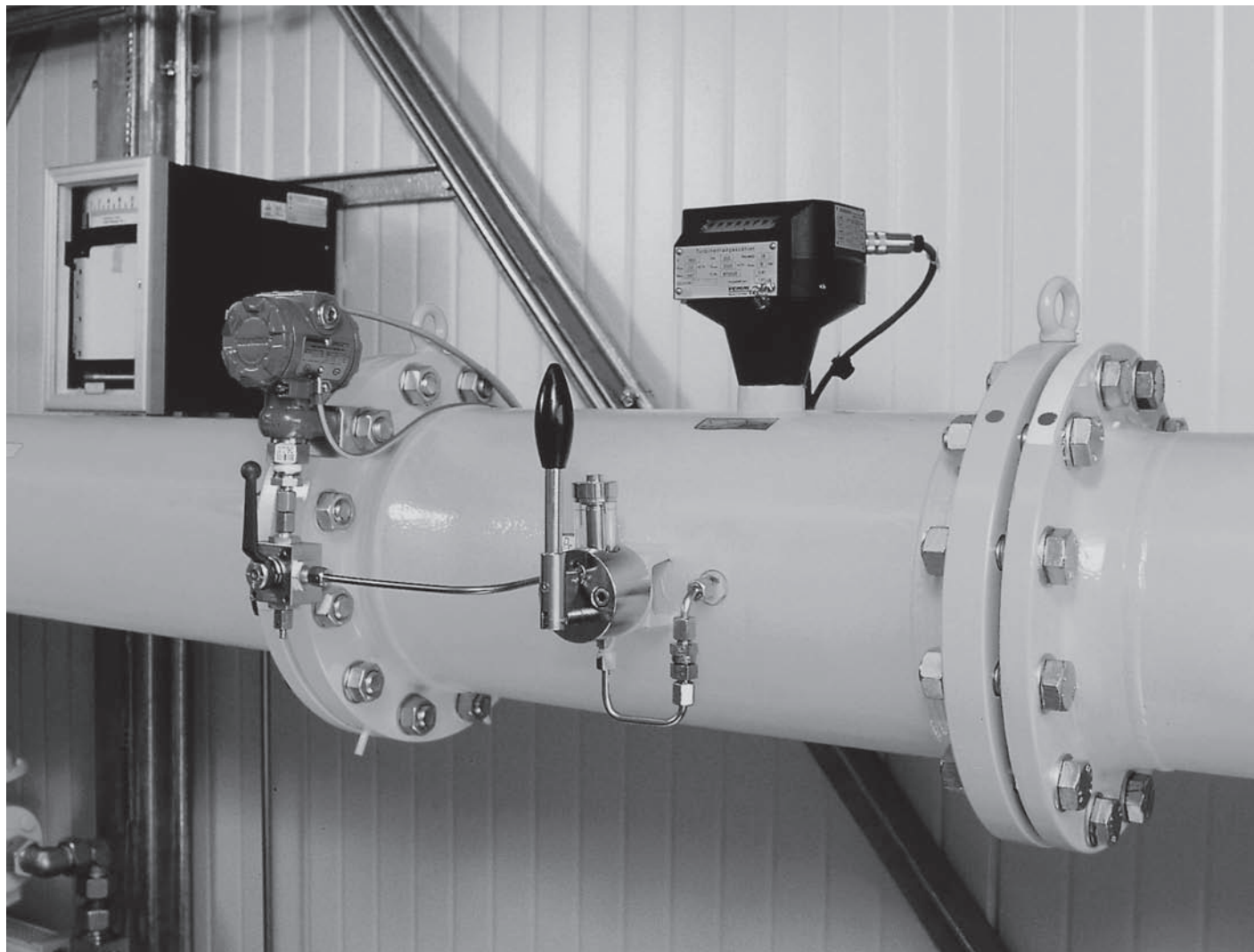


# **IGTM-CT Gas Turbine Meter** with electronic outputs and mechanical counter

## **Documentation and Technical Specifications**



**vemm**  
Messtechnik GmbH **tec**



## General

The **vemm tec** IGTM-CT Gas Turbine Meter is a highly accurate flow meter, approved for custody transfer measurement, equipped with electronic pulse outputs and a mechanical counter. This document explains the performance, ranges, dimensions, calibration and outputs of the instrument. It details the installation, safety requirements and material specifications.

The IGTM-CT measures gas volume flowing through an annular passage in the meter. The flowing gas volume is totalised on a local mechanical counter. In addition, low or high frequency pulse signals are generated to infer the gas flow and volume. The indicated gas volume is the actual volume flowing through the meter at the actual temperature and pressure. The IGTM is available in two models: CT and WT. The IGTM-CT is used for high accuracy and custody transfer applications. The IGTM-WT is an economically priced meter with a good accuracy and suitable for all other applications. A dedicated specification sheet is available for the IGTM-WT.

## Operation

The operation of the IGTM is based on the measurement of the velocity of gas. The flowing gas is accelerated and conditioned by the meter's straightening section. The straightening vanes prepare a steady flow profile and removes undesired swirl, turbulence and asymmetry before the gas enters the turbine wheel. The dynamic forces of the flowing fluid cause the rotor to rotate. The turbine wheel is mounted on the main shaft, with special high precision, low friction ball bearings. The turbine wheel has helical blades that have a known angle relative to the gas flow. The conditioned and accelerated gas drives the turbine wheel with an angular velocity that is proportional with the gas velocity.

The rotating turbine wheel drives the index head with the eight digit mechanical counter via shafts and gears.

The volume and flow rate can also be indicated electronically. A proximity probe generates a signal at each passing blade of the turbine wheel. With the device-specific K-factor and the number of pulses the passed volume can be calculated. With the measured frequency the flow rate can be determined.

## Sizes, Flow Rate and Flanges

The available nominal diameter of the IGTM-CT gas turbine meter ranges from DN 50 (2") to DN 600 (24"). Other sizes are available on request.

The IGTM-CT can be delivered with G rates ranging from G 40 to G 16 000, which means that IGTM-CT is available for flow rates from 7 m³/h to 25 000 m³/h. The MID approval is valid for meter sizes DN 80 (3") G 100 and above.

The relationship between G value and flow rate for each diameter is shown in table 3 on the last page of this brochure.

IGTM-CT meters with a Carbon Steel or Stainless Steel meter body can be manufactured either with ANSI flanges or with DIN flanges in the ranges:

- ANSI 150# RF - ANSI 600# RF (or ANSI 600 RTJ)
- PN10 - PN100

In case of a Stainless Steel meter body; please enquire for sizes above DN 150 (6")

IGTM-CT meters with a Ductile Iron (EN-GJS-400-18-LT) meter body are available in diameters from DN 50 (2") to DN200 (8") and with a pressure class PN10 - PN16 or ANSI 150# RF.

## Accuracy

Standard accuracy limits for the IGTM-CT are in accordance with the MID directive (2014/32/EU) and many other regulations:

- ± 1% for  $0.2 Q_t$  to  $Q_{max}$  (Range 1:20:  $Q_t = 0.2 Q_{max}$ )
- ± 2% for  $Q_{min}$  to  $0.2 Q_t$  (Range ≥1:30:  $Q_t = 0.2 Q_{max}$ )

As an option the accuracy limits can be improved to:

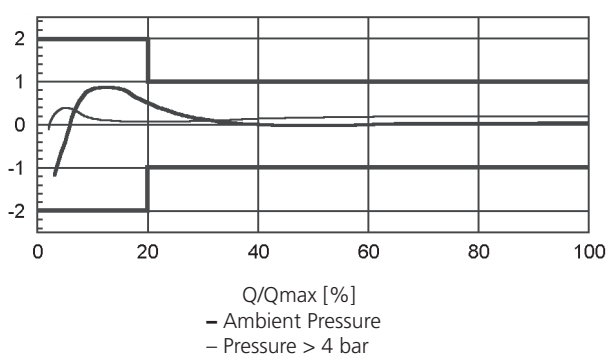
- ± 0.5% for  $0.2 Q_t$  to  $Q_{max}$
- ± 1% for  $Q_{min}$  to  $0.2 Q_t$

These limits are valid for the meter performance in ambient air. Performance is better with an application at high-pressure.

On request we can offer meters with better accuracy specifications. The repeatability of the **vemm tec** IGTM-CT is better than 0.1%. A typical performance curve at different pressures are shown in picture 1.

Picture 1

Performance curve [%]



## Approvals

The IGTM-CT is specifically designed in accordance with all relevant and published standards, like EC directives, EN 12261, AGA 7, ISO 9951 and OIML R137-1 (replacing R6 and R32).

Many national standards and laws are based on the above.

The IGTM-CT meter is approved for custody transfer in all European Community (EC) countries according to EC directive 2014/32/EU (MID). Metrological approvals are also obtained in Brazil, Algeria, Tunisia, Serbia, Malaysia, South Korea and China. Others are in process.

## Verification and Calibration

Gas flow meters for custody transfer purposes usually should have a verification (or legal calibration). Calibration can be performed at the calibration installation at our factory (traceable to PTB). Verifications according to MID Module D or F can also be arranged. Both will result in a (Verification or Calibration) Certificate, recognised by most Metrological Institutes.

Non-custody transfer meters can also be calibrated at our test installation. A calibration certificate will be provided.

In both cases (verification or calibration) a certificate with the measured values can be issued.

On request we can also take care for a high-pressure calibration, performed at our own high pressure calibration laboratory HPCL P5 (traceable to PTB) or at a certified independent institute such as NMI, PIGSAR, FORCE or EnBW (PasCaLab).

## Flow range

The flow range of gas turbine meters is mentioned in table 3 and laid down in the applicable approvals. The standard turn down ratio ( $Q_{min}:Q_{max}$ ) of an IGTM-CT is 1:20. This range is the standard performance when calibrated with air under ambient conditions.

With the DN 50 (2"), with special designs or with low density gases the range may be restricted. MID approved meters always have a range of at least 1:20.

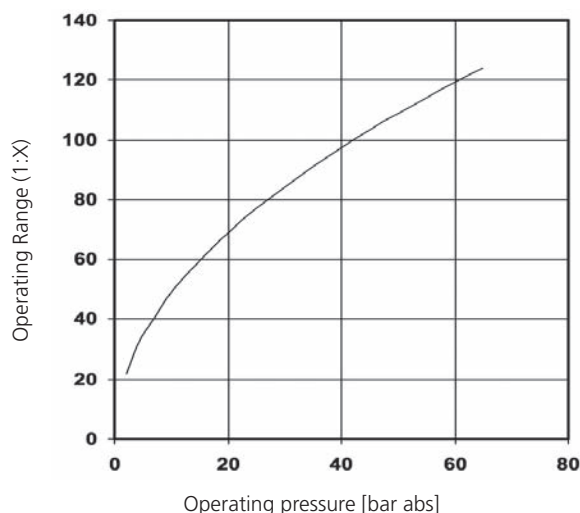
Meters with improved ranges of 1:30 or 1:40 are available. Please enquire.

At a higher pressure, the density of the gas increases and with an increasing density the available driving force at the turbine wheel increases. The larger force relatively decreases the influence of the bearing resistance and so decreases the minimum required flow  $Q_{min}$ . Because of this, the actual operating range increases:

**At higher pressures the flow range highly improves!**

Picture 2 shows this relationship.

Picture 2



Example: At 28 bar the operating range improved from 1:20 to 1:80

## Overload

The IGTM-CT is designed to deal with over-ranging of at least 20% of  $Q_{max}$ . Any over-ranging must occur slowly and without pulsations.

## Temperature Ranges

As standard the IGTM-CT is designed to operate at (gas and environmental) temperatures between -20 °C to +60 °C. Special low and high gas temperature designs are available on request. The MID approval allows operation between -25 °C to +55 °C.

## Pressure Loss

The pressure loss is an important design parameter of the IGTM-CT. The pressure loss is minimized as a result of the design of the internal flow conditioner and the shape of the channels upstream and downstream of the turbine wheel. The pressure loss of the IGTM at reference conditions (Natural gas under ambient pressure) is provided in table 3. The pressure loss under actual conditions depend on actual flow, pressure and density. Please refer to the IGTM Manual for more information.

## Gas Types

The IGTM-CT in its standard design can be used for all non-aggressive gases, such as natural gas, methane, propane, butane, city gas and fabricated gas, air, nitrogen, etc.

For aggressive gases, like sour gas and biogas, special designs are available with anodized parts, internal protection or special O-rings. Refer to table 1, for detailed requirements for different types of gases.

## Material of Construction

The materials of construction are listed in the table below.

Part	Material
Housing	Ductile Iron (EN-GJS-400-18-LT) Carbon Steel (Cast or Welded) Stainless Steel (on request)
Straightening Vane	Aluminium
Turbine Wheel	Aluminium
Metering Insert	Aluminium
Bearing Block	Aluminium
Bearings	Stainless Steel
Shafts	Stainless Steel
Gears	Stainless Steel or Synthetic Material
Magnetic Coupling	Stainless Steel
Index Head	Aluminium

## Index Head

The standard index head is equipped with a dedicated vent provision that prepares the meter for tropical use. The IGTM is certified for IP 67 applications. A high gas temperature index head can be supplied as an option.

The index head can be turned through 350° without violating the lead seal. An 8-digit non-resettable display shows the totalized volume. During the verification or calibration, the ratio of the adjustment gears is checked and (if necessary) adjusted to make the accuracy of the measurement as good as possible.

## Pulse Signals

Dependent on meter size, one revolution of the last (right hand) roll of the mechanical index can represent 0.1, 1, 10 or 100 m<sup>3</sup>. As standard, the index head is equipped with one low frequency Reed (contact closure) switch (1R1) of a high quality that gives one (de-bounced) pulse at one revolution of the last wheel of the counter.

As an option a Reed switch (1R10) can be provided that gives a 10 times higher frequency as the standard reed switch. A maximum of two Reed switches can be provided per meter. Every Reed switch is connected in series with a resistor and in parallel with a capacitor for de-bouncing the signal.

In the index head also a pulse/high frequency sensor (HF3) is provided as standard. This proximity sensor provides a middle-high frequency signal generated by a rotating impulse-disk. The signal is intrinsically safe in accordance with the NAMUR standard (EN60947-5/6) for intrinsically safe signals. A second (similar) sensor (HF4) can be installed in the index head as an option.

By installing optional HF sensors in the meter body, it is possible to sense each passing blade of the turbine wheel (HF1) and/or of the reference wheel (HF2). The detection is based on special proximity switches. The signal is also intrinsically safe in accordance with EN 60079-0 and EN 60079-11. Interface bar-

riers between hazardous area and safe area must be suitable for the application and are available on request.

The **vemm tec** IGTM-CT can be equipped with HF1/HF2 sensors only, without an index head. This option requires an electronic counter, a volume converter or a flow computer, to indicate actual and converted volume. For custody transfer purposes however, a mechanical counter is often a mandatory requirement.

## Lubrication System

The IGTM-CT is standard equipped with a lubrication system. The oil pump is dimensioned according to the size of the meter.

To achieve the long life of the IGTM-CT, regular lubrication is required. Typically, for clean gas applications, a 3-month interval between two lubrication services is recommended. Dirty gas requires a more frequent lubrication.

As an option the IGTM-CT models with PN10/16 or ANSI 150 flanges and a diameter  $\leq$  DN 100 (4") can be provided with lifetime lubricated bearings.

## Surface Treatment and Painting

Before applying a corrosion-protective layer, each ductile iron IGTM meter body is shot blasted SA 2.5. Carbon steel bodies are mechanically treated. The standard colour of the meter body is white (RAL 9001). Stainless steel bodies are supplied without coating. The colour of the index head is black.

Alternative surface treatments like other colours, special coatings or zinc treatments can be offered on request. These special treatments can improve the protection against corrosion.

## Material and Safety Tests

All IGTM-CT meters are tested in accordance with the appropriate standards and customer requirements:

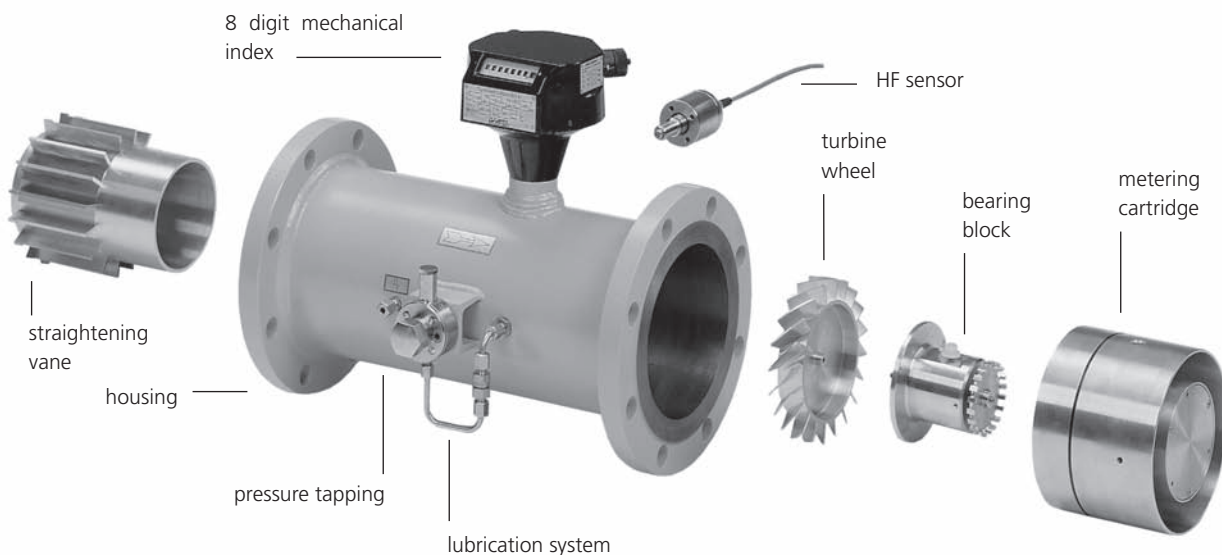
- Hydro test at 1.5 x maximum operating pressure
- Air seal test at 1.1 x maximum operating pressure
- Material certificate per EN 10204 3.1
- CE-PED compliance: Directive 2014/68/EU and 2014/32/EU (MID)
- Electronic sensors are approved according to ATEX

A certification package can be ordered as an option. Other tests like MI, TÜV certification, NDT and US testing and others are available on request.

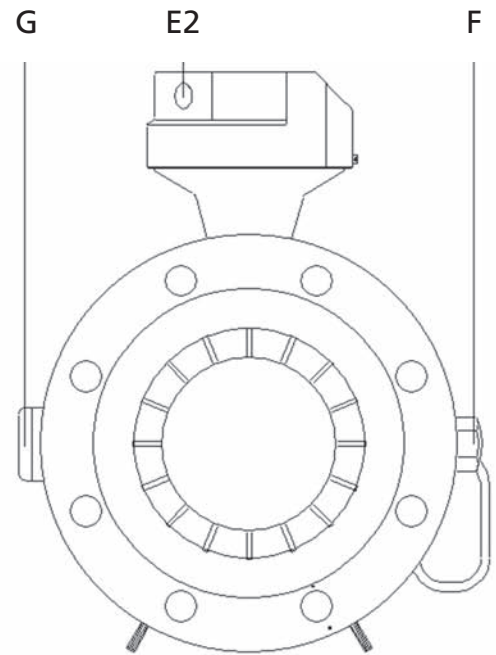
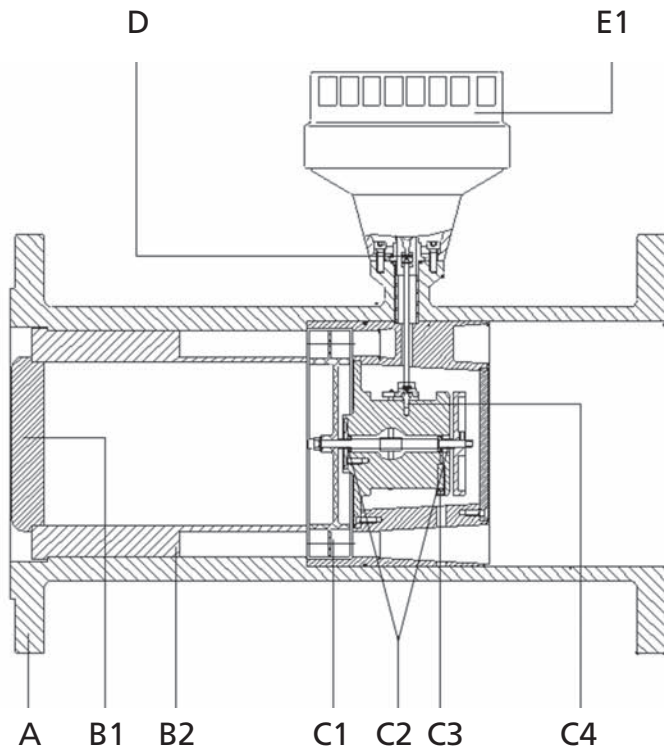
Code	Description	Max. frequency *	Remarks
1R1, 2R1 1R10, 2R10 HF3, HF4	Reed switch Reed switch, freq. x 10 HF NAMUR sensor (in the index head)	< 0.3 Hz < 3 Hz < 150 Hz	1R1 standard, 2R1 optional ** 1R10 and/or 2R10 optional ** HF3 standard, HF4 Optional
HF1	HF NAMUR sensor (at the turbine wheel)	< 4.5 kHz	Optional
HF2	HF NAMUR sensor (at the reference wheel)	< 4.5 kHz	Optional (only for IGTM-CT sizes DN100mm (4") and up)

\*) Maximum pulse frequency depends on meter size: please refer to table 3

\*\*) A maximum of 2 reed switches can be supplied per meter







- A** Pressure containing meter housing with end-flanges
- B** Flow deflector (straightening vane)
  - B1** Central cone
  - B2** Guiding vanes
- C** Metering insert cartridge with turbine wheel
  - C1** Turbine wheel
  - C2** Precision Bearings
  - C3** Bearing block
  - C4** Internal gears, shafts and axis
- D** Magnetic coupling (gas tight sealed)
- E** Index head with nameplates
  - E1** Mechanical counter
  - E2** Connector for Pulse transmitters [1R1; HF3 + options]
- F** Oil Pump
- G** High Frequency pulse transmitters [HF1; HF2] (Option)

## Documentation

The IGTM-CT gas turbine meter comes with an installation, operation and maintenance manual. Calibration certificates and material certificates can be provided as an option. Depending on the order and the meter chosen, the optionally ordered certification package contains:

- 3.1 certificate with declaration of conformity
- Material certificates for pressure containing parts
- Welding test certificates (when applicable)
- Pressure test certificate
- Calibration certificates (as ordered)
- Applicable CE compliancy certificate (MID / PED / ATEX)

## Installation

Usually gas turbine meters are installed with a certain straight upstream pipe length. The IGTM-CT is equipped with an internal flow conditioner that takes care that the meter meets the requirements of the MID Directive, EN 12261 and OIML recommendations. This allows the meter to be installed with minimum 2D upstream piping.

The temperature sensor should be installed in the downstream pipe section. Optionally a thermo-well can be installed in the meter body.

The meter is equipped for horizontal installation as standard. Meters  $\leq$ DN 100 (4") diameter can also be operated vertically. If the meter is provided with a lubrication pump, please indicate vertical use on your order. Meters that are used under MID approval must be installed horizontally.

The gas flow must be free from liquids, dust and particles. These can damage the delicate bearings and the rotor. Also when dust collects over time it has an adverse effect on the metering accuracy. Non-clean gases should be filtered with a 5-micron particle filter.

Pulsating gas flow and vibrations should be avoided.

The meter axis should be identical to the upstream piping axis. Gaskets immediately upstream of the meter should not protrude.

The meter is preferably installed indoors, but is suitable for outdoor installation (IP67). If the meter is installed outdoors, it is recommended to protect the meter against direct sunlight.

## Additional Instrumentation

The indicated volume (under actual conditions) will often be converted to volume at base conditions by a volume converter or flow computer. Parameters for these conversions are:

### • Pressure

A pressure tapping enables the measurement of the static pressure near the turbine wheel. The pressure measurement point is located on the meter housing and marked with Pm (pressure at metering conditions). The bore is 3 mm and perpendicular to the wall. This bore is as standard provided with a fitting. Connection with 6 mm stainless (standard) tubing or larger is recommended. Alternative connections or fittings can be offered on request.

### • Temperature

The temperature measurement should preferably be located within 3 D downstream of the meter. The temperature should be measured within the center third of the pipe. As an option, your IGTM-CT can be equipped with an integrated thermowell.

No devices that can influence the pressure or the temperature of the gas should be installed between a gas meter and the sensor.

## Volume Converters and Additional Equipment

**Vemm tec** can provide you with sophisticated volume converters with features such as curve correction, tariff counters, pulse or current outputs, and other customer specified functions. They come with dedicated communication with Mod-Bus® or other protocols via RS232 and RS485 and can be equipped with GSM, GPRS or other modems.

We can also provide you with the additional equipment such as IS-barriers, F/I-converters, transmitters, filters, straightening vanes and meter tubes.

We will be happy to send you any further information.

## Ordering Information

In order to quickly process your enquiry, we need the following information for adequate pricing and sizing:

- Nominal pipe size in mm or inches for installing the meter
- Application: Custody transfer, accurate measurement or industrial measurement.
- Preferred body material: Ductile iron, carbon steel or stainless steel
- Flow rate: Maximum, minimum (actual or standard/normal cubic meter per hour, please specify); or G-size.
- Pressure: Maximum, minimum and normal operating pressure (indicate if you specify in absolute pressure or gauge pressure)
- Temperature: Maximum, minimum and normal operating temperature
- Gas type, composition or analysis (if available)
- Flange connection, pressure rating and face type
- Output signals required (LF reed switch, HF at index head or HF at turbine wheel, dual pulse output)
- Installation conditions (Indoor-Outdoor, ambient conditions)
- Flow direction horizontal (left-right; right-left) or vertical (up-down; down-up)
- Optional services and additional equipment required (calibrations, barriers, volume correctors, filters, meter tubes)
- Please always mention the country in which the meter will be mounted into a system. We need that for allocating the internal responsibility and for determining the required approvals

## Alternatives

For industrial application **vemm tec** offers the IGTM-WT; an aluminium gas turbine meter that can be clamped between PN10; PN16 and ANSI 150# RF flanges. This model is available for DN 50 (2") to DN 200 (8"). Please ask for our documentation for more information.

For low flow applications **vemm tec** offers the OMEGA VI rotary gas meter range in the diameters DN 50 (2") to DN 100 (4") for flows between 0.6 m<sup>3</sup>/h to 480 m<sup>3</sup>/h. The Omega VI has a high turn down ratio; up to 1:200. Please enquire for more information.



Table 1  
Gas types

Gas type	Symbol	Density @1.013 bar [kg/m³]	Meter housing	Notes
Acetylene	$C_2H_2$	1.17	Special	Aluminium parts Teflon coated
Air		1.29	Standard	
Ammonia	$NH_3$	0.77	Standard	O-rings / Lubrication
Argon	Ar	1.78	Standard	
Biogas			Special	Viton O-rings / special Internal
Butane	$C_4H_{10}$	2.70	Standard	
Carbon dioxide	$CO_2$	1.98	Standard	Except foodstuff industry
Carbon monoxide	CO	1.25	Standard	
City gas		0.90	Standard	
Ethane	$C_2H_6$	1.36	Standard	
Ethylene (gas phase)	$C_2H_4$	1.26	Standard	Special Internal
Flue gases			Special	Viton O-rings / Lubrication
Freon (gas phase)	$CCl_2F_2$	5.66	Standard	O-rings / Lubrication
Helium	He	0.18	Standard	Special internal
Hydrogen	$H_2$	0.09	Special	Special flow range
Hydrogen sulphur (0.2%)	$H_2S$	1.54	Special	Viton O-rings / special Internal
Methane	$CH_4$	0.72	Standard	
Natural Gas		0.83	Standard	
Nitrogen	$N_2$	1.25	Standard	
Pentane	$C_5H_{12}$	3.46	Standard	
Propane	$C_3H_8$	2.02	Standard	
Propylene (gas phase)	$C_3H_6$	1.92	Standard	Special internal
Sour gas			Special	Viton O-rings / lubrication
Sulphur dioxide (0.2%)	$SO_2$	2.93	Special	Special internal
Other gas mixtures	Please enquire			

Table 2  
Dimensions and weights

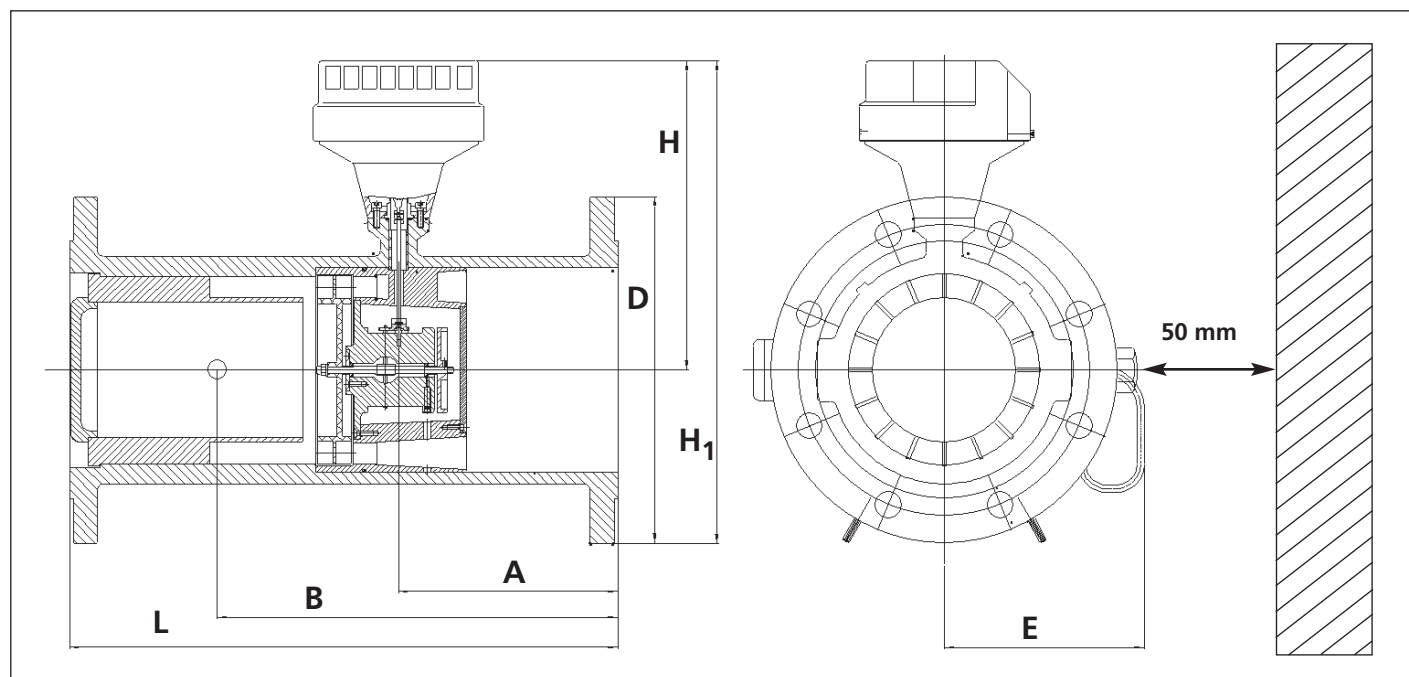


Table 2  
Dimensions and weights

DN [mm]  (Inch)	Size G	A [mm]	B [mm]	E [mm]	D [mm]	H Height	Overall size		Pressure class  PN or ANSI	Body material	Weight [kg]
							Height H1 [mm]	Length L [mm]			
DN 50 (2")	40 or 65	62	109	102	165	215	298	150	PN 10/16	Ductile Iron	11
				127	165	200	283		PN 10/16	Steel	24
				127	165	200	283		PN 25/40	Steel	24
				127	180	205	295		PN 63	Steel	24
				140	195	215	313		PN 100	Steel	33
				102	152	215	291		ANSI 150	Ductile Iron	11
				127	152	200	276		ANSI 150	Steel	24
				127	165	200	283		ANSI 300	Steel	24
				127	165	200	283		ANSI 400/600	Steel	24
DN 80 (3")	100 or 160 or 250	92	160	120	200	205	305	240	PN 10/16	Ductile Iron	25
					200	192	292		PN 10/16	Steel	26
					200	192	292		PN 25/40	Steel	26
					215	192	300		PN 63	Steel	32
					230	192	307		PN 100	Steel	35
					191	205	301		ANSI 150	Ductile Iron	25
					191	192	288		ANSI 150	Steel	24
					210	192	297		ANSI 300	Steel	28
					210	192	297		ANSI 400/600	Steel	29
DN 100 (4")	160 or 250 or 400	120	205	135	220	230	340	300	PN 10/16	Ductile Iron	27
				140	220	215	325		PN 10/16	Steel	24
				140	235	215	333		PN 25/40	Steel	39
				140	250	215	340		PN 63	Steel	42
				140	265	215	348		PN 100	Steel	48
				135	229	230	345		ANSI 150	Ductile Iron	29
				140	229	215	330		ANSI 150	Steel	36
				140	254	215	342		ANSI 300	Steel	43
				140	254	215	342		ANSI 400	Steel	43
				140	273	215	352		ANSI 600	Steel	50
DN 150 (6")	400 or 650 or 1000	182	280	190	285	255	398	450	PN 10/16	Ductile Iron	45
				215	285	250	393		PN 10/16	Steel	45
				215	300	250	400		PN 25/40	Steel	40
				215	345	250	423		PN 63	Steel	74
				215	355	250	428		PN 100	Steel	90
				190	279	255	395		ANSI 150	Ductile Iron	50
				215	279	250	390		ANSI 150	Steel	63
				215	318	250	409		ANSI 300	Steel	70
				215	318	250	409		ANSI 400	Steel	80
				215	356	250	428		ANSI 600	Steel	100
DN 200 (8")	650 or 1000 or 1600	240	340	230	340	270	440	600	PN 10	Ductile Iron	76
					340		440		PN 10	Steel	78
					340		440		PN 16	Ductile Iron	76
					340		440		PN 16	Steel	78
					360		450		PN 25	Steel	90
					375		458		PN 40	Steel	100
					415		478		PN 63	Steel	125
					430		485		PN 100	Steel	160
					343		442		ANSI 150	Ductile Iron	80
					343		442		ANSI 150	Steel	83
					381		461		ANSI 300	Steel	106
					381		461		ANSI 400	Steel	135
					419		480		ANSI 600	Steel	155

Table 2  
Dimensions and weights

DN [mm] (Inch)	Size G	A [mm]	B [mm]	E [mm]	D [mm]	H Height	Overall size		Pressure class  PN or ANSI	Body material	Weight [kg]
							Height H1 [mm]	Length L [mm]			
DN 250 (10")	1000 or 1600 or 2500	300	415	240	395	285	483	750	PN 10	Steel	110
					405		488		PN 16	Steel	110
					425		498		PN 25	Steel	110
					450		510		PN 40	Steel	130
					470		520		PN 63	Steel	155
					505		538		PN 100	Steel	220
					406		488		ANSI 150	Steel	110
					445		508		ANSI 300	Steel	150
					445		508		ANSI 400	Steel	170
					508		539		ANSI 600	Steel	240
DN 300 (12")	1600 or 2500 or 4000	360	385	260	445	320	543	900	PN 10	Steel	120
					460		550		PN 16	Steel	130
					485		563		PN 25	Steel	150
					515		578		PN 40	Steel	180
					530		585		PN 63	Steel	240
					585		613		PN100	Steel	345
					483		562		ANSI 150	Steel	160
					521		581		ANSI 300	Steel	210
					521		581		ANSI 400	Steel	240
					559		600		ANSI 600	Steel	290
DN 400 (16")	2500 or 4000 or 6500	480	625	300	565	355	638	1200	PN 10	Steel	355
					580		645		PN 16	Steel	380
					620		665		PN 25	Steel	415
					660		685		PN 40	Steel	455
					670		690		PN 63	Steel	500
					715		713		PN100	Steel	600
					597		654		ANSI 150	Steel	432
					648		679		ANSI 300	Steel	450
					648		679		ANSI 400	Steel	500
					686		698		ANSI 600	Steel	590
DN 500 (20")	4000 or 6500 or 10000	600	730	390	670	375	710	1500	PN 10	Steel	540
					715		735		PN 16	Steel	580
					730		742		PN 25	Steel	640
					755		755		PN 40	Steel	700
					699		725		ANSI 150	Steel	620
					775		765		ANSI 300	Steel	740
					775		765		ANSI 400	Steel	770
					813		785		ANSI 600	Steel	925
DN 600 (24")	6500 or 10000 or 16000	720	900	440	715	430	790	1800	PN 10	Steel	620
					840		850		PN 16	Steel	670
					845		855		PN 25	Steel	730
					813		840		ANSI 150	Steel	750
					915		890		ANSI 300	Steel	980
					915		890		ANSI 400	Steel	1020
					640		900		ANSI 600	Steel	1240



Table 3  
IGTM-CT gas turbine meter: technical specifications

The indicated frequency values and k-factors of HF1/HF2 and HF3/HF4 are for information only.  
The final values will be mentioned at the meter's nameplate and in the calibration certificate.

Nominal diameter [mm] [inch]	Size rating G	IGTM-CT		Pressure loss at $Q_{max}$ 1 bar with Nat. Gas [mbar]	Rotating speed turbine wheel at $Q_{max}$ [min <sup>-1</sup> ]	Turbine wheel		Maximum frequency			k-factor		
		$Q_{max}$ [m <sup>3</sup> /h]	$Q_{min}$ (standard flow range) [m <sup>3</sup> /h]			blade angle	number of blades	HF1/HF2 approx. [Hz]	HF3/HF4 approx. [Hz]	1R1 Reed [Hz]	HF1/HF2 approx. [Imp/m <sup>3</sup> ]	HF3/HF4 approx. [Imp/m <sup>3</sup> ]	1R1 Reed [Imp/m <sup>3</sup> ]
DN 50 (2")	G 40 *)	65	13	5,5	8900	45	16	2800	80	0,18	155000	4400	10
	G 65 *)	100	10	11,7	13700	45	16	4300	120	0,28	155000	4400	10
DN 80 (3")	G 100	160	8	3,7	6200	45	16	1900	50	0,04	42200	1200	1
	G 160	250	13	8,6	9600	45	16	2900	80	0,07	42200	1200	1
	G 250	400	20	13,8	8900	30	16	2600	70	0,11	23500	670	1
DN 100 (4")	G 160	250	13	3,1	4300	45	16	1200	60	0,07	17000	800	1
	G 250	400	20	6,8	6900	45	16	1900	90	0,11	17000	800	1
	G 400	650	32	10,8	6500	30	16	1700	80	0,18	9400	440	1
DN 150 (6")	G 400	650	32	3,1	3400	45	20	1100	70	0,18	6280	360	1
	G 650	1000	50	7,1	5200	45	20	1700	100	0,28	6280	360	1
	G 1000	1600	80	11,3	4800	30	20	1600	60	0,04	3570	135	0,1
DN 200 (8")	G 650	1000	50	2,5	2200	45	20	790	40	0,03	2840	150	0,1
	G 1000	1600	80	4,3	3500	45	20	1300	70	0,04	2840	150	0,1
	G 1600	2500	130	10,2	3100	30	20	1100	60	0,07	1510	80	0,1
DN 250 (10")	G 1000	1600	80	2,5	2000	45	24	830	60	0,04	1870	135	0,1
	G 1600	2500	130	4,9	3100	45	24	1300	90	0,07	1870	135	0,1
	G 2500	4000	200	7,9	2900	30	24	1200	90	0,11	1110	80	0,1
DN 300 (12")	G 1600	2500	130	2,5	1900	45	24	780	60	0,07	1120	80	0,1
	G 2500	4000	200	4,9	3000	45	24	1300	90	0,11	1120	80	0,1
	G 4000	6500	320	7,9	2800	30	24	1200	130	0,18	660	75	0,1
DN 400 (16")	G 2500	4000	200	2,5	1600	45	24	610	60	0,11	550	55	0,1
	G 4000	6500	320	4,9	2600	45	24	990	100	0,18	550	55	0,1
	G 6500	10000	500	8,6	2300	30	24	1300	130	0,28	470	50	0,1
DN 500 (20")	G 4000	6500	320	2,5	1400	45	24	540	60	0,17	310	40	0,1
	G 6500	10000	500	5,0	2300	45	24	860	100	0,28	310	40	0,1
	G 10000	16000	800	8,8	2000	30	24	750	30	0,04	170	8	0,01
DN 600 (24")	G 6500	10000	500	2,4	1100	45	24	420	40	0,02	150	15	0,01
	G 10000	16000	800	4,9	1800	45	24	670	70	0,04	150	15	0,01
	G 16000	25000	1300	8,6	1400	30	24	500	50	0,02	75	7	0,01

\*) Not approved under MID