New NFOGM tool for ultrasonic liquid oil metering station uncertainty analysis

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THIS
SALE
Gulf
GALLONS
PRICE INCLUDING TAX
ACCURATE DELIVERY FROM 5GPM TO FULL FLOW AT ANY PRESSURE


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ACCURATE DELIVERY FROM 5GPM TO FULL FLOW AT ANY PRESSURE

NPD measurement regulations

Extract of Section 8 – Allowable measurement uncertainty:

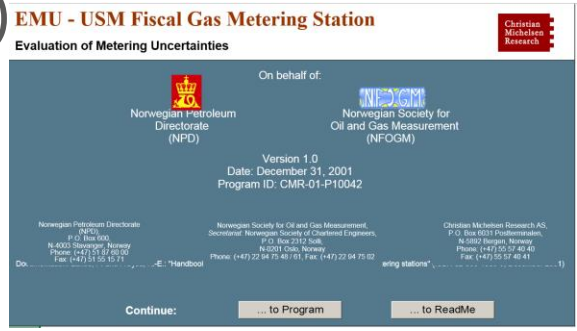
Measurement system	**Uncertainty limit at 95 percent (%) confidence level** *(expanded uncertainty with coverage factor k=2)*
Oil metering for sale and allocation purposes	0,30 % of standard volume
Gas metering for sale and allocation purposes	1,0 % of mass
Fuel gas metering	1,5 % of standard volume
Flare gas metering	5,0 % of standard volume
Sales measurement of LNG	0,50 % of measured energy contents per ship load

It shall be possible to document the total uncertainty of the measurement system. An uncertainty analysis shall be prepared for the measurement system within a 95 percent confidence level. In the present regulations a confidence interval equal to ± 2 σ, i.e. coverage factor k=2, is used. This gives a confidence level slightly higher than 95 percent.

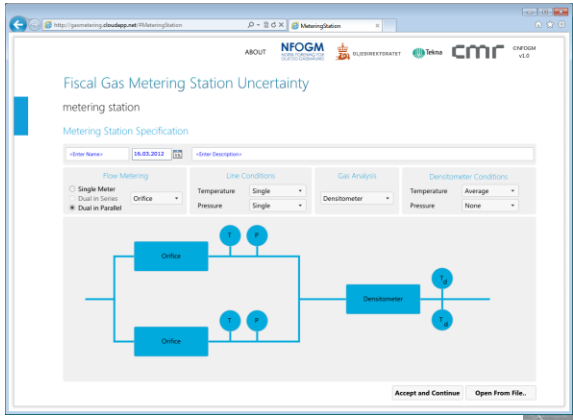
Handbooks for uncertainty calculations

Uncertainty evaluation of fiscal oil and gas metering stations:

- Orifice gas metering stations (1999 & 2003)
- Turbine oil metering stations (1999 & 2003)
- Ultrasonic gas metering stations (2001)
  - Excel-based uncertainty programs



- Gas flow metering stations (2012-14)
  - Silverlight-based uncertainty program



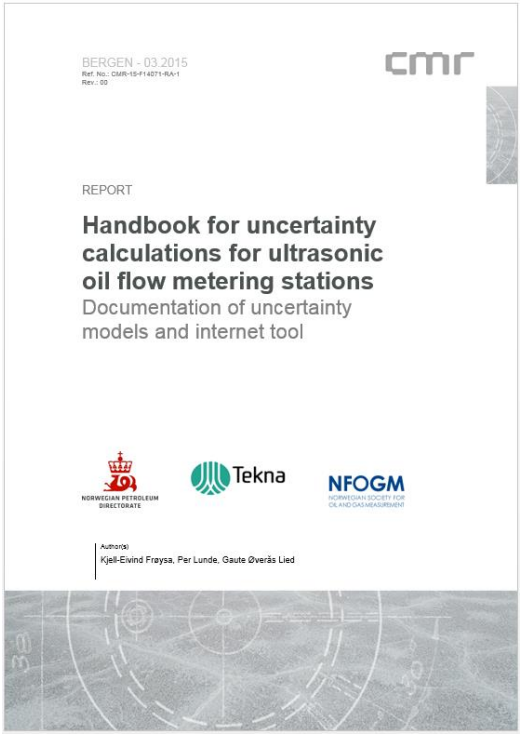
The current project

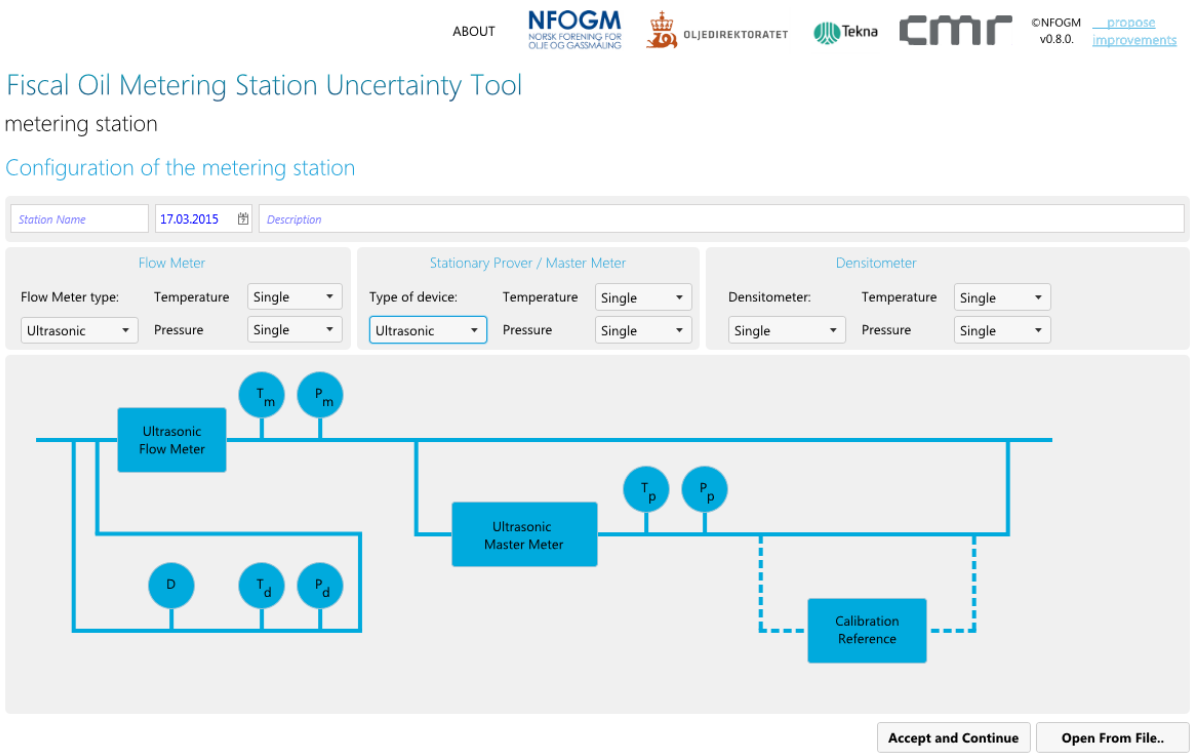
- Development of uncertainty model and user friendly tool for calculation of uncertainty of ultrasonic oil metering stations.
- (Similar to the project on gas metering stations carried out earlier.)

- Project carried out by CMR under a contract with NFOGM.
- Supported by NFOGM, NPD and Tekna.

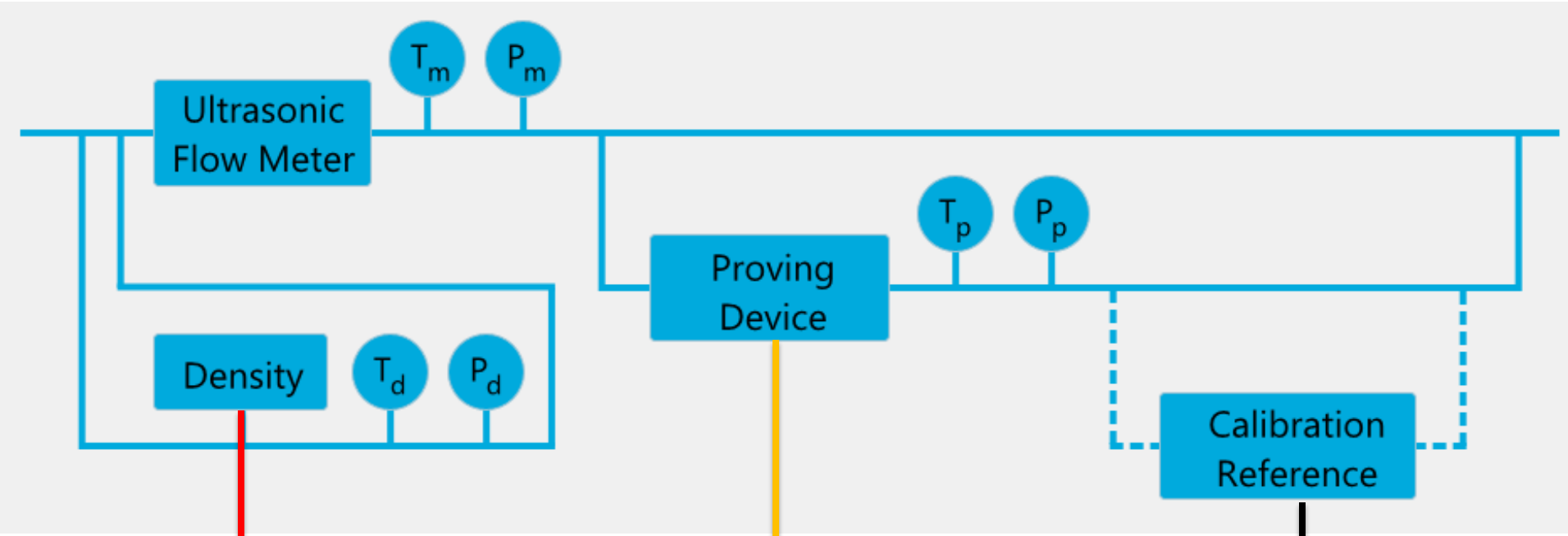
Output of project

- Handbook with documentation of the uncertainty model and the uncertainty program.
- Interactive, web-based tool for uncertainty analysis of ultrasonic oil metering station. (Microsoft Silverlight Technology.)





Lay-out of the metering station

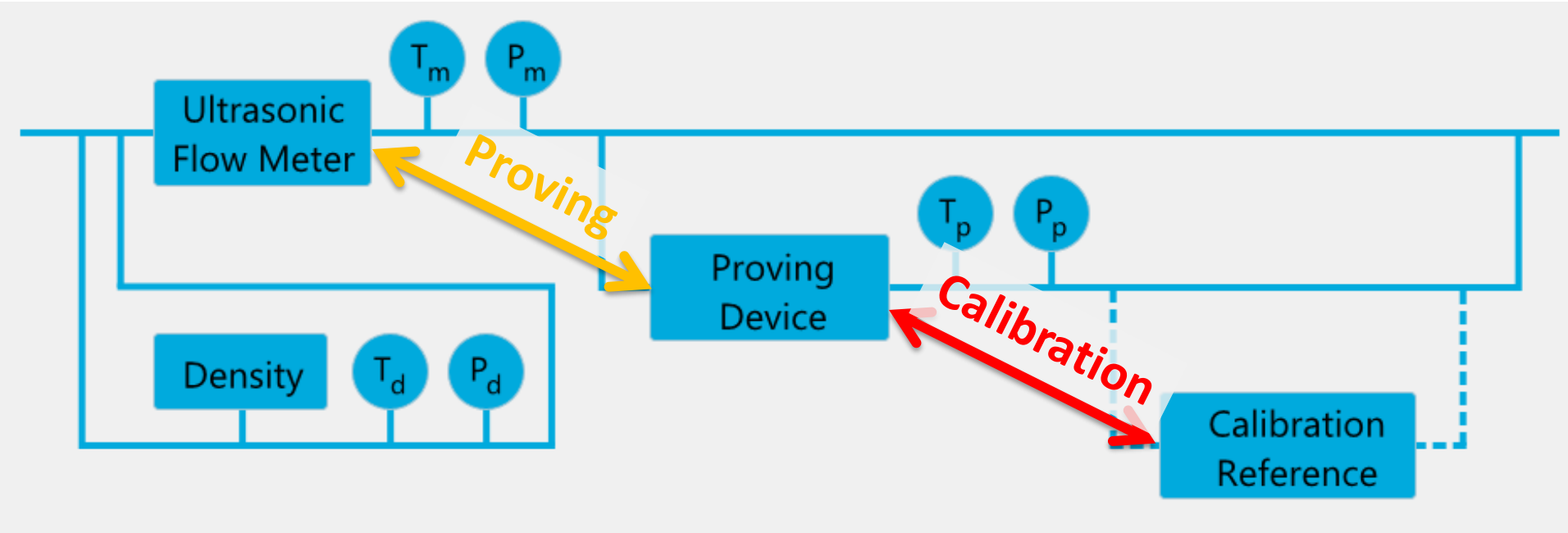


- Densitometer
- Sampling and analysis
- *(Sediment and water not covered)*

- Displacement prover
- Ultrasonic Master Meter
- Turbine Master Meter

- On-site calibration
- Off-site calibration

Important concepts

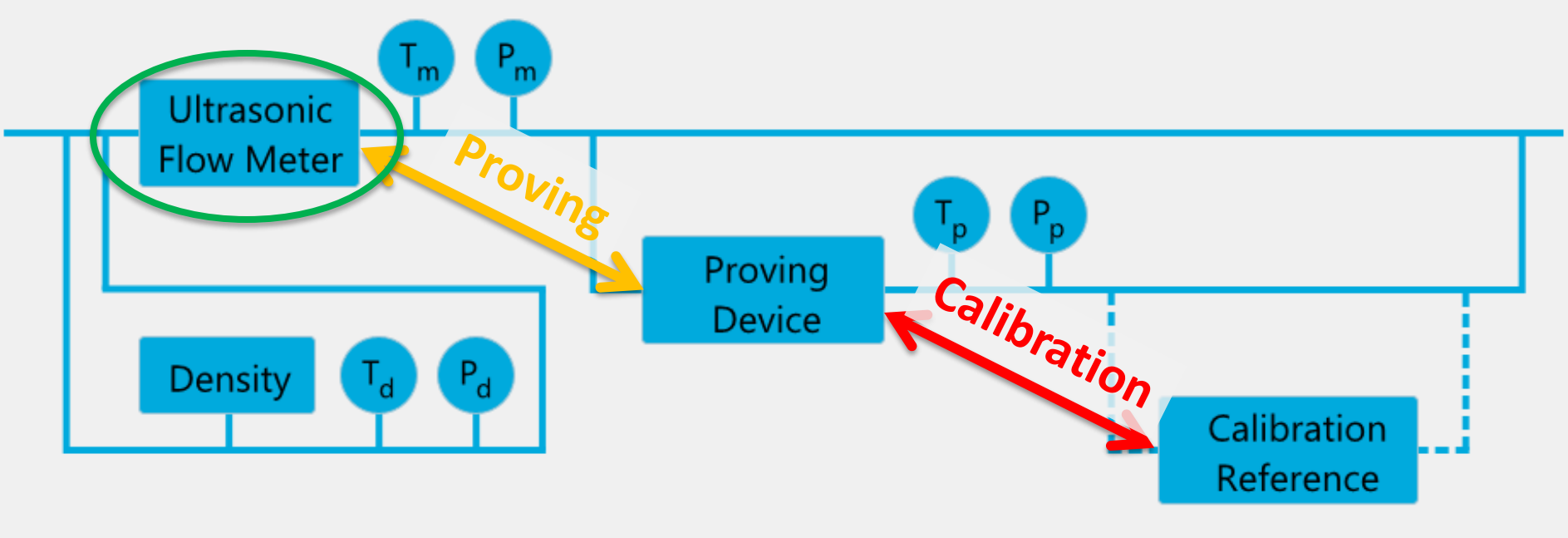


- **Calibration:** The procedure used to determine the volume of a prover.
- **Proving:** The procedure used to determine a meter factor

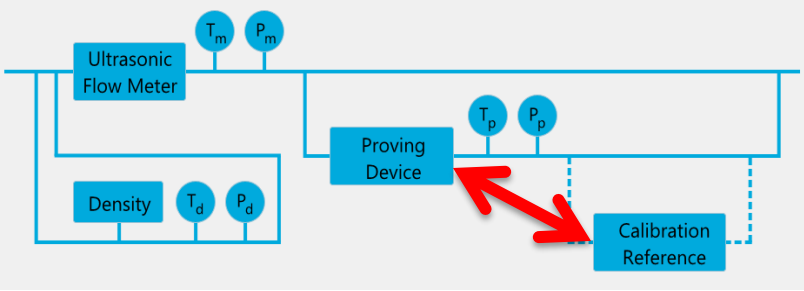
Ref. API MPMS Chapter 4.1 Proving Systems – Introduction

Uncertainty contributions

- Uncertainties related to **calibration**
- Uncertainty related to **proving**
- Uncertainty related to **duty operation**
- Uncertainty in **volume correction factors**



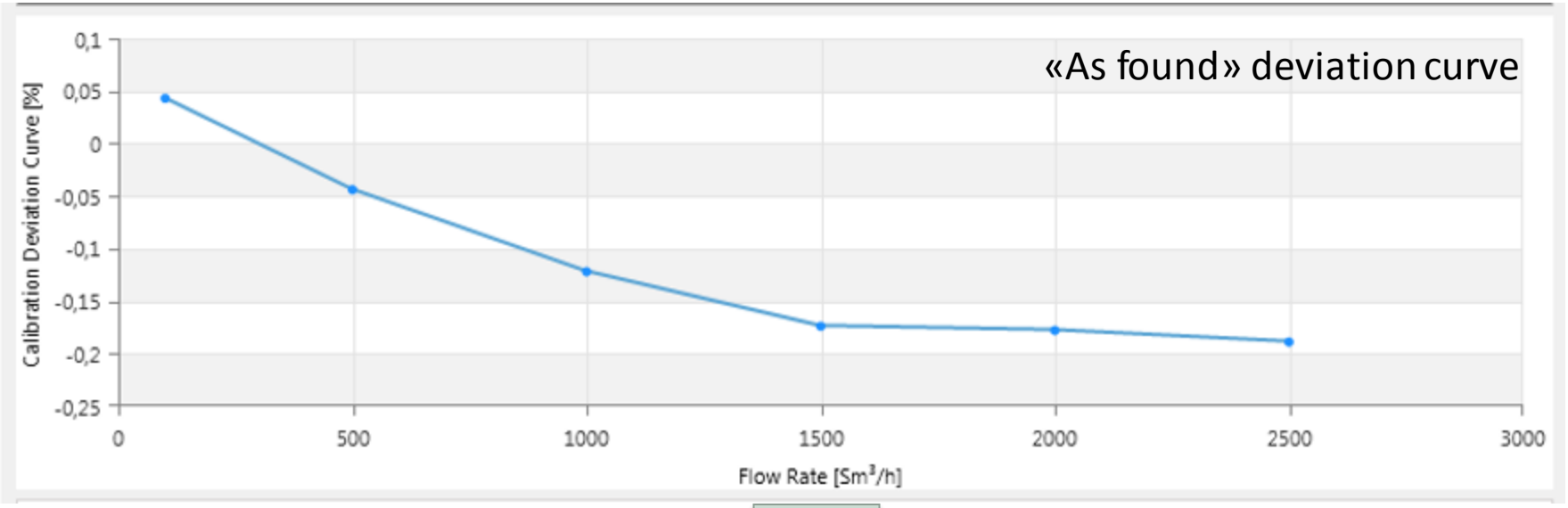
Uncertainties related to calibration



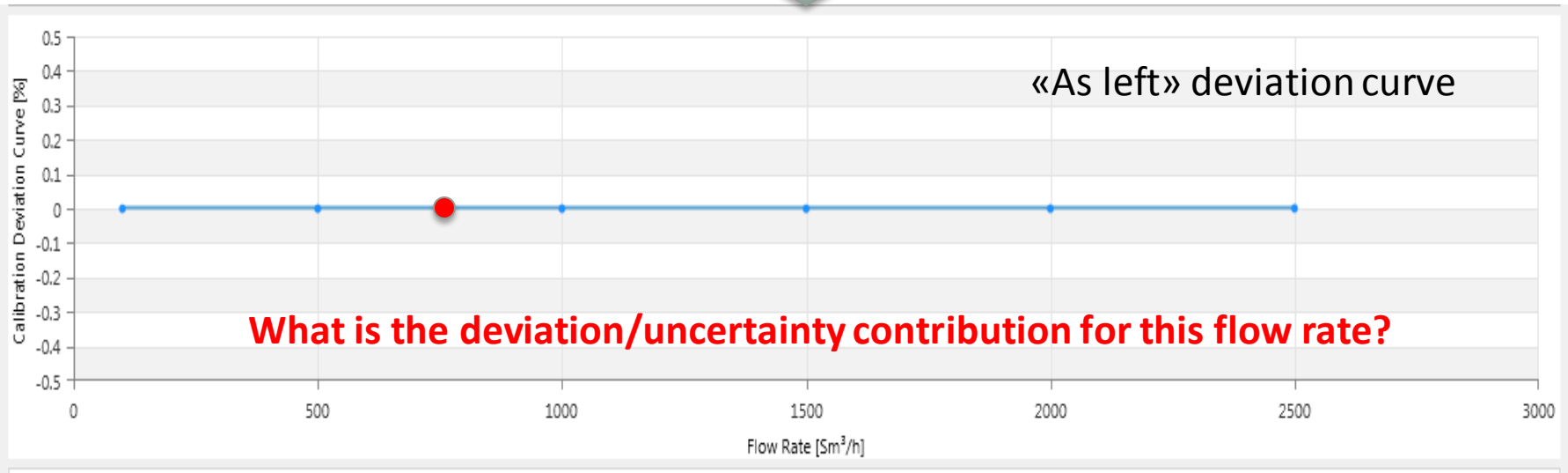
- **Calibration reference uncertainty**
  - Small volume prover, or
  - Flow laboratory
- **Repeatability**
  - NPD uncertainty requirement of 0.027 % for flow meter calibrations
    - number of runs per flow rate
    - maximum deviation

Run number	Flow rate	Meter factor
1	2112.22 Sm^3/h	1.0002
2	2113.41 Sm^3/h	1.0005
3	2111.73 Sm^3/h	1.0004
4	2112.67 Sm^3/h	1.0007
5	2112.01 Sm^3/h	1.0005

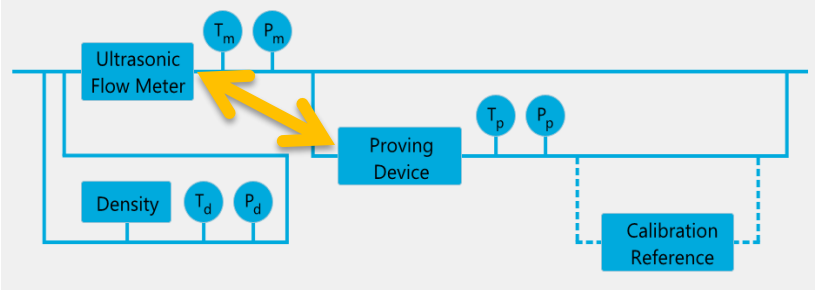
Uncertainty contributions



Linearisation



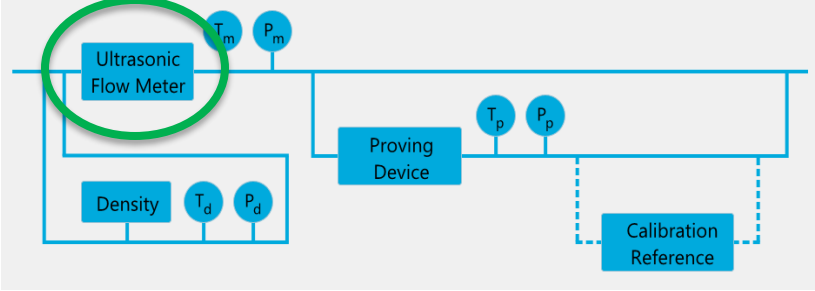
Uncertainty contributions



Uncertainties related to proving

- **Linearity**
  - Found from «as-found» deviation curve at calibration
- **Repeatability**
  - Number of runs
  - Maximum deviation
- **Flow profile and fluid effects on master meter**
  - Larger for off-site calibration than on-site calibration
  - Depends on type-testing of the meter type in question

Uncertainty contributions



Uncertainties related to metering

- **Linearity**
  - Due to variations in flow rate from proving
- **Repeatability**
- **Flow profile and fluid effects on flow meter**
  - Depends on
    - how often the meter is proved
    - process variations (flow rate, pressure, temperature, oil density and viscosity,…)

…a brief look through parts of the uncertainty program…

Fiscal Oil Metering Station Uncertainty Tool

metering station

Configuration of the metering station

Station Name | 24.02.2015 | Description

Flow Meter

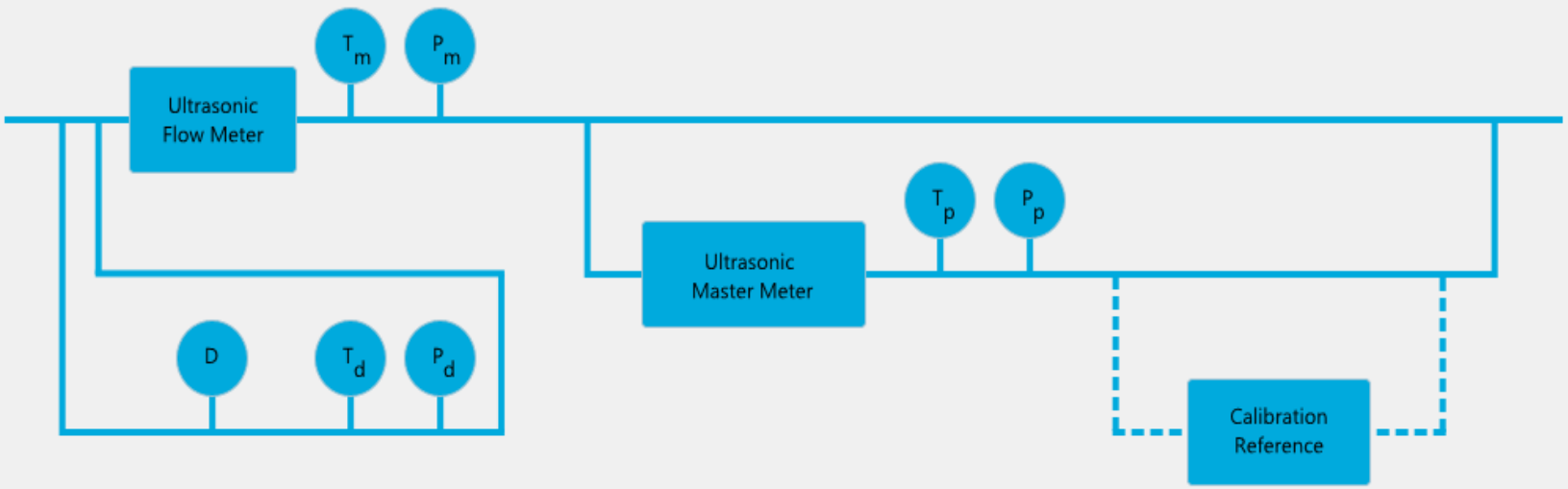
Flow Meter type: Ultrasonic | Temperature: Single | Pressure: Single

Stationary Prover / Master Meter

Type of device: Ultrasonic | Temperature: Single | Pressure: Single

Densitometer

Densitometer: Single | Temperature: Single | Pressure: Single



Accept and Continue | Open From File..

Fiscal Oil Metering Station Uncertainty Tool

Oil Properties

Input regarding oil product type and operating conditions like base pressure and temperature.

Specify density at reference conditions			
Oil density at reference conditions	ρ_o	800	kg/m³

Specify Oil Product Type (API standards or user defined)

(•) Crude Oil ( ) Fuel Oil ( ) Jet Group ( ) Gasoline ( ) Other

API Standard Constants for selected oil product type		
API Constant	K0	613.97226
API Constant	K1	0
API Constant	A	-1.6208
API Constant	B	0.00021592
API Constant	C	0.87096
API Constant	D	0.0042092

Specification of model uncertainties for Correction Temperature Liquid (Ctl) and Correction Pressure Liquid (Cpl)

Ctl Model Unc. :	(•) API	( ) User Defined [%, 95% conf.]	0.05
Cpl Model Unc. :	(•) API	( ) User Defined [%, 95% conf.]	0.096

Calibration of ultrasonic master meter

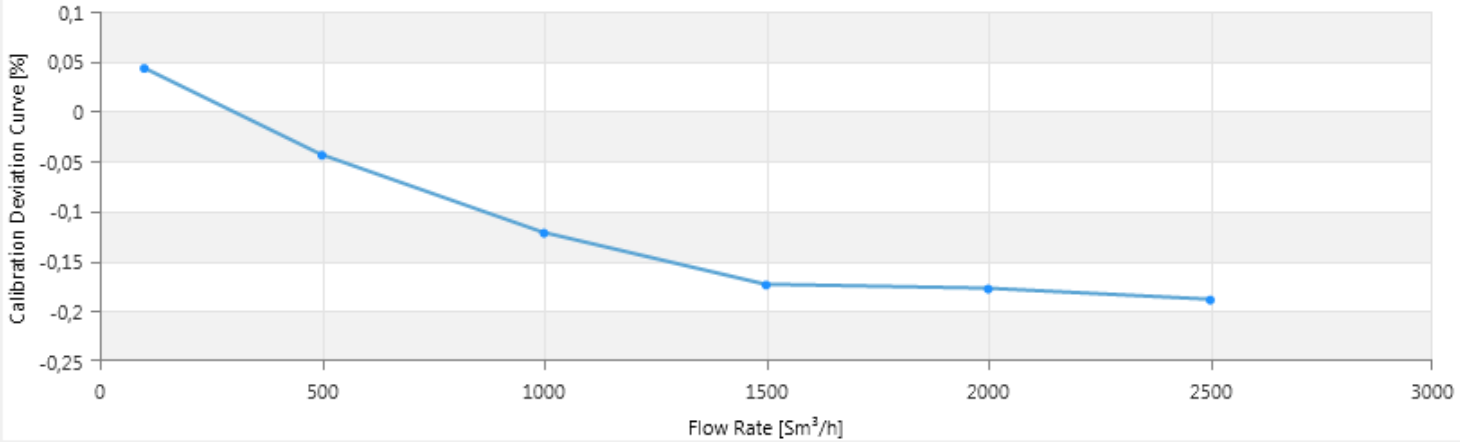
Input regarding calibration conditions and uncertainty in the calibration procedure.

CALIBRATION Conditions | MASTER METER Calibration

Uncertainty in calibration of master meter against calibration reference

Add Flow Rate Point **Remove Last Point**

#	Rate Sm^3/h	Calib. Ref. Uncertainty %, 95% Conf.	Deviation Curve (Uncorrected) %	Master Meter Repeat. %, 95% Conf.	Total %, 95% Conf.
1	100	0.031	0.043	0.027	0.0411
2	500	0.031	-0.044	0.027	0.0411
3	1000	0.031	-0.122	0.027	0.0411
4	1500	0.031	-0.174	0.027	0.0411
5	2000	0.031	-0.178	0.027	0.0411
6	2500	0.031	-0.189	0.027	0.0411



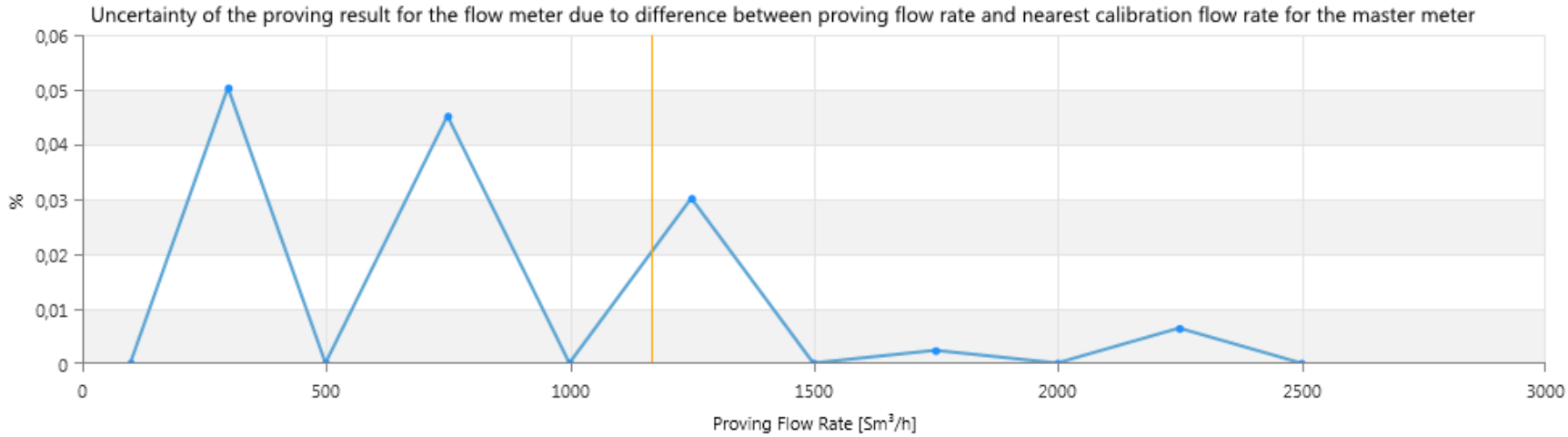
Documentation

Uncertainty in proving of flow meter against master meter

Proving Flow Rate: 1 166 Sm^3/h

Uncertainty Element	Uncertainty	Unit	Confidence	Std. Uncert. u_i	Sens. Coeff. s_i	Variance $(s_i \cdot u_i)^2$
Flow meter repeatability at proving	0.027	%	95% (norm)	0,0135 %	1,000 E+0	1,823 E-4 (%)^2
Master meter repeatability at proving	0.027	%	95% (norm)	0,0135 %	1,000 E+0	1,823 E-4 (%)^2
Flow profile and fluid effects on master meter	0.03	%	95% (norm)	0,015 %	1,000 E+0	2,250 E-4 (%)^2
Uncertainty contribution from difference in proving flow rate and calibration flow rates	0.02	%	95% (norm)	0,01 %	1,000 E+0	9,963 E-5 (%)^2

Sum of variances, $\Sigma (s_i \cdot u_i)^2$	0,0007 (%)^2
Relative Combined Standard Uncertainty	0,026 %
Relative Expanded Uncertainty (95% Confidence level, k=2)	0,053 %

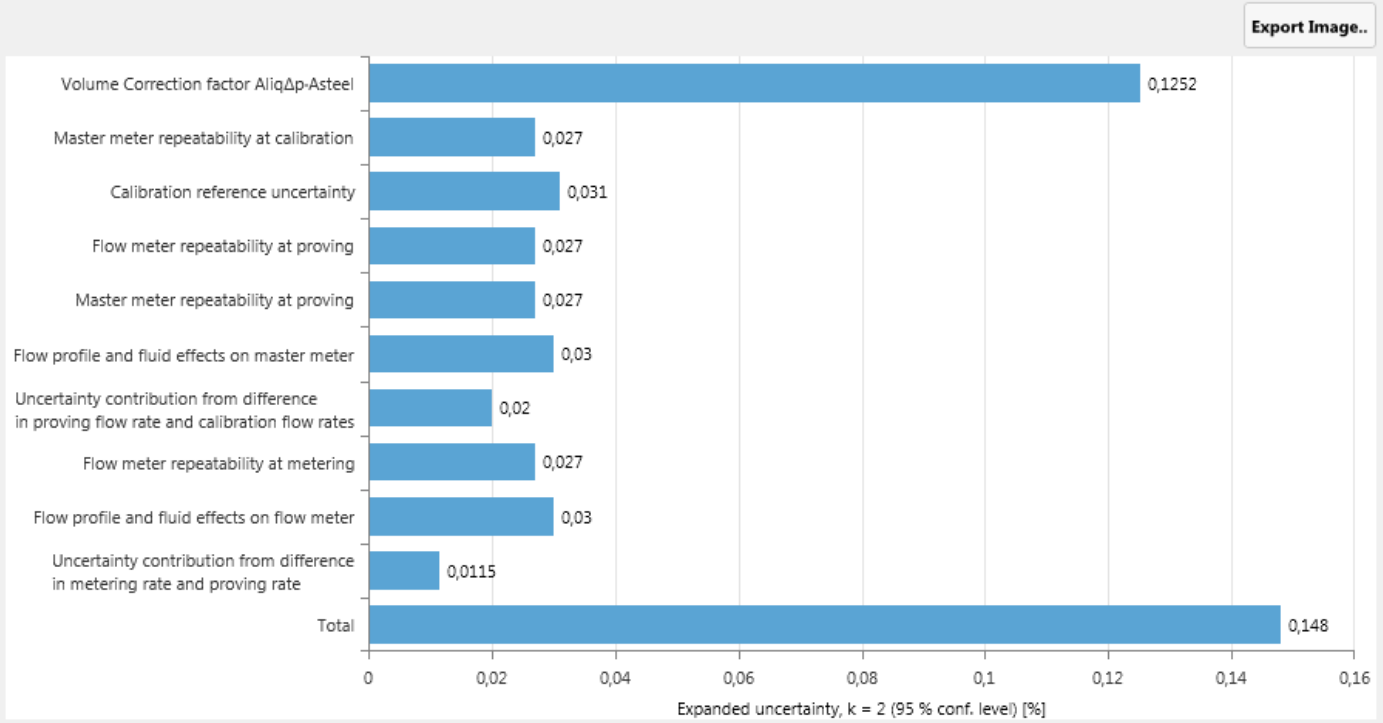


Documentation

Fiscal Oil Metering Station Uncertainty Tool

Uncertainty Budget Charts

USM Meter, Actual Volume Flow



USM Meter, Standard Volume Flow

USM Meter, Mass Flow

Proving, Proving Uncertainty

Metering, Metering Uncertainty

Oil, Reference Density

Volume Correction factor AliqΔp·Asteel

Volume Correction factor AliqmΔp·Asteel

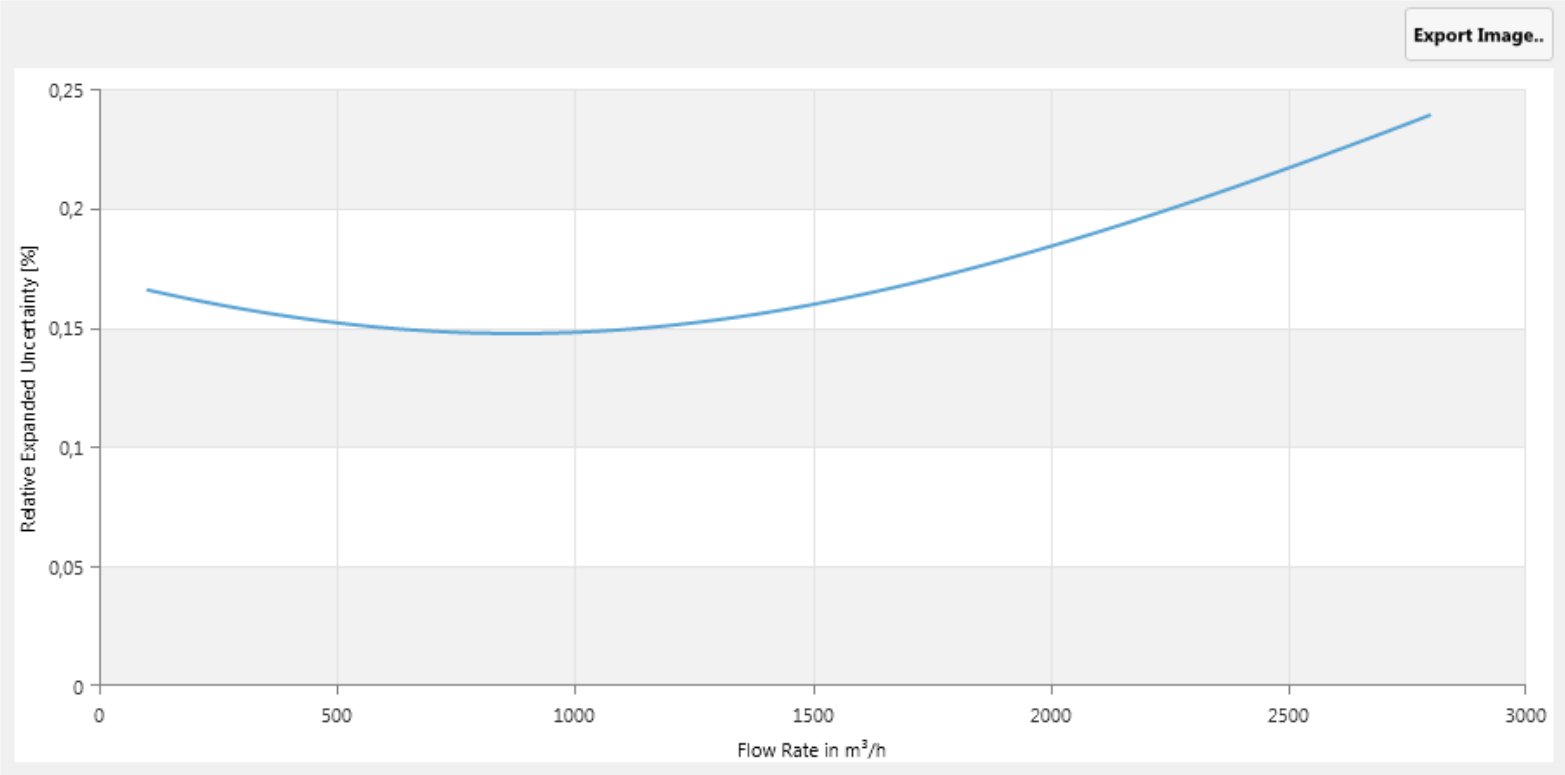
Volume Correction factor AliqΔmΔp·Asteel

Fiscal Oil Metering Station Uncertainty Tool

Uncertainty Range Plots

Flow Rate Range 100 to 2 800 Sm³/h kg/h m³/h

USM Meter, Actual Volume Flow



USM Meter, Standard Volume Flow

USM Meter, Mass Flow

Summary

- Interactive uncertainty program for ultrasonic oil metering stations.
- User-friendly input
- Easy to get an overall analysis
- Uncertainty analysis according to ISO GUM

- …finished within few weeks.