy and absolute reliability of our flowmeters
- Standard every single flowmeter leaving the factory is wet-calibrated by direct volume comparison, the most accurate method there is.
- Calibration facilities:
  - 8 piston provers
  - 2 calibration towers

Traceable to international primary standards

Calibration Towers

World's Largest Calibration Rig

- Max. flow rate: 30.000 m^3/hr
  a flow of almost ½ million liters of water within 1 minute
- Flow meter sizes from 2.5 mm to 3000 mm can be calibrated
- Uncertainty down to 0,02%

Calibration Towers

Overview Towers

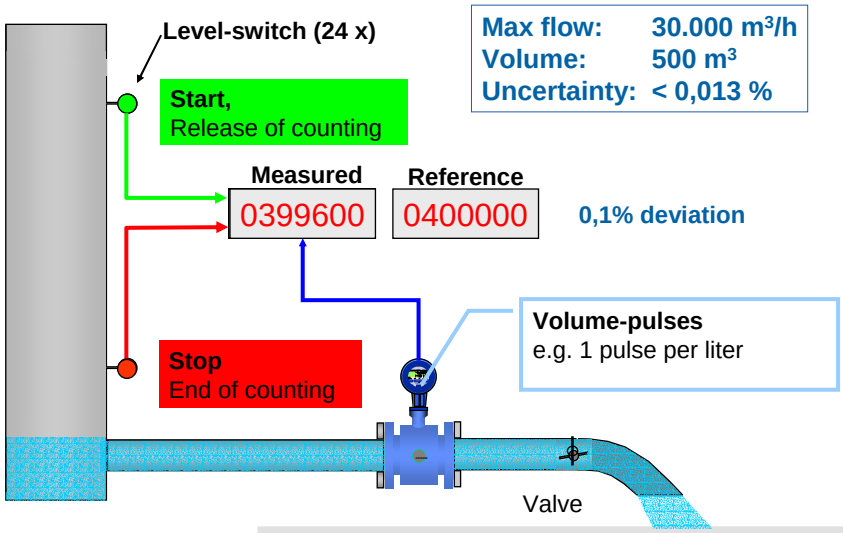
Name	Flow range [m^3/hr]	Diameter range [Mm]	[Inches]	Uncertainty
Test rig 4 (*)	11 - 30.000	200 – 3.000	8 - 120	0.03 %
Test rig 5	2.5 - 2.500	50 – 600	2 - 24	0.03%

* RvA accreditation

Calibration Towers

Overview Towers

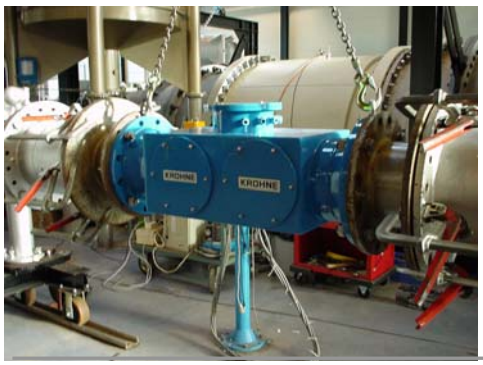
Max flow: 30.000 m^3/h
Volume: 500 m^3
Uncertainty: < 0,013 %



Calibration Towers

Installation of a flowmeter

Standard Accurate Calibration



Calibration of KROHNE's most accurate ultrasonic flowmeter ALTOSONIC V (accuracy: ±0,20% of MV, repeatability: 0.04% (band)) on the calibration tower

Special Calibrations

Calibration of an EMF with diameter DN 3.000
for a water application

Analysis of uncertainty

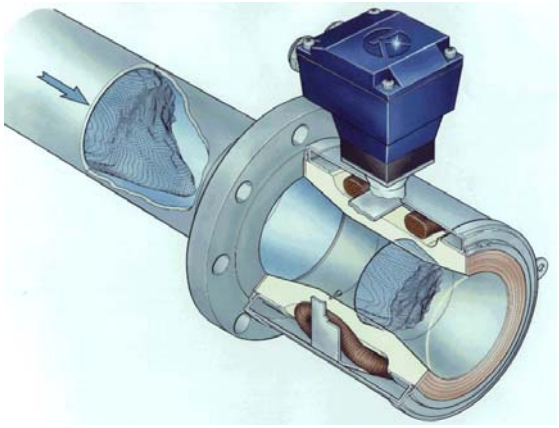
Uncertainty budget for Tower calibration rigs

First step: **Determination of volume in tower**

Equipment used:

- 2.200 ltr. Volume tank with active level switches for start/stop
  - Uncertainty 0,005% determined at NMi Dordrecht
    - based on 10 consecutive runs
    - Uncertainty for density of water included
    - Volume @ 20°C
- Master meter EMF type Krohne Profiflux IFM5080k
  - Flow profile optimisation inside
  - T_k stability by selection <10ppm/K

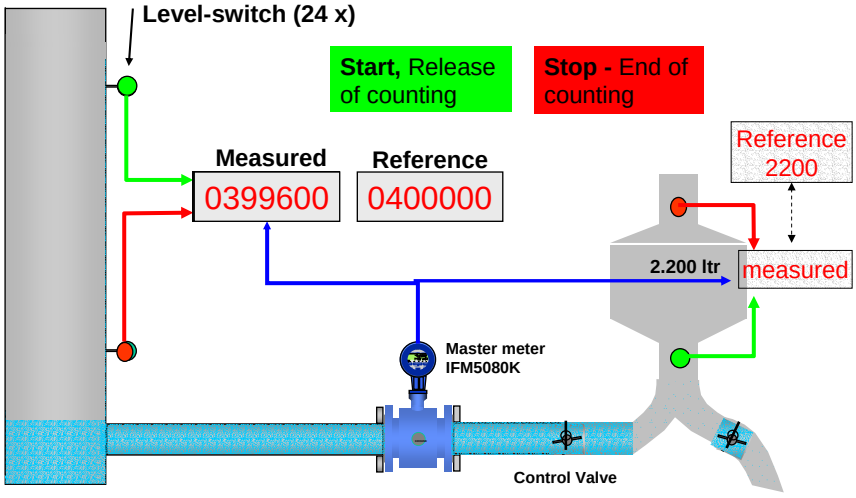
Master meter flow profile correction



Flow profiles measured by PTB Berlin:
Water, 20°C, DN 100, 85 m3/h
Left: 3 D downstream of gate valve, 25% open
Right: 5 D downstream of gate valve inside reduced measuring section of IFS 5000

Calibration Towers

Calibration of tower volume



Analysis of uncertainty

Uncertainty budget for Tower calibration rigs

- Determination of meter factor from master meter
  - Volume trough flowmeter corrected for compressibility
  - Volume in 2.200ltr tank corrected for temperature
    - Uncertainty for volume of 2.200ltr tank @ 20°C
    - Uncertainty in expansion coefficient of SS of the tank
    - Uncertainty for temperature in 2.200ltr tank
    - Uncertainty for static pressure in the master meter
    - Uncertainty for compressibility of water

Result is a meter factor determination with total uncertainty <0,010%

Analysis of uncertainty

Uncertainty budget for Tower calibration rigs

- Determination volume in tower by master meter
  - Indicated volume by master meter/meter factor
  - 10 runs of complete tower
  - Indicated volume corrected for temperature (assumption: Tower temperature is water temperature)
    - Uncertainty in indicated volume
    - Uncertainty for temperature of tower
    - Uncertainty thermal expansion coefficient of steel
    - Uncertainty in meter factor of master meter

Result:
Volume in total tower (over 370 m^3) uncertainty: < 0,013%
Uncertainty of any volume over 30 m^3: < 0,018%
Uncertainty of any compartment (smallest 11 m^3): < 0,026%

Analysis of uncertainty

Uncertainty budget for Tower calibration rigs

Second step: **Uncertainty of total calibration rig**

At normal testcondition for a meter under test we face the following uncertainties:

- Evaporation of water (estimated and calculated for minimum flow range 0,005 m^3/h)
- Water temperature change during calibration
- Absolute water temperature reading (assumed to be the tower temperature)
- Difference in water temperature measured and at the top of the water column
- Counted number of pulses from the meter under test (minimum specified to be over 20.000 pulses)
- Thermal expansion coefficient of the material the tower is made from

Result:

Under all these conditions a Uncertainty of the Tower is < 0,029% (calculated according EA-4/02)

Analysis of uncertainty

Uncertainty budget for Piston Prover calibration rigs

First step: **Determination of cross-section of the cylinder**

Required equipment:

Mechanical length measurement equipment to measure the ID of the cylinder

- Measurements at 56 spots well distributed over the cylinder
- Cross-section calculation as an average for the cylinder
  - Uncertainty in measurement device
  - Uncertainty in cross-section partially deviating from the mean

Result:

One mean cross-section with uncertainty <0,004%

Analysis of uncertainty

Uncertainty budget for Piston Prover calibration rigs

Second step: **Determination uncertainty in electronic ruler**

Required equipment:

Mechanical length measurement equipment to measure the Displacement indication of the Ruler (Laser based equipment)

- Measurement of al increments of the Ruler (4µm intervals)
  - Uncertainty in measurement device

Result:

Uncertainty in minimum increments of the Ruler <0,001%

Analysis of uncertainty

Uncertainty budget for Piston Prover calibration rigs

Third step: **Determination uncertainty Displaced volume**

Out of cross-section and ruler increments a volume can be calculated. We then face the following uncertainties:

- Deviation between displaced volume from piston and water drained to the meter under test (remaining air in total system)
- Temperature of the cylinder against reading of instrument
- Temperature of ruler

Uncertainty for wear is proven to be neglectable

Result:

Uncertainty in flow < 0,014% (calculated according EA-4/02)

BMC

Definition Best Measurement Capability (EA-4/02 par 1.3) :

…smallest uncertainty…that an laboratory can achieve…performing routine calibrations of nearly ideal measurement standards intended to …reproduce a unit…, or when performing more or less routine calibrations of nearly ideal … instruments designed for the measurement of that quantity

New interpretation (RVA-Dutch Council of Accreditation) is :

BMC must include results proven in a Transfer Standard test program.

BMC

Definition Best Measurement Capability (EA-4/02 Appendix A) :

"Nearly ideal" means that the best measurement capability should not be dependent on the characteristics of the device to be calibrated. … it should be understood that such a device should be available.

If it is established that, in a particular case, even the most 'ideal' available device contributes to the uncertainty of measurement, this contribution shall be included in the determination of the best measurement capability…

Practically the last sentence comes into force for the unit flow.

Annex to ISO/IEC 17025 accreditation-certificate
number: **K 070**

of **KROHNE Altometer**
Calibration
Dordrecht

Valid from: **08-06-2004** until **18-12-2004** Replaces annex dated: **07-01-2004**

	Measured quantity, Instrument, Gauge	Range	Best measurement capabilities (k=2)	Remarks
7	FLUID QUANTITIES			
7.1	Gas and liquid flow			
	Liquid flow rate (water)	(0,005 – 5) m^3/s	0,04 %	PST4

Next challenging step:

To define a transfer standard for liquid flow
with uncertainty **<0,01%**