Instromet®

ROTARY PISTON
GAS METER
HANDBOOK

CONTENTS

INTRODUCTION

Rotary piston meters have a long history in the gas industry and are often simply referred to as "rotary meters". In this document the operation, the performance, the installation and the output facilities of Instromet rotary piston meters are summarised.
Comparisons are made between rotary piston meters and other meter types, such as diaphragm meters and turbine meters.
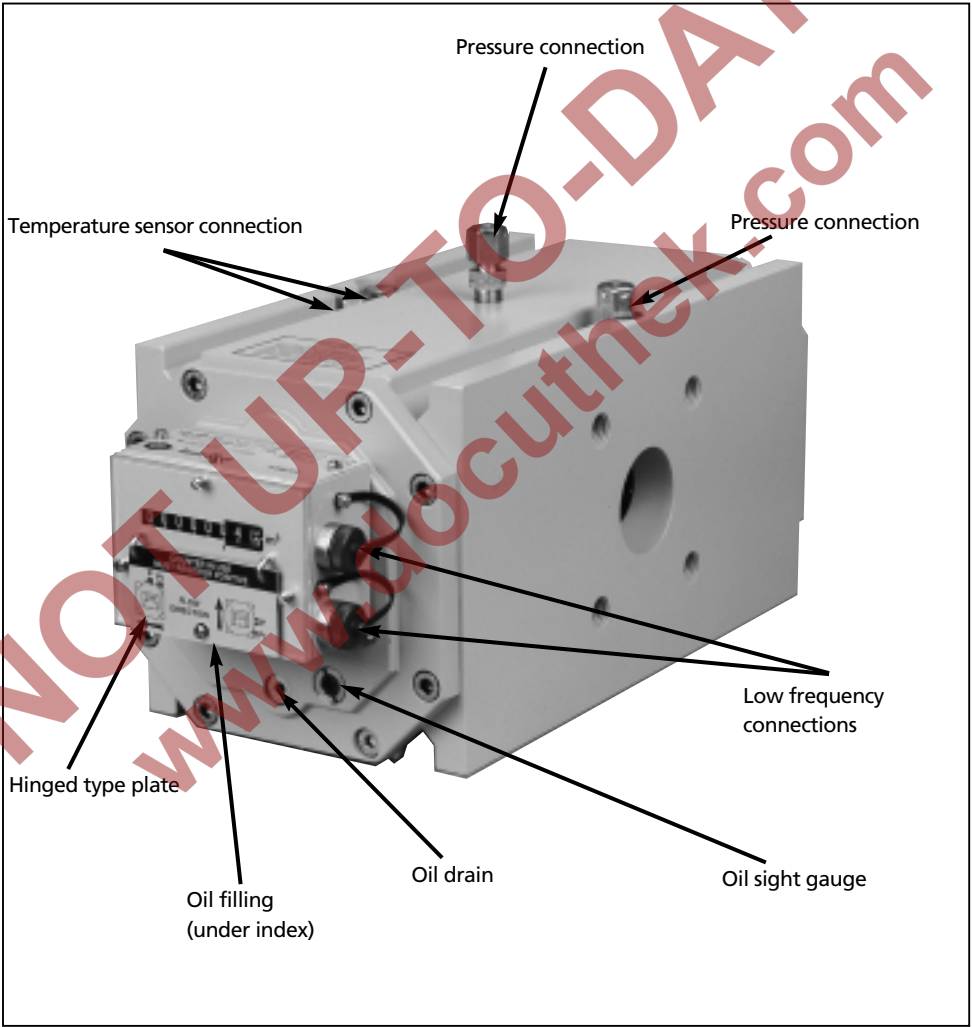

*Figure 1. Instromet IRM 1 (A) rotary gas meter.*

1.   OPERATION

1.1   Operating principle

A schematic drawing of a typical rotary piston meter is given in figure 1. Two figure eight shaped rotors are geared through external synchronisation gears. The clearance between the rotors and the housing is small in order to minimise leakage. For every full revolution each rotor transports a defined volume from inlet to outlet.

At first glance the rotary piston meter is a true positive displacement meter. The volume of the space between housing and rotor determines the meter factor, and the volumetric flow rate is proportional to the rotational speed of the rotors.

The rotors in turn drive a counter. The counter is geared to indicate the volume passed through the meter in the appropriate units (m^3 or ft^3). The rotor shafts can be equipped with a sensor. In this way a frequency signal proportional to flow rate, is generated.
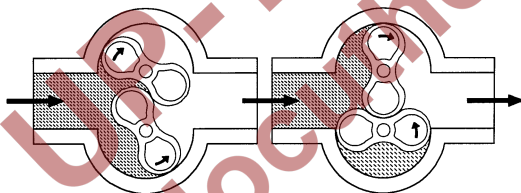
Figure 2.   Operation of rotary piston meter.

1.2   Conversion of volume to quantity (mass, standard volume)

The rotary piston meter is one link in the chain to determine quantity. Quantity can be expressed in terms of standard, normal or base volume or in terms of mass. The volume measured by the meter under operating pressure and temperature can be converted to volume at standard or base pressure and temperature in several ways.

The most common method is the PTZ method. The pressure of the gas is determined at a representative point and the temperature is normally measured immediately upstream. The base temperature and base pressure have fixed values. Base pressure is mostly 1.01325 bar, but base temperature values of 0° C, 15° C and 60° F are used. The compressibility Z can be calculated from the gas composition. This compressibility is not a constant, but varies with temperature and pressure. Several correlations exist to calculate compressibility from the composition and pressure and temperature. The most authoritative correlation is given in ISO 12213.

The equation to calculate the base volume is:

$$V_b = V_m \cdot \frac{P_m}{P_b} \cdot \frac{Z_b}{Z_m} \cdot \frac{T_b}{T_m}$$

In this equation the subscript "m" indicates measured values at operating conditions or, in case of Z_m, the compressibility at operating conditions determined from the composition and operating temperature and pressure. The subscript "b" is used for the values at base conditions. For low pressures the value of Z_b / Z_m is very close to 1 and under those conditions the effect of compressibility can be disregarded.

An alternative method uses the density at operating conditions, measured by a densitometer, and the density at base conditions. The latter can either be measured directly or can be determined from the composition. The equation in this case is:

$$V_b = V_m \cdot \frac{\rho_m}{\rho_b}$$

In this equation ρ_m and ρ_b are the densities at operating and at base conditions respectively.

Instromet manufactures a range of high quality automatic volume correctors for a variety of applications and with a wide choice of options. In addition, the Instromet ENCAL gas chromatograph provides the composition of natural gas on-line. This makes it possible to calculate the compressibility and the density at base conditions ρ_b for highest accuracy metering. It also provides the heating value so that the total amount of energy supplied can be determined.

2. PERFORMANCE

2.1 Standards

Instromet IRM rotary piston meters are made to satisfy OIML recommendations R6 and R32 for fiscal metering and all national metrological standards derived from these OIML recommendations.
They are also designed to match the requirements of ANSI B 109.3.

2.2 Range

The minimum and maximum flow rates between which a meter operates within specified accuracy limits is defined as the range. The maximum error for this purpose is specified in OIML R32 as plus or minus 2 % of the actual value at low flow rates and plus or minus 1 % at high flow rates (figure 3).
The transition point Q_t between high flow rates and low flow rates, defined in OIML R 32, is shown in table 1.
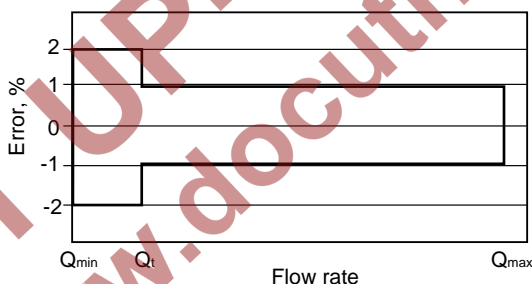
Figure 3. *Error envelope for rotary piston meters according to OIML recommendation.*

Range	$\dfrac{Q_t}{Q_{max}}$ [%]
1:10	20
1:20	20
1:30	15
1:50	10

Table 1. *The threshold flow rate Q_t, distinguishing high flow rates from low flow rates, according to OIML R 32.*

If no leakage occurred, the error of the meter would be zero.
The meter factor would be determined by the enclosed volume between rotor and housing wall only and the range of the meter would be infinite. However, a small positive clearance has to be allowed in order to prevent friction. In the appendix the equation is derived that describes the leakage over the rotor. The leakage flow rate can be expressed as:

$$Q_l = A\,Q + \frac{C\,\Delta P\,h^3}{\mu} = Q_e + Q_s\,,$$

with Q_l the leakage flow rate, C and A constants, Q the meter flow rate, h the height of the gap, ΔP the pressure drop over the gap and μ the dynamic viscosity.

The first term Q_e can be seen as the fluid that is entrained with the rotor and only results in a slight change of the meter factor. This entrainment is independent of pressure or viscosity. The second term Q_s is the true leakage which is constant and independent of flow rate. The resulting error curve for the meter can be expressed as:

$$E = \frac{Q_s}{Q_{indicated}}\,, \text{ with } Q_{indicated} \text{ the flow rate indicated by the meter.}$$

By designing a meter with a very small leakage Q_s compared with the maximum flow rate Q_m, Instromet can provide a meter with a very large linear range. As the clearances that can be realised in practice are limited to some absolute minimum values, the larger meters perform better than the smaller ones. The range for air may be from 1:100 for small meters to 1:300 for the largest model.

Conventionally, meter behaviour is given for air at atmospheric pressure. For atmospheric air the viscosity μ is about 18 μPa s (180 μPoise). For natural gas the viscosity is about 11.4 μPa s (114 μPoise). As a consequence the error for gas relates to the error for air as:

$$\frac{E_{gas}}{E_{air}} = \frac{\mu_{air}}{\mu_{gas}} = 1.6$$

For gas the range is reduced by the converse i.e. by a factor 0.6.

TYPE/UNIT RATING	Q-MAX. RATED CAPACITY [m³/h]	RANGE (air)	
		at ± 1 %	at ± 2 %
G 16	25	1:80	1:125
G 25	40	1:100	1:130
G 40	65	1:120	1:150
G 65	100	1:130	1:170
G 100	160	1:150	1:250
G 160	250	1:200	1:280
G 250	400	1:200	1:300
OIML R32 requirement	ANY	1:10	1:50

Table 2.   The range of Instromet IRM meters when allowing an error of ± 1 % and of ± 2 % at minimum flow rate.

Turbine meters generally have a much smaller range, specifically at low pressures. At very high pressures they may approach or exceed the figures of the IRM.

The IRM easily satisfies OIML requirements on range for diaphragm meters.

2.3   Leakage

There are several reasons why the clearance between rotor and housing cannot be reduced beyond certain limits. In a practical installation the pipework may exert considerable stresses on the meter body. These stresses will distort the body and would block the rotor if the distortion became sufficiently large. Variations in temperature over the body can also introduce deformations that would have the same result.

To minimise these problems two different roads can be followed:

● Ensure that the external forces cannot be transferred to the rotor and piston.
● Design a meter with very high rigidity so that external forces do not distort the metering parts.

The first avenue is followed with the IRM 1 that is designed with a separate metering module inserted in a pressure housing (fig. 4). A flexible rubber seal forms the connection between the housing and the meter module, and as a result mechanical stresses are not transferred to the metering mechanism. Both the rotor and the housing of the meter module are made of aluminium to avoid thermal stresses that would result from different coefficients of expansion. As it is also

immersed in the gas stream, thermal stresses on the module are reduced to a minimum. Because the module is not affected by external forces Instromet has been able to reduce the clearances between the rotors and the rotor housing. This in turn reduces the leakage particularly at low flow rates thereby increasing the performance of the meter considerably.

In the IRM 3 the dimensions of the body are optimised for highest rigidity. This has resulted in a design that is sufficiently strong to insulate the metering parts from any mechanical stresses that might occur in the installation, up to the meter's maximum pressure rating.
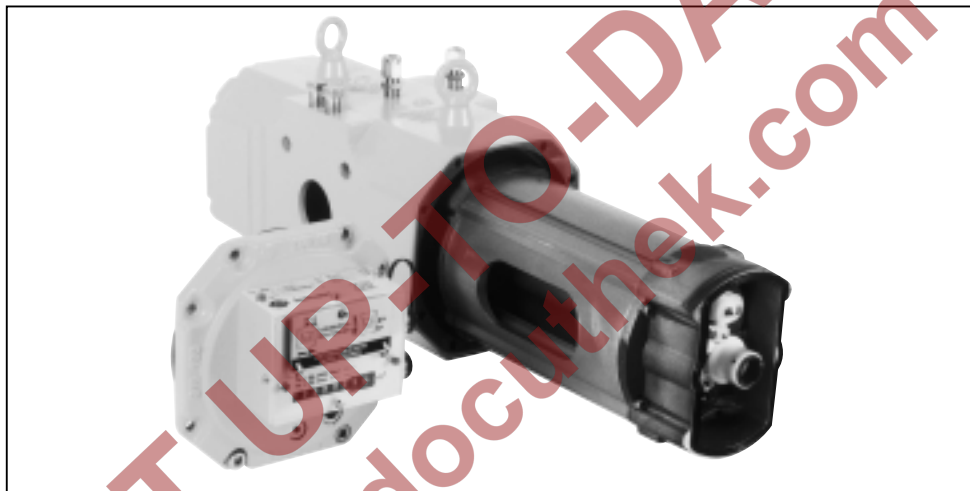

Figure 4.   Instromet IRM 1 (G) meter with module inserted in pressure housing.

Of course, the gas has to be clean. Particles of a size comparable to the rotor clearance will block the rotor if caught between the two surfaces of the moving rotor and the housing. Reliable and sufficiently fine filters are readily available and practice has shown that this is not a problem in normal operation in a conventional installation.

The leakage Q_S is only dependent on the geometry, the pressure differential ΔP and the dynamic viscosity μ. By virtue of the separate meter module, the geometry is independent of pressure. The pressure differential is only required to compensate for mechanical friction e.g. from bearings and the mechanical counter. It is therefore independent of the pressure. The dynamic viscosity μ for gases changes very little with pressure and temperature.

Also variations in gas composition as they occur in practical natural gas systems would not significantly affect the viscosity. Different gases (nitrogen, propane, helium), however, have different viscosities and the different leakage will have an effect on the performance at very low flow rates.

2.4 Sensitivity

The Instromet IRM meters will start running at a much lower flow rate than its minimum flow rate. Once started, it will continue to run at even lower flow rates. Figures for starting and stopping flow are given in table 3. Below the Q_{min} as defined by OIML the meter may exhibit an error outside of the ± 2 % level. However, though the flow rate is lower than Q_{min}, it will still repeat quite well down to much lower levels.

Meter size	Q_{max} [m³/h]	Q_{min} [m³/h]	Start rate [m³/h]	Stop rate [m³/h]
G 16	25	0.2	0.03	0.012
G 25	40	0.3	0.06	0.04
G 40	65	0.4	0.06	0.05
G 65	100	0.6	0.075	0.05
G 100	160	0.65	0.075	0.05
G 160	250	0.9	0.1	0.06
G 250	400	1.3	0.2	0.06

Table 3.   The minimum flow rates above which the absolute error is less than 2 %, and the flow rates where the rotor starts, and where it stops rotating.

2.5   Pressure dependence

The meter module of the Instromet IRM 1 meters, as it is surrounded by gas of equal pressure, is completely pressure balanced. The volume of the compartments that transmit gas from inlet to outlet remains the same independent of the pressure.

For a given gas, the meter factor, the range, and the linearity of the Instromet IRM are therefore in the first approximation, independent of pressure and consequently independent of Reynolds number.

Both turbine meters and orifice plate meters are fundamentally dependent on Reynolds number.

2.6   Accuracy/Uncertainty

One has to clearly distinguish the uncertainty of the volumetric flow measurement as performed by the rotary meter and the uncertainty in the resulting quantity measurement. In the latter the uncertainty in the measurement of pressure and

temperature, and the accuracy with which the gas composition is known, all play a role.

Another factor is the repeatability of the measurement. For Instromet IRM meters, the repeatability is well within 0.05 %, which is the best that can be achieved in gas flow metering. It means that if a measurement is repeated at the same flow rate, the meter will have the same error within 0.05 %. This value may have a systematic bias, given by the value of the error curve at that flow rate. Normally this systematic error is not compensated for and is regarded as a part of the uncertainty.

The uncertainty in the volumetric flow measurement is thus given by the maximum error in the range over which the meter will be used. As the range of the Instromet IRM 1 meter exceeds most normal operating ranges by a large margin, it is in many cases possible to choose meter or operating conditions such, that the maximum error is limited to no more than 0.1 %, even when using a standard meter.

The manufacturing accuracy of Instromet IRM meters is such that the meter factor can be predicted within ± 0.2 %. A set of calibration curves for 9 meters size G 100 is given in figure 5. These meters were produced in three subsequent years and three were randomly picked from each year.
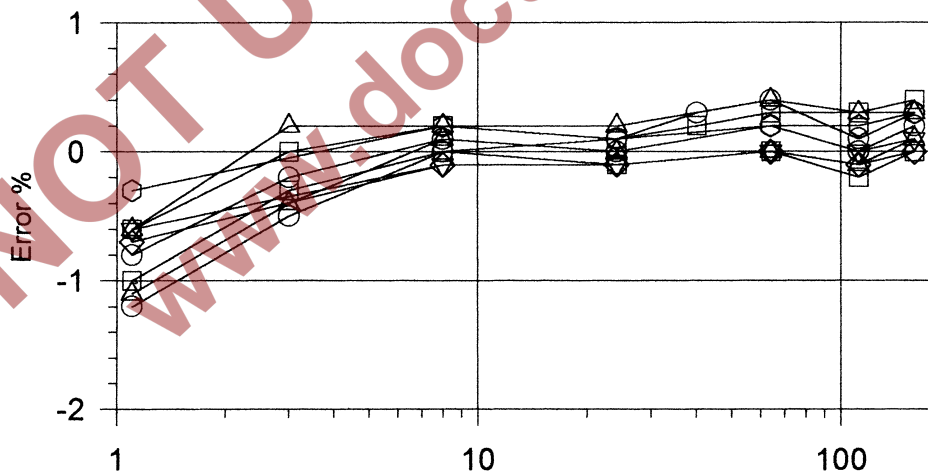

Figure 5. Calibration curves of 9 Instromet IRM 1 (A) meters, size G100, randomly chosen from the production of 1993 to 1995, 3 of each year.

The total uncertainty for high pressure volume metering can presently be as low as 0.4 %. This includes an uncertainty of 0.3 % in the reference standards for flow measurement.

Turbine meters can achieve similar uncertainties as positive displacement meters. However, especially at low pressure, the range over which this can be accomplished, is much smaller.

Conversely with orifice plates, the uncertainty of the coefficient of the plate alone already amounts to 0.6 % and the repeatability over several hours is reportedly not much better. Total uncertainty for orifice plates is normally well over 1 %.

2.7   Linearity

Linearity shows itself in the calibration curve (error curve) as being more or less flat. A meter with an absolutely flat calibration curve is absolutely linear. Linearity is another way of expressing the uncertainty.

In conventional rotary piston meters the pressure point is upstream of the meter. There is, specifically for larger capacity meters, a flow resistance between this pressure point and the measuring chambers that gives a pressure drop that cannot be neglected at high flow rates. Also, as the pressure drop over the meter mechanism increases with flow rate, the leakage will increase. For high flow rates the momentum of the gas directly impinging on the rotor can have an effect on the meter error. All of these effects result in a tilt in the error curve.
In the Instromet IRM 1 meter the pressure tapping is on the outer shell, in close proximity to the meter module. The aperture connecting the measuring chamber with the shell space is much larger than the connection to the pipe. The measured pressure is virtually equal to the pressure in the measuring chambers, and the error curve is horizontal. As the leakage has been reduced to a very low level, the effect of increasing pressure differentials is also minimal. As a result the error curve of the Instromet IRM is nearly flat. It has been demonstrated that the error remains within a band of 0.5 % over a range of at least 1:20.

In the IRM 3 pressure tappings are located on both sides, directly in front of the rotor. Using the upstream pressure tapping gives a flat curve for both flow directions.

As explained above, when looking at linearity, the Instromet IRM meter closely approaches the ideal.

Orifice meters on the other hand have a square root character and can only be linearised through root extraction devices.

Turbine meters that are highly linear are also available from Instromet.

2.8   Calibration

The meter factor of all Instromet IRM meters is verified with air at atmospheric

pressure. Thanks to the precision of the manufacturing process no further checks are needed to guarantee the performance of the meter over the full range. Customers' wishes or legal requirements for calibration at a larger number of points can of course be satisfied. Instromet's specially developed test installation is recognised by NMi, the official Dutch legal Metrology Service and by several other European Metrology services, such as the German PTB. Individual calibrations can be witnessed and certified by the representative of NMi or other Official Bodies to satisfy, for example, EEC requirements.

Instromet IRM meters have excellent long and short term repeatability. As their performance is independent of pressure and does not drift, they are excellent instruments for high accuracy metering without needing any recalibration or inspection. "As long as it's running it's accurate!" These properties make the Instromet IRM an excellent reference standard meter.

2.9   Legal metrology aspects

Instromet IRM meters can be supplied to satisfy any known National or International (such as EEC) legal requirements. Where appropriate, special National Requirements can be met.

Calibration of Instromet IRM meters is traceable to the International Standards of length and weight, and is carried out by the Official Dutch legal Metrology Service NMi.

Instromet has NMi representatives permanently on site at each of its calibration sites. Type approval of meters is obtained after extensive tests by NMi, both on accuracy and performance, conducted both at Instromet facilities and at the NMi facilities. Where applicable, tests are carried out at the special NMi facilities in Delft to determine any electromagnetic interference.

Figure 6.
Rotary meter calibration
facility - The Netherlands.

2.10   Stability

The stability of rotary piston meters is well known. There are no known phenomena that make the meter factor change slowly and as a result cause drift. The nature of the positive displacement principle dictates that every revolution carries the same volume of gas from entry to exit. Any pollution would block the rotor rather than change the volume.

The meter body is normally constructed of aluminium, ductile iron or steel and the internal meter module of aluminium with Buna-N O-ring seals. This is fully compatible with commercially distributed fuel gas. Industrial gases however may have to be judged on their compatibility with the above materials.

The high quality ball bearings are continuously lubricated by an oil mist. Bearing friction will therefore be very low and stable.

The oil level can be inspected through a sight glass and will under normal operating conditions last for many years. The Instromet IRM 1 meters differ from conventional designs by having only one sight glass and fill opening for both ends of the rotor; this makes maintenance easier. As access only has to be from the front, space requirements are reduced.

2.11   Short term stability

Short term stability of the measurement is generally determined by the meter's sensitivity to varying temperature and pressure and to variations in gas quality. As described in previous paragraphs however, these factors do not affect the performance of the IRM meter, and reliability is assured within very wide limits.

Temperature

Appropriate materials, tolerances and lubrication are chosen in such a way that the operating temperature can be varied safely between -20 and +60 °C for standard meter designs.
Within this range, the direct influence of temperature on the accuracy is negligible. The meter module is all aluminium and therefore there are no temperature expansion effects affecting the operation of the meter.

Pressure

Standard meter design is for pressures up to 16 bar for aluminium and ductile iron. The IRM 1 can be supplied with high pressure bodies to satisfy any recognised safety standard such as ASTM, API, DIN, and similarly the construction can be according to ASME, ANSI, BS, AD-M or Stoomwezen.
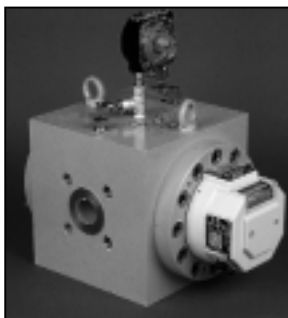
Figure 7.   Instromet IRM 1 (S) meter.

Gas composition

Gas composition does not affect the indication of the meter other than by its viscosity. In normal applications the gas composition variations are limited and the influence of gas composition on meter behaviour is negligible.

2.12   Direction of flow

Rotary piston meters will register the flow regardless of its direction. The mechanical register will add the positive and negative flows arithmetically. Meters can thus be supplied for either direction of flow.

2.13   Flow variations

Rotary piston meters have an immediate response to forced flow variations. Care should therefore be exercised when accelerating the rotor. The inertia of the rotor may be such that, when increasing the pressure in a system by suddenly opening a valve, the full pressure increase applies over the rotor, engendering the risk of bending the rotors and blocking the meter.

The effect of flow variations of a sinusoidal nature is negligible for very low frequencies of pulsation. The rotor speed follows the flow variations accurately. For higher frequencies the rotor will not be able to follow the flow variations and the rotors will be subject to pulsating pressures. If sufficiently large these could result in damage to the meter.
By nature of its design the meter itself will generate flow pulsations. Depending on the shape of the rotor these will be more or less severe. For the traditional figure eight shaped rotors and a forced pressure differential over the meter the flow pulsations approximate a sine wave with an amplitude of 13 % of the average flow. The special construction of the Instromet IRM 1 meter with a dead volume closely coupled to the pulsation source provides a built-in damping that attenuates pulsations as compared with traditional constructions.

17

2.14   Security of Supply

From a metrological point of view it may be an ideal feature of the rotary piston meter that it blocks the flow in case of failure. From the point of customer relations however, it may be commercially much more desirable to deliver unmetered gas than to block the gas flow to a customer.

The special construction of the Instromet IRM 1 meter has made it possible to incorporate an optional automatic by-pass in the meter module (figure 9). If the pressure drop over the module exceeds a value determined by the spring, the by-pass valve opens and gas can flow through the apertures into the outlet and on to the customer. The spring is set at a value that would never occur in normal operation. Consequently blockage of the rotor, though it will not block the gas flow, will result in a higher pressure drop over the meter. In a meter and regulator station this can be automatically compensated for by choosing an appropriate regulator with an external sensing line and connecting this downstream of the meter.

Detection of blockage is straightforward: if the meter does not turn and there is a flow of gas, the meter is blocked and the gas is flowing through the by-pass. In the unlikely case that there is no evidence of the presence or absence of flow, a check on the differential pressure will confirm it.
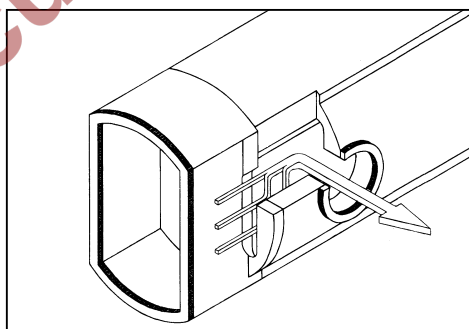
Figures 8 and 9.   Special high pressure IRM with integrated bypass and pressure differential gauge.

2.15   Noise and pulsations

As has been explained above, the meter itself generates pulsations, even in a steady gas flow. The frequency of these pulsations is equal to 4 times the rotational velocity of the rotors. At Q_{max} this may be, depending on meter type and size, up to about 300Hz. As a result the meter will make a humming noise. In traditional meters this noise will be transferred directly from the body to the

surroundings. In the Instromet IRM 1 meter, the meter module is supported in rubber, and contact to the outer shell and the piping is much reduced. Noise will therefore be less than for traditional rotary piston meters. Measurements have shown reductions of up to 10 dB. The noise decreases with meter size for a typical installation. For a given size, noise decreases even more with decreasing flow rate.

Therefore, if ultra-low noise is desired, the wide range of the Instromet IRM 1 meter makes it possible to choose an oversized meter which will run at a lower speed and thus reduce the noise to very low levels. The remaining useful range will still be suitable for many applications.

Depending on its geometry, the installation will have certain natural resonance frequencies. For flow rates where the frequency generated by the meter coincides with one of these natural frequencies, resonance will occur. This may result in a systematically higher or lower pressure of the gas in the measuring chamber. For conventional rotary piston meters this may result in appreciable systematic errors at specific flow rates. The Instromet IRM 1 meters are less susceptible to this effect for two reasons.

First, the additional pressure difference that results from resonance changes the leakage rate to a lesser extent than in a conventional meter. This is one of the benefits of smaller clearances. This effect dominates over the higher or lower gas quantity that is contained in a measuring chamber as a result of the pressure variation.

The second reason is the presence of a space between outer shell and meter module. Pulsations in piping systems can normally be damped by a succession of volumes and restrictions. The space between meter module and outer shell in the Instromet IRM 1 forms the first volume that attenuates pulsation.

The error that still remains as a result, will only occur at specific flow rates. In a practical application, flow rate will normally vary to some extent and average out the errors. However, when using Instromet IRM meters as a reference, pulsations have to be damped, or flow rates chosen such that resonance peaks are avoided.

2.16 IRM Duo

As explained above, pulsations are a characteristic of all rotary meters which, if severe enough, cause a resonance in the installation piping. These pulsations increase directly with increased volume and pressure until the resultant resonance begins to have a detrimental effect on the installation. A rotary meter is therefore normally limited to a maximum flow of about 400 m³/h (14,000 cfh) at lower pressures and to about 250 m³/h (8,000 cfh) at high pressure.

It has long been known that if the pulsations created by the rotors could be reduced or eliminated, the upper measurement boundaries of a rotary meter could be increased dramatically. After several years of research and experimentation Instromet found that by coupling two pairs of rotors in the same body in such a way that the major pulsations oppose each other, a smooth pulsation free flow of gas would result. This is the basis for the patented IRM Duo. The principle has been applied not only to commercial rotary meters but also to master meters where the quiet performance and extra-ordinary turn down ratio has made a dramatic break through in calibration and testing. A variant of the IRM Duo called the Rotary Piston Prover is used by a number of international metrological authorities as a meter.
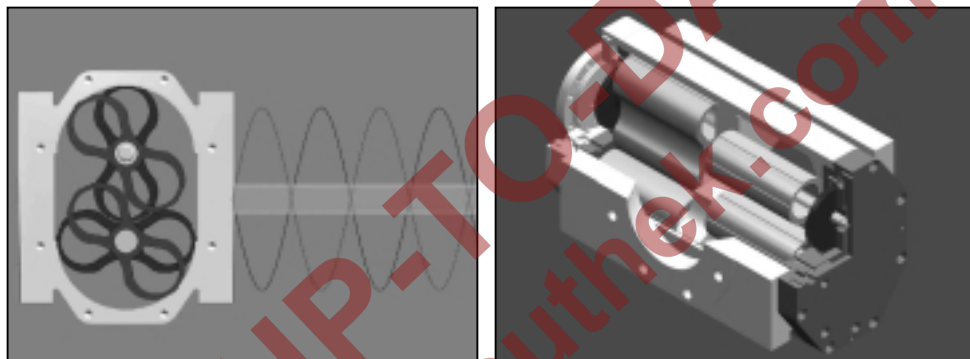
Figures 10 and 11.   IRM DUO.

2.17   IRM 3

The years of experience and knowledge acquired in producing the cartridge design have enabled Instromet to develop a vastly improved conventional design as an alternative to the IRM 1.

As has already been explained the performance of rotary meters at lower flow rates is determined by the unregistered amount of gas leaking across the rotors. The turn down ratio or the range, is inversely proportional to this leakage. The amount of gas leaking across the rotors is itself directly proportional to the clearance length, the cube of the clearance height of the leakage path and to the viscosity of the gas. It is also inversely proportional to the clearance width. In the IRM 1 most of the effort went into minimising the clearance height which has the greatest effect. Controlling the gaps between the rotors and the cartridge housing, however, requires very precise grinding of the rotors which is both difficult and expensive.
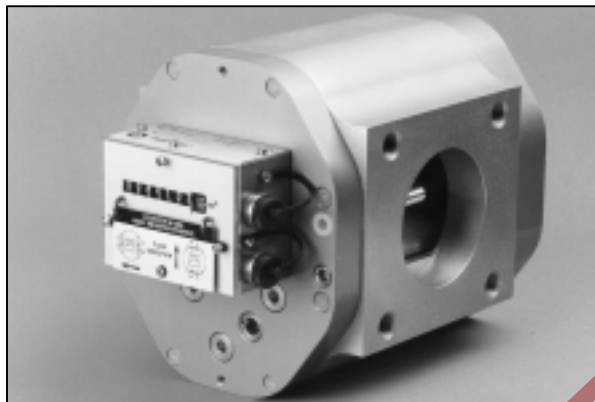
Figure 12.   IRM 3.

In designing the IRM 3, Instromet's engineers looked into the other two dimensions. By reducing the length of the rotors to a square form, the profile of the rotor is minimised in relation to the displaced volume - thus less leakage. At the same time by increasing the clearance width at the tips of the rotors, it is more difficult for the gas flow to leak past again improving performance. In direct comparison with conventional rotary meters the outlines (in relation to leakage) of the *squared shaped rotor* design are reduced by more than 40 %. As a consequence, the unregistered amount of leakage is decreased by a factor of 1.6. As the diameter of the rotors have been consequently increased, the clearance width is also increased, reducing the unregistered gas leakage by another factor of 1.6. The two changes in combination actually give a total reduction of 2.5.
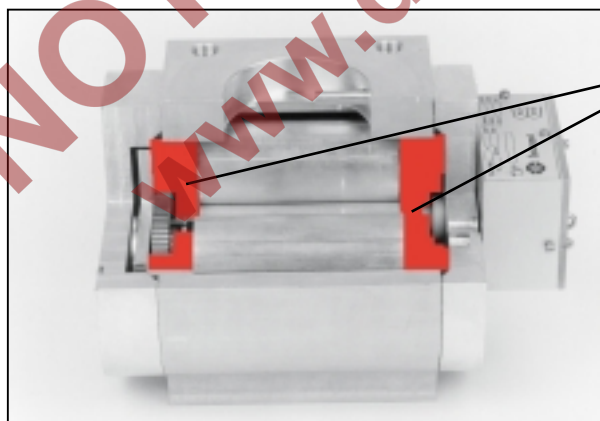
Internal end plates

Figure 13.   IRM 3.

The design of the body also deadens the sound caused by the internal moving parts and contributes to the meter's quietness.

21

The weakest point of a conventional rotary meter is its sensitivity to installation stresses. Except for the cartridge type, the smallest distortion to an aluminium body can cause the rotors to block as the aluminium cannot withstand high tensions. The IRM 3 uses rather massive (25-35 mm) plates on both ends of the meter body which gives the meter such rigidity that there must be considerable bending and torsion before the clearances and thus the accuracy of the meter can be affected. Additional rigidity is inherent in the square shaped rotors which resists distortion from external forces as well as internal damage caused by overloading the meter, pressure shocks, impurities in the gas etc.

In other rotary meter types the weakest part of the internal construction is usually the main shaft. These shafts on which the timing gears are fitted have a particular tendency to twist due to their narrow diameter. Since the main bearing is fitted on the shaft between the impeller and the timing gear, the diameter of the shaft and therefore its strength is limited to the internal dimensions of the bearing. Increasing the diameter of the shaft and thus its strength would require a larger bearing with consequential detriment to the turn down ratio.

The IRM 3 uses a radical different concept. In the IRM 3 the timing gear is fitted between the rotor and the main bearing, thereby removing any limit to the size of the shaft. The resultant resistance to twisting is at least 10 times higher than in other meters thus making the IRM 3 less sensitive to abnormal forces of the rotors.

The modified position of the bearings gives the IRM 3 another unique advantage. By placing the timing gears between the rotor and the main bearing the meter can be disassembled and the bearings can be replaced without removing the timing gears from the shaft. During disassembling the timing is not disturbed making repair for even less experienced shops a fast and easy job.

By using the Squared Shaped Rotor design, the dimensions and weight of the meter is completely different to conventional designs. The flange to flange length of the meter is still in accordance with recognised standards thus making the IRM 3 exchangeable with other positive displacement meters. But the biggest improvement is made regarding installation depth. Experience shows that the interchangeability between, for instance turbine gas meters and positive displacement gas meters is not always possible since the installation depth of the turbine meter is smaller than an equivalently sized rotary meter. Indoor installations where the adjacent piping is close to a wall give particular problems. Since the installation depth of the IRM 3 is scarcely larger than the adjacent flanges, its depth is comparable to other meter types such as turbine meters.

As the length of the meter is about 40 % smaller than equally sized conventional types, the weight of the IRM 3 is significantly less. Even the largest in the series

(G650 / 38 M) is a mere 70 kilos (154 lbs) and does not require to be floor mounted.

The short square design enables the measurement chamber to fill rapidly during operation lowering the pressure drop across the meter.

The IRM 3 differs from the IRM 1 another way in that the upper limits of maximum flow have been breached by using dual rotors (see 2.16) for the largest sizes. The 4" G400 / 23 M and the 6" G650 / 38 M have a performance, quietness and smoothness not possible in any other type of rotary meter. They are well suited as reference meters for calibration installations.

3.   INSTALLATION

3.1   Installation length

Rotary piston meters are not sensitive to installation conditions. The standard for turbine flow meters, ISO 9951, requires the manufacturer to state the installation conditions that will not give a shift of more than 0.33 % from the undisturbed situation.
Instromet IRM 1 rotary piston meters meet this requirement easily without any external straightener nor any straight inlet length.

Even the high level disturbance as defined in ISO 9951, consisting of two bends, in perpendicular planes, with a segmental orifice blocking half the pipe area located between the two bends, will not cause any appreciable error.

However, a regulator mounted directly in front of a meter may cause the meter to register a (normally negative) error. Instromet can provide Instromet IRM 1 meters with inlet straighteners incorporated in the pressure envelope, that allow the meter to be mounted directly behind the regulator. The error will still remain inside a ± 0.33 % band. Pressure drop over the meter will consequently be slightly increased.

In comparison, for the installation of orifice plates straight lengths of up to eighty times the nominal pipe diameter D are required according to ISO 5167. Even then, only a best error of 0.6 % can be achieved.

Instromet SM-RI turbine meters equipped with X4X straighteners need no extra straight length to satisfy the requirements of ISO 9951 for severe perturbations. The meter can be installed 2D downstream of the bends specified in the standard. However, when mounting such a turbine meter immediately downstream of a regulator, a Tee or an external perforated plate is generally needed to reduce the error to acceptable levels.

3.2   Vertical Installations

In vertical installations it is strongly recommended that the flow never be from the bottom upwards. This is because the rotors move towards each other at the exit (upper) side of the meter and any dirt or foreign objects falling downwards will be trapped between the rotor tips causing the meter to block. If an upwards flow is unavoidable, then a filter should be placed above i.e. downstream of the meter.

3.3 Overspeeding

Instromet IRM 1 meters are designed to withstand a 20 % higher flow rate than the maximum rating for short periods. They should not be run at higher speeds, as bearing damage and ultimately rotor damage will occur.

Overspeeding is generally caused by filling up or pressurising a section of pipe through the meter in an uncontrolled way. The design of the installation should be such that pressurising can be done through a small diameter tube, preferably connected in such a way that the meter is located in the smallest volume.
By choosing the internal diameter of the pipe by-passing the main valve as indicated in table 4, the flow rate will be limited to the listed value (for natural gas).

If a meter is mounted in an installation that is separately pressurised, particular care has to be taken when subsequently pressurizing the pipework downstream of the metering installation. Preferably the downstream piping should be pressurized through a pipe sized according to the table and by-passing the meter.

It is often advocated that downstream pipework be pressurised through a valve which by-passes the downstream valve of the metering installation, and which uses a diameter d2 one fourth of the diameter D of the downstream valve. This valve still has to be very carefully operated in order to prevent overspeeding of the meter (figure 14).
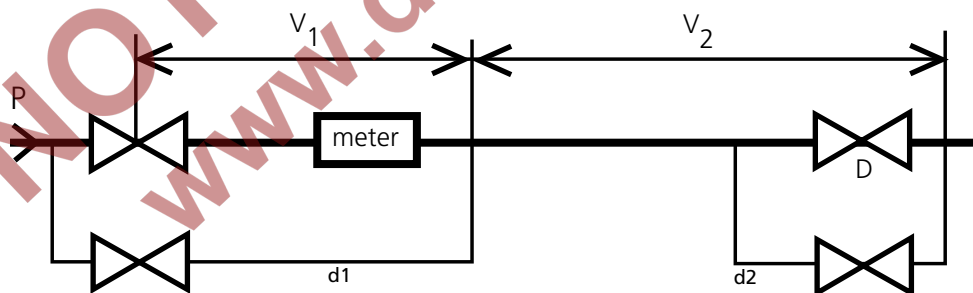
d1 and d2 to be chosen according to table 1

Figure 14.   Recommended way to pressurize installation.

As has been mentioned earlier, trying to accelerate the rotor in too short a time interval could cause damage. **VALVES SHOULD BE OPENED VERY CAREFULLY.**

d [mm]	Flow rate [m³/h]
10	60.P
12	90.P
15	140.P
20	250.P
25	400.P

Table 4.   Maximum flow rate for by-pass of internal diameter d (P in bar).

Figure 15.   IRM 3 with Type 333 Volume Corrector.

3.4   Commissioning

Experience has shown that blockage of rotary piston meters by debris will rarely occur in installations that have been in operation for some time. In new installations welding beads and swarf may be left over from the construction process.

New installations should therefore be thoroughly cleaned. Purging the installation with compressed air before the meter is installed is very effective, provided sufficiently high air velocities can be achieved.

It is good practice to provide a sieve upstream of the meter to help reduce the risk of debris damaging the meter. Instromet can provide suitable sieves.

3.5   Pressure drop

The pressure drop over the meter is proportional to the gas density and the square of the flow rate.

The pressure drop for Instromet IRM 1 meters is given in figure 16 as a function of flow rate for a gas with an absolute density of 0.8 kg/m³, which is equivalent to the density of an average natural gas.
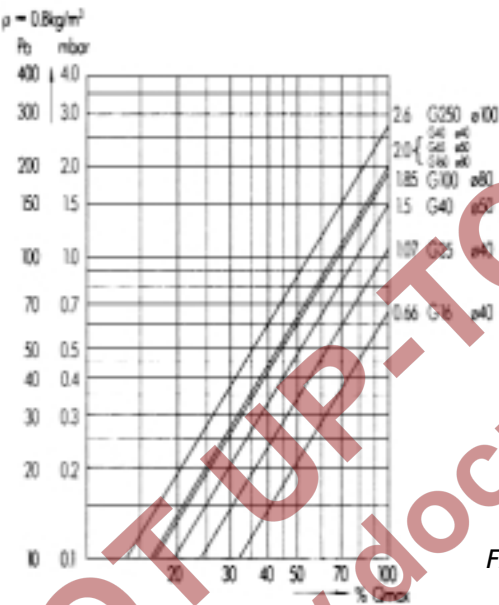

Figure 16.   Pressure drop over Instromet IRM 1 meter for natural gas.

3.6   Physical size

Rotary piston meters take up somewhat more space than turbine meters. As they are more tolerant with respect to installation conditions, the total installation may turn out to be more compact.

Figure 17.
Instromet IRM 1 (A) rotary gas meter with compact index and electronic volume corrector, model 555.

27

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