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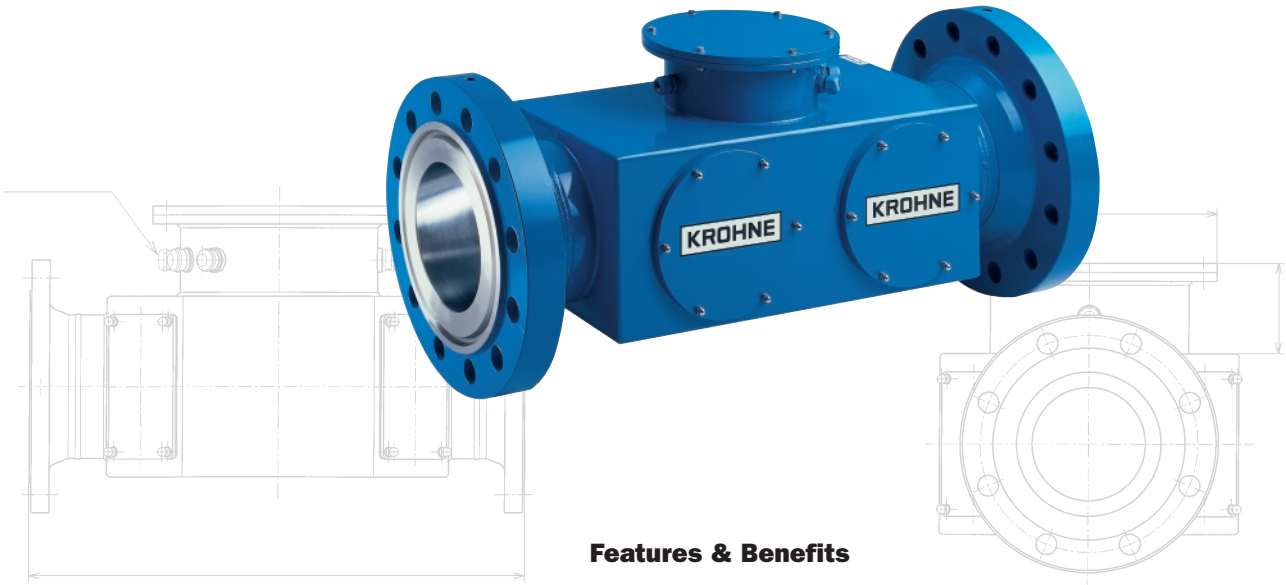
GR/PRINTO

ALTOSONIC V
Ultrasonic flowmeter system

for custody transfer of oil and oil products



Features & Benefits

- High accuracy
- Compliance with OIML
- Viscosity independent
- No moving parts, no wear
- Maintenance-free
- High dynamic range
- Multiple parameter outputs
- No periodical calibrations needed
- Negligible pressure loss
- Bi-directional flow measurement

ALTOSONIC V

Highly accurate ultrasonic flowmeter system
Innovative technology to set new standard in custody transfer

Introducing ALTOSONIC V

ALTOSONIC V is an unique flowmeter system for custody transfer flow measurement of hydrocarbons. It offers substantial improvements in accuracy and turndown required for custody transfer of high value petroleum products. Until now, ultrasonic flowmeters were not capable of meeting the stringent requirements for true fiscal and commercial metering. ALTOSONIC V is the first ultrasonic flowmeter in the world to gain approval for custody transfer applications defined by the OIML R-117 guidelines. ALTOSONIC V received type approvals from NMi and PTB.

Operating and maintenance costs of flow metering can be significantly reduced by ALTOSONIC V. Operating costs are low because there is negligible pressure drop and no filters are required. Maintenance is nearly none as there is no wear and periodical re-calibrations are not required.

ALTOSONIC V operates independent of the viscosity, which makes it ideal for measurements in pipelines handling different products. Re-calibration, and expensive calibration facilities, are no longer necessary, nor is the change of devices when changing products.

The principle of ultrasonic flow measurement is based on the difference in transit time of pulses sent up- and downstream. Depending on the viscosity, the flow in the center of the pipeline will be slightly faster than near the pipe walls. KROHNE Altometer introduced a five beam ultrasonic flowmeter, enabling an improved accuracy of the average flow measurement over the cross-section of the pipe.

KROHNE Altometer has over 20 years of experience in ultrasonic flow measurement. ALTOSONIC V has been developed in co-operation with and extensively tested in field applications by internationally recognised laboratories and multinational petroleum companies.

Features & Benefits

High measuring accuracy & repeatability

- Accuracy: ± 0.15% of measured value
- Repeatability: 0.04% band
- Viscosity independent (Q/v = 1:1000)
- Negligible effect of distorted flow profiles and swirl

High reliability

- Multiple beams ensure redundancy and validation of results
- Redundant electronics
- Internal diagnostics

Multi-measurement purposes

- Standard volumetric flow rate and totalization
- Additional information on Volume 15°C / 60°F (acc. to API), mass flow, reference density and VCF calculation possible with external transmitters

Low capital cost

- Large sizes available. High turndown ratio reduces the number of parallel flowlines i.e. instruments
- System includes meter body and flow processor
- No filters (strainers) required
- Long economic lifetime
- Easy and low cost installation
- Many options to suit wide range of (transfer) metering needs
- Bi-directional flow measurement possible

Low operational costs

- No change of devices necessary when changing products
- No re-calibration when changing products
- Negligible pressure drop, saving on extra pump capacity, and minimising flow problems

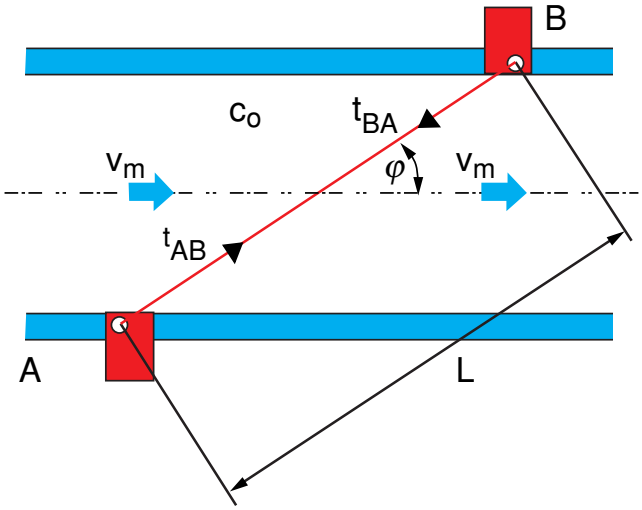
Low maintenance costs

- No (mechanical) moving parts. No wear
- No need for periodical re-calibrations
- Rugged and reliable design

Measuring principle

Basics of ultrasonic flow measurement

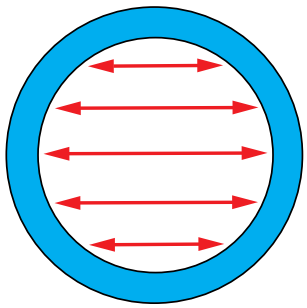
The ultrasonic flowmeter ALTOSONIC V is based on the difference in transit-time method. Two transducers, built-in at opposite sides of a pipeline, send receive acoustic signals through the flow in two opposite directions. One signal is sent downstream the flow and one is sent upstream, both along the same path. A sound wave travels faster with the flow than one propagated against the flow. The difference in both transit times is proportional to the medium's mean flow velocity.



A / B	Sensor A / B transmitter and receiver
C_o	Sound velocity of product
GK	Meter k-factor
L	Length of measuring beam
t_{AB}, t_{BA}	Transit time of ultrasonic waves from sensor A to sensor B and B to A
v_{AB}, v_{BA}	Propagation rate of ultrasonic waves between sensor A to B and B to A
V_m	Mean velocity of flowing liquid
φ	Angle between pipe axis and measuring beam

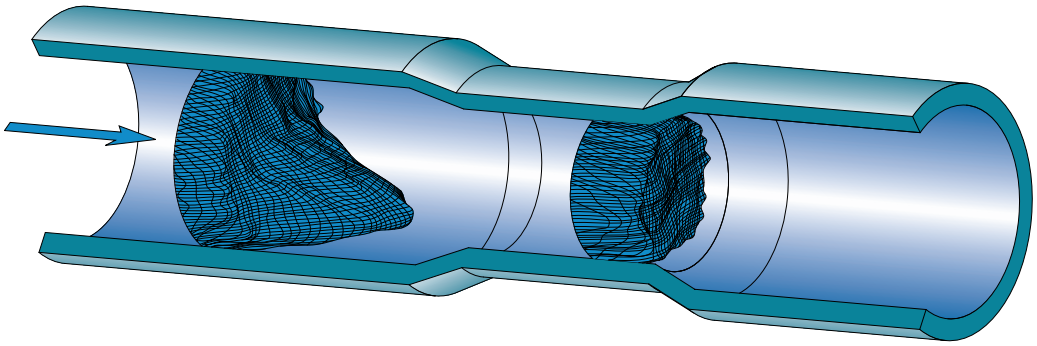
Multi-channel ultrasonic flow measurement

The accuracy of flow measurement depends on the flow velocity, pipe diameter and medium's viscosity. The Reynolds number reflects the distribution of the flow velocity over the cross section of a pipe. The shape of a flow profile can vary between constant (turbulent flow) and parabolic (laminar flow) depending on flow velocity, density, diameter, and viscosity.
ALTOSONIC V measures the average flow velocity along 5, in parallel, measuring beams thereby covering a large range of the flow profile across the metering section. Hence a wealth of information is available on the profile, both in laminar and turbulent flow conditions, and allows highly accurate measurements of the average velocity of a flow over the pipe cross-section. Also in situations with non-symmetric flow profiles and swirl the 5 measuring beams ensure accurate flow measurements. KROHNE holds a patent for this method, whereby flow measurements are independent of the flow profile and the Reynolds number.



Correction for flow profile disturbances

Much research has been done on how to reduce the flow profile dependence of ultrasonic flowmeters. For ALTOSONIC V a geometrical method is used to reduce this dependence based on the idea that an undisturbed, fully developed profile does not show any effects of flow profile dependence. With a confusor, disturbed profiles can be transformed in a shape approximating the original axisymmetrical undisturbed profile. The figure illustrates how the flow profile is transformed in the measuring section after the confusor.



Technical data

Outputs generated by flowmeter system (standard):

- Volumetric flow rate
- Volumetric flow totalization
- Sound velocity (for product identification)
- Identification of viscosity
- Indication of flow direction

Calculated output parameters based on external transmitters (optional):

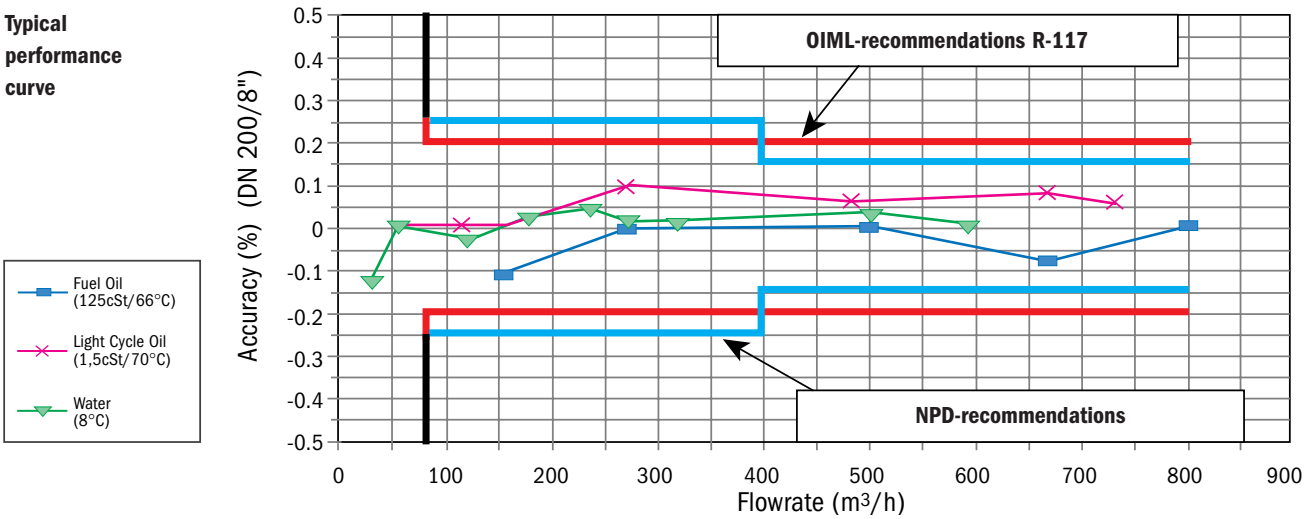
- Mass flow
- Mass flow totalization
- VCF (Volume Correction Factor) calculation according to API
- Volume computation and totalization according to API (e.g. 15 or 20°C/60 or 68°F)
- Reference density

Generated outputs in conjunction with external sensors (optional):

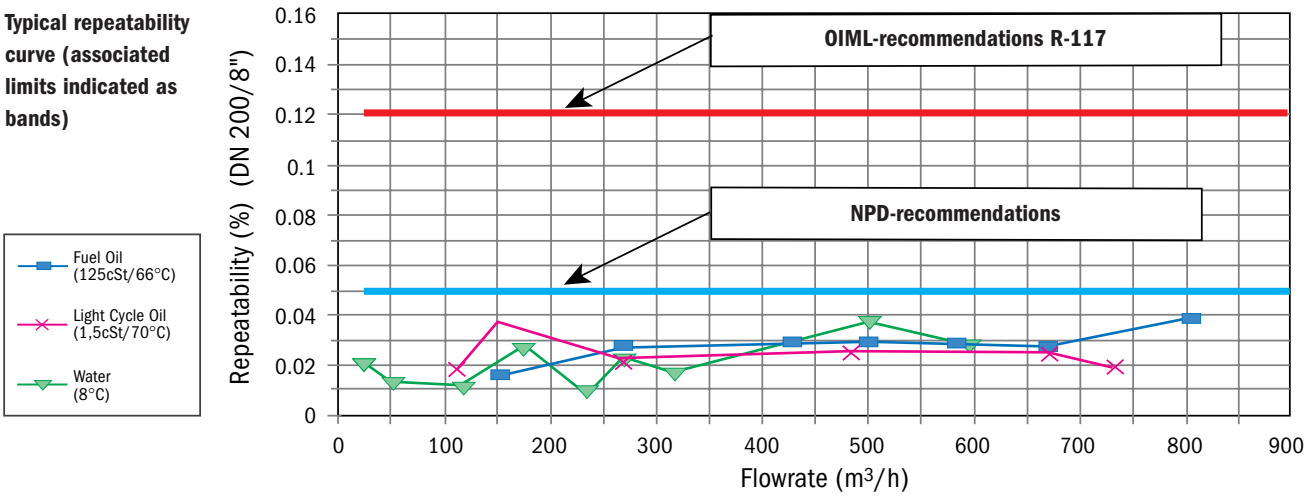
- Process temperature
- Process pressure
- Process density
- Viscosity

Performance (MV = measured value)		**ALTOSONIC V** performance	**Maximum permissible uncertainties according to ...** **OIML R-117 – Class 0.3**	**NPD**
Accuracy				
Turndown ratio	2:1	± **0.15** % of MV	± 0.20 % of MV	± 0.15 % of MV
	10:1	± **0.20** % of MV	± 0.20 % of MV	± 0.25 % of MV
	20:1	± **0.25** % of MV	–	–
Repeatability				
band		**0.04** %	0.12 %	0.04 % (laboratory conditions) 0.05 % (field conditions)

Typical performance curve



Typical repeatability curve (associated limits indicated as bands)



The complete flowmeter system

The ALTOSONIC V flowmeter system consists of three basic parts: the primary head or ultrasonic flow sensor (UFS-V), the signal converters (UFC-V) and the flow processor (UFP-V).

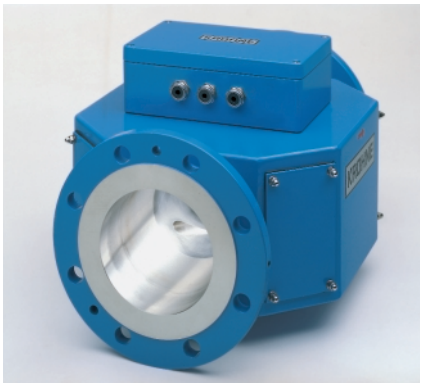
The primary head and the signal converter are suitable for mounting in hazardous areas. The converter is placed in a copperfree aluminium, explosion proof, cabinet.

KROHNE offers the option to install the flow processor either in the field or in the process control room. For the field (F) version the flow processor is placed in a cabinet identical to the cabinet of the converter. The process control room (19") version has display/operator interfaces.

In addition, for extra flow calculations ALTOSONIC V flowmeter system has options available to connect for example a temperature and pressure transmitter, a densitometer, a viscositymeter and a watercut meter to the flowmeter system.

Operating principle

A multi-channel flowmeter body with 10 sensors is installed in the pipeline. 5 Acoustic sensor pairs located in the flowmeter body are controlled by the UFC-V signal converter. The converter performs the actual flow measurement for the five channels. Raw data of each individual channel are sent to and processed by a flow processor (UFP-V).
The flow processor calculates the volumetric flow and can perform the flow computations as required.



UFS-V primary head

- Flowmeter system has multiple beams for higher accuracy and redundancy.
- The center part of the flowmeter tube is made of a solid block of metal with an inlet and an outlet cone where flanges are welded on. The cones ensure a symmetrical flow profile inside the measurement section of the primary head.
- The flowmeter construction allows for bi-directional flow measurements (option).
- The 10 sensors are made of an all-metal construction. The sensor housings are integrated in the flowmeter body. Their inner parts can be exchanged or serviced under full operating conditions without the need for re-calibration.

UFC-V signal converter

- The signal converters are placed in an explosion proof cabinet.
- The copperfree aluminium cabinet is suitable for mounting in hazardous areas and in offshore environments.
- Optional a cover cabinet in SS 316 material is available.
- The length of the coaxial sensor cables for the converters is 5 m (15 ft). Optional a cable length of 10 m (30 ft) is available.

UFP-V flow processor

- The flow processor calculates volumetric flow based on flow measurements from the 5 sensor pairs. As a result of the (corrected) computations, the system is insensitive to viscosity changes, and distorted flow profiles. KROHNE holds a patent for these (corrected) computations.
- As an option the flow processor is able to process inputs from pressure, temperature, density and viscosity transmitters for flow computations. Net volume according to API can calculated and outputted.
- The UFP-F version is for mounting in hazardous areas. The flow processor is placed in an explosion proof cabinet, identical to the UFC converter cabinet.
- The UFP-V 19" version is for mounting in the control room. The flow processor has a display and key pad.

Technical data

Inputs

Standard	**Digital inputs (4 inputs)**	Opto-coupler (12 V DC). Reset of alarms, reset of internal totalizers, start calibration, stop calibration,
	Pt 100 input (1 input)	Intrinsically safe. In use for primary head temperature measurement
Optional	**Analog inputs (4 inputs)**	Current 4 – 20 mA. Intrinsically safe. Input for e.g.
	for loop powered sensors	temperature, pressure and density transmitters. Others to be defined
	Pt 100 input (2 inputs)	Intrinsically safe. Input for temperature sensor.
	Frequency input (2 inputs)	0 – 5 kHz. Intrinsically safe. Input for densitometer. Other to be defined.

Outputs

Standard	**Pulse/frequency dual outputs**	0 – 1 kHz (the two signals are 90° phased shifted, optional 180° phased shifted) Function: Actual flow
	Analog outputs (1 output)	4 – 20 mA. Non intrinsically safe. Function Actual flow
	Contacts (4 outputs)	SPST contacts. NO (Normally Open) Contact rating: 125 V AC, ≤ 1 A / 30 V DC, ≤ 3 A Function: Forward flow, Reverse flow. Warning, Alarm
	RS 422 / RS 485	2 wire RS 485 (half duplex) or 4 wire RS 422 (full duplex) for Modbus protocol (master or slave). Functions: For transmission of various available output parameters.
Optional	**Analog outputs (2 outputs)**	4–20 mA. Intrinsically safe Function: Corrected volume, volume correction factor (VCF) (in conjunction with external transmitters)

Power Supply

UFC-V converter	**Voltage**	230 V AC Optional 100 V AC, 115 V AC, 24 V DC
	Frequency range	47–63 Hz
UFP-V flow processor (F & 19" version)	**Voltage**	230 V AC Optional 100 V AC, 115 V AC, 24 V DC
	Frequency range	47–63 Hz

Materials

UFS-V primary head	**Primary head & Flanges**	Stainless steel 316/316 L. Other materials (e.g. Duplex, SMO) on request
	Sensor & Sensor windows	Stainless steel 316/316 L. SMO on request
	Painting	RAL 5015. Other on request
	Cable glands	6 times M20 x 1.5 plastic. Optional: brass or SS 316
UFC-V converter	**Cabinet**	Copper free Aluminium AISI 12 according to ISO 3522-81
	Option: cover cabinet	Stainless steel 316
	Painting	RAL 5015. Other on request
	Cable glands	5 times M20 x 1.5 Brass. Optional: SS 316 4 holes & plugs for M20 x 1.5
UFP-V flow processor (F version)	**Cabinet**	Copper free Aluminium AISI 12 according to ISO 3522-81
	Option: cover cabinet	Stainless steel 316
	Painting cabinet	RAL 5015. Other on request
	Cable glands	12 holes & plugs for M20 x 1.5 2 holes & plugs for M25 x 1.5
UFP-V flow processor (19" version)	**Frontpanel**	Aluminium
	Display	10.4" TFT colour. 640 x 480 resolution

Dimensions UFC-V converter & UFP-V flow processor

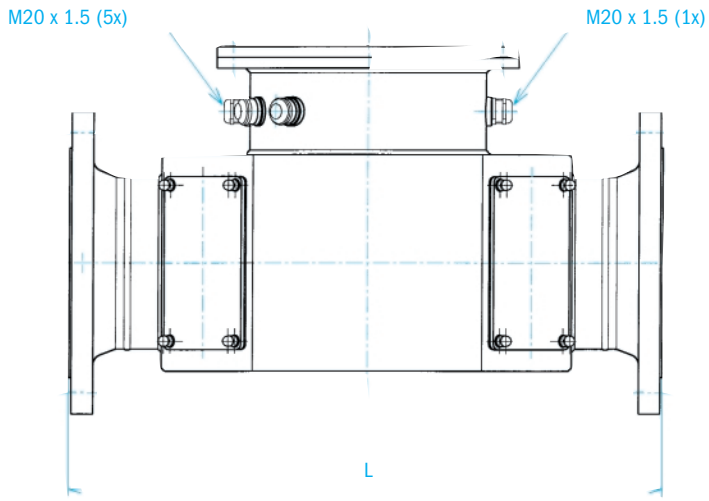
Dimensions in mm (inches)					
Explosion proof cabinet for UFC-V converter & UFP-V flow processor – F version					
According to **CENELEC:**	Length		Height		Width	
● Standard	560	(22.05)	380	(14.96)	295	(11.61)
● Optional cover cabinet	Available on request					
Optional according to **FM / CSA**	Available on request					

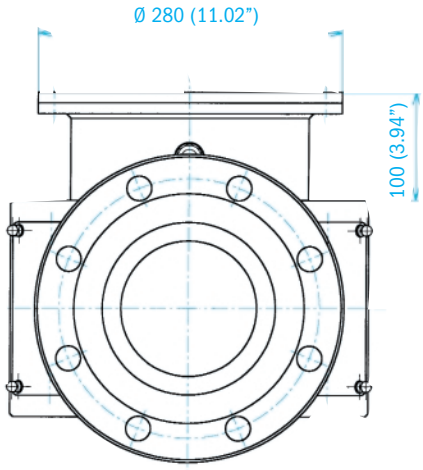
Dimensions UFP-V flow processor 19" version

Dimensions in mm (inches)	Height	Depth	
Computer	6 units	320	(12.60)
I/O rack	4 units	220	(8.66)

Dimensions & flange ratings UFS-V (primary head)

Meter size (nominal diameter) mm	inches	**Flange class**	**Overall length L** mm	inches
100	4	150 lb	500	(19.69)
		300 lb	500	(19.69)
		600 lb	550	(21.65)
150	6	150 lb	600	(23.62)
		300 lb	600	(23.62)
		600 lb	650	(25.60)
200	8	150 lb	900	(35.43)
		300 lb	900	(35.43)
		600 lb	950	(37.40)
250	10	150 lb	1000	(39.37)
		300 lb	1000	(39.37)
		600 lb	1100	(43.30)
300	12	150 lb	1100	(43.30)
		300 lb	1100	(43.30)
		600 lb	1100	(43.30)
350	14	150 lb	1200	(47.24)
		300 lb	1200	(47.24)
		600 lb	1200	(47.24)
400	16	150 lb	1300	(51.18)
		300 lb	1300	(51.18)
		600 lb	1300	(51.18)
≥ **500**	≥ 20	on request		





Flow tables

Flow rate **in m³/h**

Meter size		Minimum linear flow at turndown ratio of ...			Maximum linear flow
mm	inches	20 : 1	10 : 1	2 : 1	
100	4	14	28	140	280
150	6	30	60	300	600
200	8	60	120	600	1 200
250	10	90	180	900	1 800
300	12	125	250	1 250	2 500
350	14	175	350	1 750	3 500
400	16	225	450	2 250	4 500
450	18	285	570	2 850	5 700
500	20	355	710	3 550	7 100
600	24	500	1 000	5 000	10 000
700	28	690	1 380	6 900	13 800
800	32	900	1 800	9 000	18 000
900	36	1 135	2 270	11 350	22 700
1000	40	1 420	2 840	14 200	28 400

Flow rate in **BPH**

Meter size		Minimum linear flow at turndown ratio of ...			Maximum linear flow
mm	inches	20 : 1	10 : 1	2 : 1	
100	4	88	176	880	1 760
150	6	189	378	1 890	3 780
200	8	377	754	3 770	7 540
250	10	565	1 130	5 650	11 300
300	12	785	1 570	7 850	15 700
350	14	1 100	2 200	11 000	22 000
400	16	1 415	2 830	14 150	28 300
450	18	1 795	3 590	17 950	35 900
500	20	2 235	4 470	22 350	44 700
600	24	3 145	6 290	31 450	62 900
700	28	4 360	8 720	43 600	87 200
800	32	5 715	11 430	57 150	114 300
900	36	7 140	14 280	71 400	142 800
1000	40	8 915	17 830	89 150	178 300

Flow rate in **US Gallons/min**

Meter size		Minimum linear flow at turndown ratio of ...			Maximum linear flow
mm	inches	20 : 1	10 : 1	2 : 1	
100	4	62	124	620	1 240
150	6	132	264	1 320	2 640
200	8	264	528	2 640	5 280
250	10	396	792	3 960	7 920
300	12	550	1 100	5 500	11 000
350	14	770	1 540	7 700	15 400
400	16	990	1 980	9 900	19 800
450	18	1 255	2 510	12 550	25 100
500	20	1 563	3 126	15 630	31 260
600	24	2 200	4 400	22 000	44 000
700	28	3 050	6 100	30 500	61 000
800	32	4 000	8 000	40 000	80 000
900	36	5 000	10 000	50 000	100 000
1000	40	6 240	12 480	62 400	124 800

Application areas

ALTOSONIC V for Metering installations on:

- offshore platforms
- FPSO's
- tankers
- oil terminals
- refineries
- pipeline systems

ALTOSONIC V for measurements over a large viscosity range:

- crude oil
- liquid petroleum gases (such as butane, propane)
- refined oil products
- petrochemicals

ALTOSONIC V for Calculations and measurements for:

- custody transfer
- loading and offloading operations
- inventory control
- pipeline leak detection
- liquid identification
- interface detection in multi-product pipelines
- allocation measurements

Process conditions

Process liquids	Hydrocarbons, water, solvents, etc.
Viscosity range	Certified in range 0.2 to 150 mPas (higher viscosities have negligible effect on the accuracy)
Liquid density	490 – 1200 kg/m³
Process temperature	–20 to +120°C / –15 to +250°F
Ambient temperature	
standard UFS-V	–40 to +55°C / –40 to +130°F
standard UFC-V	–20 to +65°C / – 4 to +149°F
optional UFC-V	–50 to +55°C / –58 to +130°F
standard UFP-V F version	– 0 to +40°C / – 0 to +104°F
standard UFP-V 19" version	– 0 to +50°C / – 0 to +120°F
Operating pressure	ISO / DIN ratings to PN 100 ANSI class ratings to class 600 higher pressure ratings up to 250 bar (3 600 psig) / class 1500 on request
Full-scale range	
Flowrate **$Q_{100\%}$**	280 – 28 000 m³/h (for size DN 100 to 1000) 178 – 178 300 bph (for size 4" to 40") 1240 – 124 000 US Gal/min (for size 4" to 40")
Flow velocity **v**	0.5 – 10 m/s (1.5 – 30 ft/s)
Protection class	to IEC 529 /EN 60529
– UFS-V (Primary head)	IP 67 (equivalent to NEMA 6)
– UFC-V & UFP-V F version	
standard explosion proof cabinet	IP 55 (equivalent to NEMA 4)
optional with stainless steel cover cabinet	IP 65/67 (equivalent to NEMA 6)
– UFP-V flow processor (19" version)	Front panel: IP 65 (equivalent to NEMA 4)
Explosion safety	
CENELEC	for installation in Zone 1. EN 50 014, EN 50 018, EN 50 020
– UFS-V primary head	EEx ib IIC T6
– UFC-V converter	EEx d [ib] IIB T5
– UFP-V flow processor (F)	EEx d [ib] IIB T5
FM (factory mutual)/UL/CSA	Pending
EMC/low voltage	in conformity with CE Guidelines EMC and electrical safety CENELEC EMC standards EN 50 081-1 and EN 50 082-2
Vibration level	in conformity with IEC 068 2-29 bump tests and in conformity with random vibration tests to IEC 068

Installation

Mounting location	The primary head must be completely filled at all times	
Inlet/outlet sections		
Straight inlet run	20 D upstream, 10 D upstream with flow conditioner/straightening vane.	
Straight outlet run	5 D downstream	
Cables connecting ...	Maximum cable length	Type
UFS-V and UFC-V	5 m (15 ft) [Optional: 10 m (30 ft)]	Supplied by KROHNE Altometer: Five times coaxial transducer cables for the converter
UFC-V and UFP-V (F version) UFC-V and UFP-V (19" version)	1200 m (3940 ft)	Advised by KROHNE Altometer: Shielded twisted pair cable. RS 485
Restrictions acoustic attenuation	according to OIML R-117	
Gas bubbles	Limit: % Vol. under operating conditions ≤ 1%	
Solids	Guideline value: % Vol. ≤ 5%	

Type approvals

Dutch	NMi, No. 5076, 5077, 5078 and 5082
German	PTB, No. 5722, 6222 and 6422
GOS	GOS standard, No. 6690

Calibration of ALTOSONIC V

KROHNE Altometer calibration facility

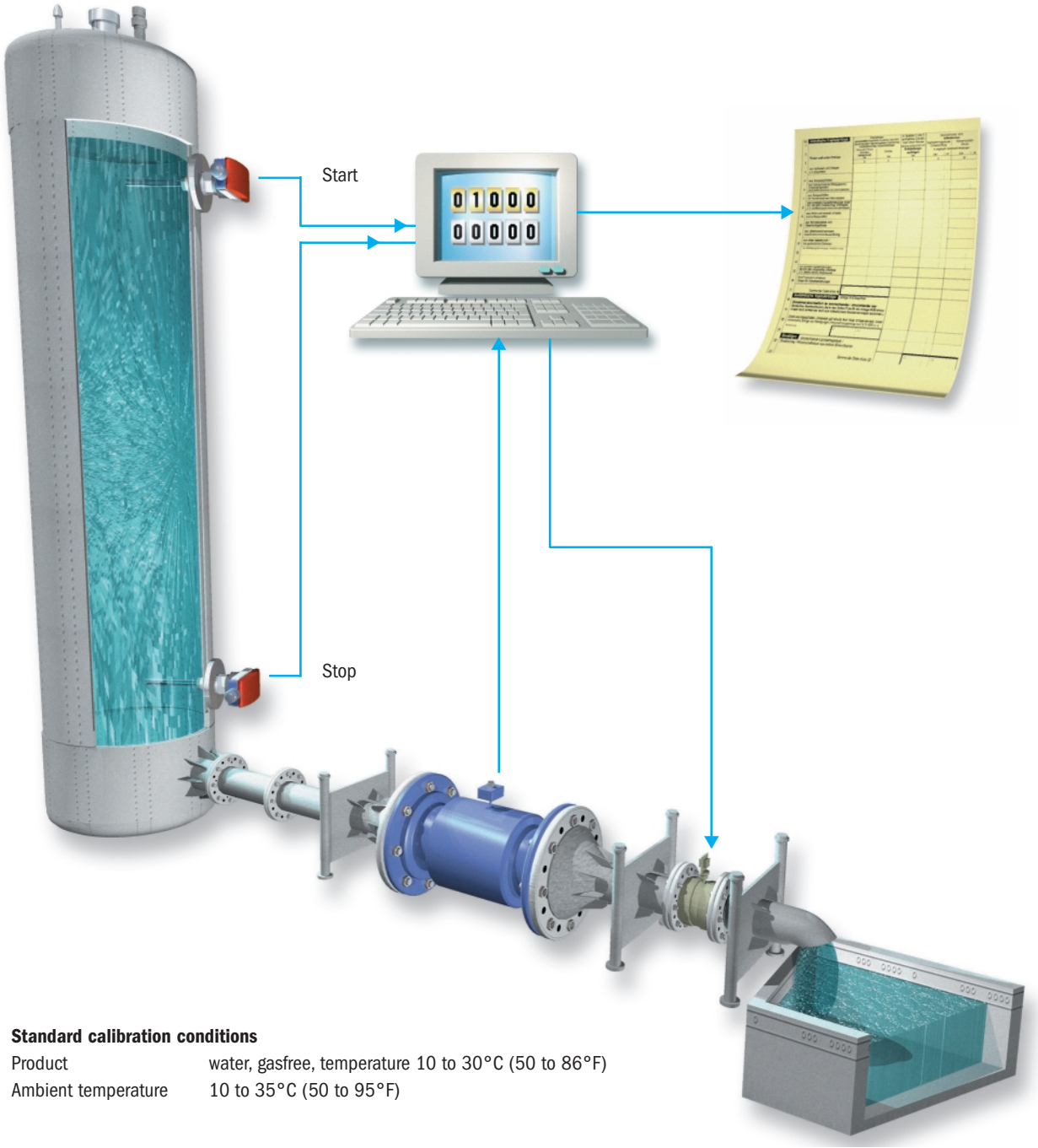
The KROHNE Altometer calibration rigs operate by direct volumetric comparison, the most accurate method for calibrating ultrasonic flowmeters. The test rigs are traceable to National Standards. The calibration installation consists of a prover tank with a nominal volume up to 400 m^3 (105 000 US Gal) and several counters controlled by a computer. Wet calibrations can be done for meter sizes up to 120" (3.000 mm) and flow ranges of 18 – 40 000 m^3/hr (80 – 175 000 US Gal/min). The best measurement uncertaintly of the certified calibration rig, tested by the Dutch Board of Weight and Measures NMi, is less than ± 0.013% of the measured volume.

Standard factory calibration on water

Standard factory calibrations on all ALTOSONIC V instruments are carried out on water against fixed volumes (measuring tower).
The standard calibration comprises of a 5 point linearity check and a repeatability measurement of 5 times at 75% of the flow rate.

Optional calibration on different viscosities

On request, ALTOSONIC V can be calibrated with different viscosities than water at other test laboratories according to customer specifications. Calibrations can be carried out on viscosities up to a maximum of 120 cSt and flow rates up to 4.000 m^3/h.



Standard calibration conditions

Product	water, gasfree, temperature 10 to 30°C (50 to 86°F)
Ambient temperature	10 to 35°C (50 to 95°F)