ENERGY SOLUTIONS CENTER

Track: Natural Gas Basics
Unit 11: Gas Meter Operation & Selection

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Presentation Outline

- General Information
- Diaphragm, Rotary, Turbine, Orifice & Ultrasonic Meters
- How to read the meter
- Clocking a meter
- Applications appropriate for each type of meter
- Sizes ranges and pressure limitations
- Pulse Outputs, Remote heads, Telemetry, and AMR
- Meter Pros/cons

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Gas Meter General Information

In General

- A gas meter is used to measure the volume of natural gas used by a customer
- Gas meters are used at residential, commercial, and industrial buildings that consume natural gas
- Gases are more difficult to measure than liquids, as measured volumes are highly affected by temperature and pressure
- Gas meters measure a defined volume, regardless of the pressurized quantity or quality of gas

Meter Types

- **Positive displacement**
  - Diaphragm and rotary meters
  - Positive displacement because they have well defined measurement compartments that alternately fill and empty as the meter rotates
  - By knowing the volume displaced in each meter revolution and by applying the proper gear ratio, the meter will read directly in cubic feet or cubic meters

Meter Types

- **Inferential**
  - Turbine and orifice meters
  - Have no measurement compartments to trap and then release the gas
  - These meters are inferential meters in that the volume passing through them is "inferred" by observing or measuring some physical characteristic

Temperature and Pressure

- Natural gas is highly compressible
- Gas meters measure a positive displacement of volume
- Because pressure and temperature effect how gas compresses, more or less BTU's may be present in a given volume of gas than what the meter can measure

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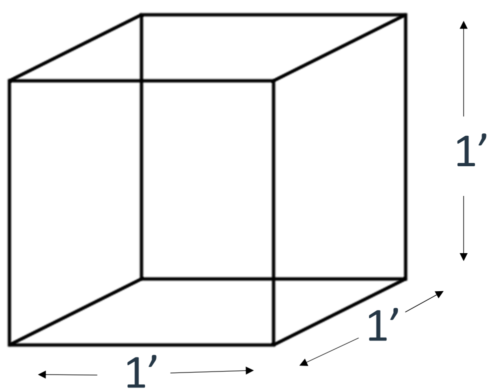
Cubic Foot



Volume = 1 C.F. Gas at base conditions of 60° F and 14.7 PSI Atmospheric pressure

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Pressure Effect

- Pressure Factor = $\frac{\text{Line Pressure + Atmospheric Pressure}}{\text{Base Pressure}}$

  = $\frac{\text{Line Pressure + 14.69 PSI at sea level}}{\text{14.73 PSI}}$

- 2PSI Factor = $\frac{\text{2 + 14.69 PSI}}{\text{14.73 PSI}}$ = 1.13

  13% more gas

- 15 PSI Factor = $\frac{\text{15 + 14.69 PSI}}{\text{14.73 PSI}}$ = 2.01

  Double the gas

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Altitude Effects Atmospheric Pressure

Altitude Above Sea Level Feet	Atmospheric Pressure psia	Barometer Reading Inches Hg	Altitude Above Sea Level Feet	Atmospheric Pressure psia	Barometer Reading Inches Hg
Sea Level	14.69	29.92	4,000	12.68	25.84
250	14.56	29.64	4,500	12.45	25.36
500	14.42	29.38	5,000	12.22	24.89
750	14.29	29.09	6,000	11.77	23.98
1,000	14.16	28.86	7,000	11.33	23.09
1,250	14.04	28.59	8,000	10.91	22.22
1,500	13.91	28.33	9,000	10.50	21.38
1,750	13.79	28.08	10,000	10.10	20.58
2,000	13.66	27.82	11,000	9.71	19.75
2,500	13.41	27.31	12,000	9.34	19.03
3,000	13.16	26.81	13,000	8.97	18.29
3,500	12.92	26.32	14,000	8.62	17.57

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Dresser-Roots: http://www.peconet.com/Products/RootsBulletins/rm-135.pdf

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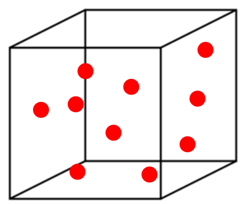
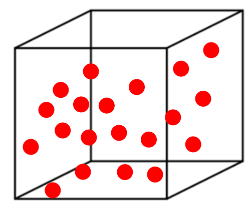
Pressure Effect on Volume of a Gas in 1 Cubic Foot



Volume = 1 C.F. Gas at 60° F and 14.7 PSI Atmospheric pressure



Volume in 1 C.F. at 14.73 PSI pressure = ~2X the gas in the same volume of space

Gas compresses under pressure and more gas fits in the same volume of space. Gas meters measure volume.

Pressure Factors

Rm-26Gas Pressure Correcting Factors

Base Pressure = 14.73 psia **Atmospheric Pressure = 14.4 psia**

Factors listed are directly usable to convert volume readings from displacement meters at various metering pressures into volumes at the standard base pressure and atmospheric pressure indicated above.
For a 14.65 base pressure, use an additional multiplier of 1.006.

PSIG	Factor	PSIG	Factor	PSIG	Factor	PSIG	Factor	PSIG	Factor	PSIG	Factor
1	1.045	61	5.119	121	9.192	405	28.47	705	48.84	1005	69.20
2	1.113	62	5.187	122	9.260	410	28.81	710	49.18	1010	69.54
3	1.181	63	5.254	123	9.328	415	29.15	715	49.52	1015	69.88
4	1.249	64	5.322	124	9.396	420	29.49	720	49.86	1020	70.22
5	1.317	65	5.390	125	9.464	425	29.83	725	50.20	1025	70.56
6	1.385	66	5.458	130	9.803	430	30.17	730	50.54	1030	70.90
7	1.453	67	5.526	135	10.142	435	30.51	735	50.86	1035	71.24
8	1.521	68	5.594	140	10.482	440	30.85	740	51.22	1040	71.58
9	1.589	69	5.662	145	10.821	445	31.19	745	51.55	1045	71.92
10	1.656	70	5.730	150	11.161	450	31.53	750	51.89	1050	72.26
11	1.724	71	5.798	155	11.50	455	31.87	755	52.23	1055	72.60
12	1.792	72	5.866	160	11.84	460	32.21	760	52.57	1060	72.94
13	1.860	73	5.933	165	12.18	465	32.54	765	52.91	1065	73.28
14	1.928	74	6.001	170	12.52	470	32.88	770	53.25	1070	73.62
15	1.996	75	6.069	175	12.86	475	33.22	775	53.59	1075	73.96

Pressure Factor tables can help quickly provide pressure factors

http://www.peconet.com/Products/RootsBulletins/rm-135.pdf

Pressure Effect

- For Billing:
- Fixed factor: used when gas pressure is regulated to a set pressure and does not fluctuate
  - Ex.: Customer has a regulator that provided a fixed 2PSI
  - From prior example, 2 PSI has a factor of 1.13 All gas measure on the meter gets multiplied by 1.13
- Pressure Corrector, used when gas pressure fluctuates up and down

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Temperature Effect

- Temperature Factor $= \dfrac{460 + \text{Base Temperature (°F)}}{460 + \text{Line Temperature (°F)}}$
- 

$$\frac{460 + 60\ °F}{460 + \text{Line Temperature (°F)}}$$

- Factor at 0°F delivery $= \dfrac{460 + 60}{460 + 0} = 1.13$ 13% more gas
- Temperature effects are not as great as pressure
- We want to correct whenever the bulk of the gas will be delivered at temperatures below 60°F

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Temperature Factors

Gas Temperature Correcting Factors

Factors listed are usable to convert gas volume readings from displacement meters at various temperatures to volumes at the standard base temperature of 60°F.

°F	Factor	°F	Factor	°F	Factor	°F	Factor
-20	1.1818	20	1.0833	60	1.0000	100	0.9286
-19	1.1791	21	1.0811	61	0.9981	101	0.9269
-18	1.1765	22	1.0788	62	0.9962	102	0.9253
-17	1.1738	23	1.0766	63	0.9943	103	0.9236
-16	1.1712	24	1.0744	64	0.9924	104	0.9220
-15	1.1685	25	1.0722	65	0.9905	105	0.9204
-14	1.1659	26	1.0700	66	0.9886	106	0.9187
-13	1.1633	27	1.0678	67	0.9867	107	0.9171
-12	1.1607	28	1.0656	68	0.9848	108	0.9155
-11	1.1581	29	1.0634	69	0.9830	109	0.9139

Temperature Factor tables exist, but in general temperature fluctuates throughout the year, so temperature correction is done as the gas flows through the meter

http://www.peconet.com/Products/RootsBulletins/rm-135.pdf

Meter Indexes

Analog

Digital

Diaphragm, Rotary, Turbine, Orifice & Ultrasonic Meters

Diaphragm Meters

- Most common type of gas meter
- Positive displacement
- Regular or temperature compensated
- Remote volume pulsars available
- Sized from 250 CFH to over 5000 CFH

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250 Diaphragm Meter Capacity

Capacities (0.60 specific gravity gas)

Line Pressure PSIG (mbar)	Differential Inches W.C. (mbar)	SCFH (m^3/h)
0.25 (17)	1/2 (1.2)	250[1,2] (7.1)
1 (69)	2 (5)	583 (16.5)
2 (138)	2 (5)	600 (17.0)
5 (345)	2 (5)	656 (18.8)
10 (690)	2 (5)	742 (21.0)

1 PSI = 27.68 Inch Water Column (w.c.)

¼ PSI =~ 7" w.c. and is a typical residential delivery pressure

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How Diaphragm Meters Work

- Meter has two or more chambers formed by movable diaphragms
- Gas flows are directed by internal valves
- Chambers alternately fill and expel gas during gas flow
- As the diaphragms expand and contract, levers turn a crank shaft
- The shaft drives a counter mechanism

https://process.honeywell.com/us/en/site/elster-instromet/products

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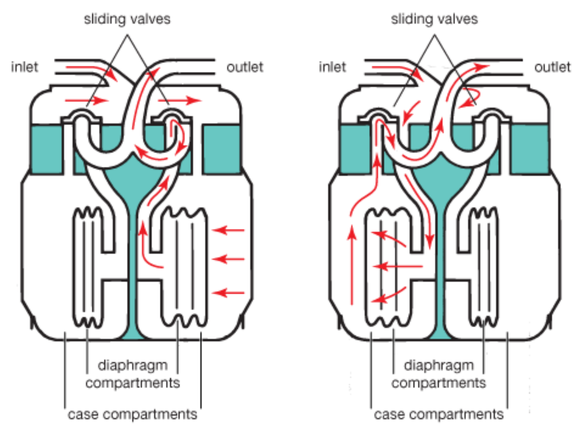
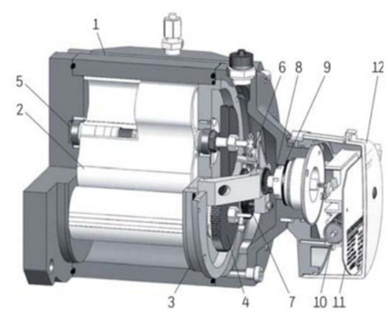
How a Diaphragm Meter Works



Rotary Meters

- Highly machined precision instruments capable of handling higher volumes and pressures than diaphragm meters
- Typically sized from 1,000 to 16,000 CFH



1 Housing
2 Impeller
3 Bearing Cover
4 Synchronizing Gears
5 Permanently Lubricated Ball Bearings
6 HF Pulser A1K (option)
7 Gear
8 Magnetic Coupler
9 Partition
10 Index
11 Main Plate
12 Index Cover

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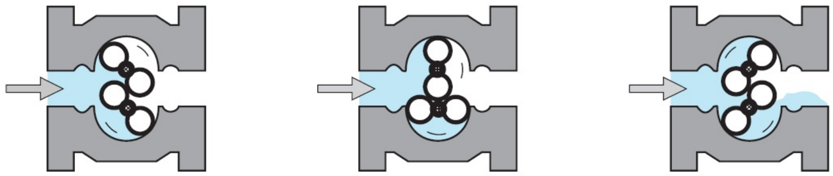
How a Rotary Meter Works



- The actual measuring cell consists of two 8 shaped impellers, which build together with the housing 4 chambers per revolution, which are periodically filled and emptied
- The number of revolutions is proportional to the passed volume
- The rotation is transferred to a mechanical index, which indicates this volume

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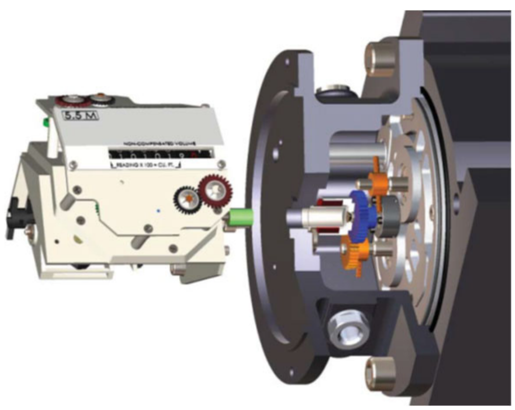
Rotary Meter Index Drive



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Rotary Meter Flow Rates

Description	Units	1.5M G25	2M G40	3.5M G65	5.5M G100	7M G130	11M G200	16M G250
Rated capacity @ 0.25 PSIG (17 mBarg)	SCFH (Sm3/h)	1500 (42.0)	2000 (56.0)	3500 (98.0)	5500 (154.0)	7000 (196.0)	11000 (308.0)	16000 (448.0)
Max. allowable pressure		285 PSIG (1965 kPa)						
Temperature range		- 40 to 140 °F (-40 to 60 °C)						

The greater the pressure, the greater the volume

Inlet Pressure	1.5M G25	2M G40	3.5M G65	5.5M G100	7M G130	11M G200	16M G250
0.25 PSIG (17 mBarg)	1,500 (42.0)	2000 (56.0)	3500 (98.0)	5500 (154.0)	7000 (196.0)	11,000 (308.0)	16,000 (448.0)
2 PSIG (140 mBarg)	1670 (46.8)	2227 (62.3)	3897 (109.1)	6124 (171.5)	7794 (218.2)	12,247 (342.9)	17,814 (498.8)
5 PSIG (345 mBarg)	1976 (55.3)	2634 (73.8)	4610 (129.1)	7244 (202.8)	9219 (258.1)	14,487 (405.6)	21,073 (590.0)
10 PSIG (690 mBarg)	2485 (69.6)	3313 (92.8)	5798 (162.3)	9111 (255.1)	11,595 (324.7)	18,221 (510.2)	26,504 (742.1)
25 PSIG (1.7 Barg)	4012 (112.3)	5350 (149.8)	9362 (262.1)	14,711 (411.9)	18,724 (524.3)	29,423 (823.8)	42,797 (1,198.3)
50 PSIG (3.4 Barg)	6558 (183.6)	8744 (244.8)	15,302 (428.5)	24,046 (673.3)	30,604 (856.9)	48,092 (1,346.6)	69,952 (1,958.7)
75 PSIG (5.2 Barg)	9104 (254.9)	12,138 (339.9)	21,242 (594.8)	33,381 (934.7)	42,485 (1,189.6)	66,762 (1,869.3)	97,108 (2,719.0)
100 PSIG (6.9 Barg)	11,650 (326.2)	15,533 (434.9)	27,183 (761.1)	42,716 (1,196.0)	54,365 (1,522.2)	85,431 (2,392.1)	124,263 (3,479.4)

www.elster-americanmeter.com

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Turbine Meters

- Turbine gas meters infer gas volume by determining the speed of the gas moving through the meter
- Good flow conditions must be present for accurate measurement
- Typically 3” (10,000 CFH) to 12” (150,000 CFH)
- Pressure up to 1480 PSI or more

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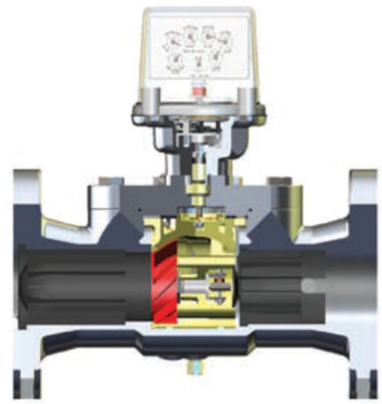
How Turbine Meters Work

- A small internal turbine measures the speed of the gas, which is transmitted mechanically to a mechanical or electronic counter
- This meters does not impede the flow of gas, but is limited at measuring lower flow rates



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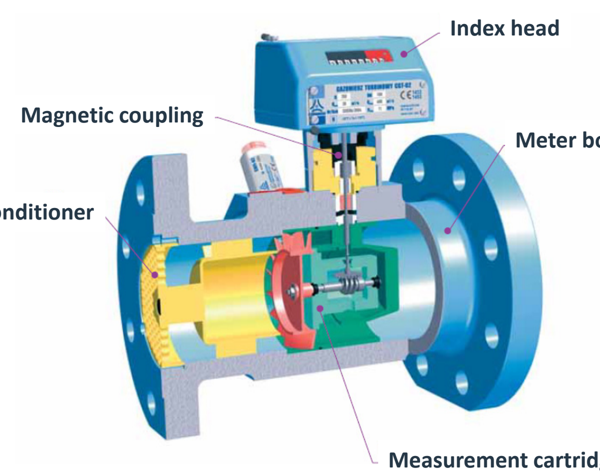
How a Turbine Meter Works



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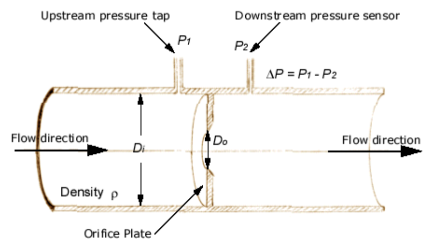
Orifice Meter

- An orifice gas meter consists of a straight length of pipe inside which a precisely known orifice creates a pressure drop, thereby affecting flow



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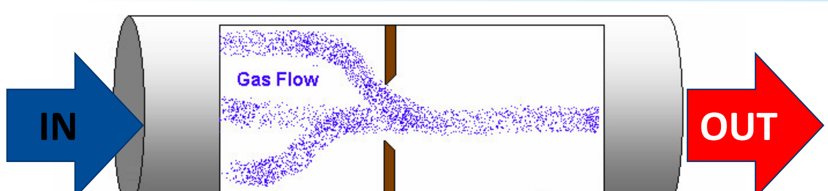
How an Orifice Meter Works



- The pressure difference is measured across the orifice plate as gas flows
- Using this pressure difference along with static pressure, density, viscosity, and temperature, the gas volume is calculated

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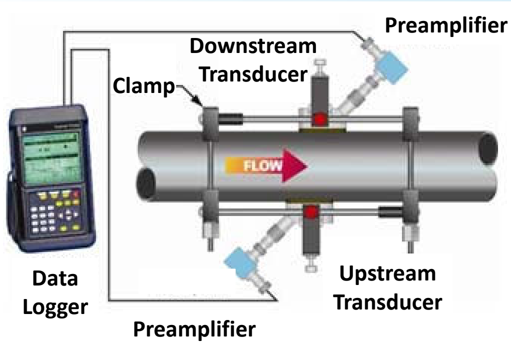
Ultrasonic Meters

- This meter is more complex than meters that are purely mechanical, as it requires significant signal processing and computations
- Ultrasonic meters measure the speed of gas movement by measuring the speed at which sound travels in the gaseous medium within the pipe

How an Ultra Sonic Flow Meter Works



- Clamp on transducers produce clean, coded signals with very minimal background noise
- Can measure the flow of any gas and then calculate mass flow using a pressure transmitter connected to the analogue input

How to Read a Meter

Dial Reading

- Read the dials left to right
- If the hand is between two numbers, always select the lower number
- When the hand is between "9" and "0," then "9" is considered the lower number
- When the hand looks as though it is DIRECTLY on the number, look at the dial to the right – if the dial on the right has passed "0," use the number that the hand is on
- If the dial on the right has not passed "0," use the number less than what the hand is on

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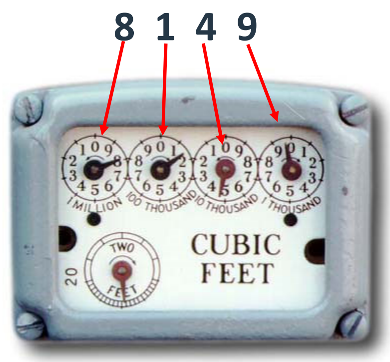
Meter Reading



1. The first dial is turning counter-clockwise. It appears to point to the “8”. The number to the right has past “0”, so **read this dial as “8.”**
2. The second dial is turning clockwise and is between "1" and "2." **Read this dial as “1.”.**
3. The third dial is turning counter-clockwise and is just before the "5.“ **Read this dial as “4.”**
4. The fourth dial is turning clockwise and is between the “9" and the “0.“ **Read this dial as “9."**

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Clocking a Meter

Clocking a Gas Meter

- Clocking a Gas meter is done to measure the BTU usage of a gas appliance to make sure the appliance is firing at the rate specified by the manufacturer.

- ½ to 2 Cubic Foot depending on meter size
- Each revolution equals ½ C.F. of gas

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Clocking a Meter

- Turn off all appliances that are connected to the gas meter you are timing except for the appliance you want to measure

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Clocking a Meter

- Turn on the appliance to be tested and no other gas appliances
- Watch the ½, 1 or 2 CF dial on the meter
- Start a stop watch when the dial is at the 6 or 12 o'clock position & time a revolution

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Clocking a Meter

- After about 3 revolutions stop the watch
- Divide the # of seconds on the watch by 3 to get the # of seconds per revolution for more accurate results
- Ex: 48 seconds for 1/2 CF Dial 3 revolutions
  - 3,600 seconds per hour / 16 seconds per revolution = 225 revolutions per hour
  - 225 revolutions X ½ C.F. per rev = 112.5 CFH
  - 112.5 CFH X 1000 BTU / CF = 112,500 BTU/Hour

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Gas Flow Timing Chart

Seconds for one Revolution of the Dial	SIZE OF METER DIAL				
	1/2 CU.FT.	1 CU.FT.	2 CU.FT.	5 CU.FT.	10 CU.FT.
	THOUSAND BTU'S PER HOUR @ 1000 BTU'S/CU.FT.				
10	180	360	720	1800	3600
11	164	327	655	1636	3272
12	150	300	600	1500	3000
13	138	277	555	1385	2770
14	129	257	514	1286	2572
15	120	240	480	1200	2400
16	112	225	450	1125	2250
17	106	212	424	1059	2118
18	100	200	400	1000	2000
19	95	189	379	947	1894
20	90	180	690	900	1800
21	86	171	343	857	1714
22	82	164	327	818	1636
23	78	157	313	783	1566
24	75	150	300	750	1500
25	72	144	288	720	1440
26	69	138	277	692	1384
27	67	133	267	667	1334
28	64	129	257	643	1286
29	62	124	248	621	1242

… or you can use a gas flow chart

Appropriate Applications & Sizes

Diaphragm Meter Applications

- Seen in almost all residential and small commercial installations
- You will also find these meters in larger commercial applications calling for up to 10,000 CFH
- These meters are very accurate and don't lose pilot fuel

Diaphragm Meters

- Diaphragm meters are usually grouped by "Class," which refers to the badged capacity of the meter in cubic feet per hour, 250 Class, 400 Class, etc.
- The badged capacity is based on a ½" water column pressure drop across the meter
  - The meter can pass more than the badged capacity at higher pressure drops, and many utilities size diaphragm meters based on a 2.0" water column pressure drop across the meter, especially when measuring at elevated pressures
- Sizes typically 250 to 5,000 CFH

Rotary and Turbine Meter Applications

- Great for larger commercial or industrial applications
- Rotary meters can measure smaller loads very well.
- Turbine meters could allow trace amounts of gas to pass through unmeasured
  - Good for very large on/off type loads that do not have small auxiliary loads when the equipment is off

Rotary Meters

- The primary application for rotary meters is for small commercial loads
- Frequently are used for production measurement of gas volumes used
- Rotary meters come as small as 500 cfh and are made in sizes up to 102,000 cfh
- Most common sizes are 1M to 16M

Turbine Meters

- The primary application for turbine meters is large commercial or industrial loads
- Turbine meters are typically sized 4” to 12”
  - 4” Turbine meter measures 12,600 CFH @ 5” w.c.
  - 4” Turbine meter measures 73,458 CFH @ 45 PSI
  - 12” Turbine meter measures 98,000 CFH @ 5” w.c.
  - 12” Turbine meter measures 571,340 CFH @ 45 PSI

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Turbine Meter Considerations

- Turbine meter sense velocity
- It is critical that the flow in the meter be smooth and laminar
- Straightening vanes and nose cone smooth out the flow inside the meter, but it is necessary to ensure that the gas entering the meter be a smooth as possible
- Restrictions upstream of the meter, such as valves, fittings and taps, can cause turbulent flow and even jetting
- To create laminar flow before the meter, long straight runs of pipe and straightening are usually employed

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Orifice Meters

- Will usually be used to handle large volume measurements
- The volume calculations for orifice meters can be quite complex and are usually accomplished by means of a flow computer
- The dimensions and tolerances for the meter and meter piping run are critical to the accuracy of the meter

Temperature and Pressure Correctors

Volume Correctors

- Electronic or mechanical correctors
- Correct for temperature and/or pressure

Pulse Outputs, Remote Heads, Telemetry, and AMR

Pulse Outputs

- Two types available
  - Low Frequency (LF) pulse output
  - High Frequency pulse output

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Pulse Outputs

- The LF transmitter consists of 2 dry reed switches, normally open, and actuated by a magnet located in the first odometer drum on the index register
  - Volume per pulse contact: CF index; 1 CF/pulse : m3 index; 0.01 m3/pulse
  - Hermitically sealed contacts
  - Minimum pulse contact time - CF index; 0.22 seconds : m3 index; 0.40 seconds
  - No polarity
  - Maximum voltage; 30 volts

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Pulse Outputs

- The HF transmitter is an inductive sensor actuated by a toothed disc – the frequency is proportional to the instantaneous flow
  - Pulses per unit volume: CF; 45.833 pulses/CF : m3; 4678.16 pulses/m3
  - Frequency at maximum flow rate: CF; 25.46 Hz : m3; 73.60 Hz
  - Has polarity, indicated on register label

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Telemetry

- Telemetry is simply an electronic devise mounted either directly to an existing natural gas meter or near the meter which automatically sends usage information to the utility
- The device allows gas flow to be electronically measured daily or more frequently such as every 15 minutes
- The system logs the daily gas use which will be uploaded to the utility via a dedicated, customer-installed phone line
- Daily use data may be available to the customer via the internet
- The timeliness of this measurement and detailed information will help the customer better manage their natural gas usage and associated energy costs

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Automatic Meter Reading (AMR)

- AMR, is the technology of automatically collecting consumption, diagnostic, and status data from gas metering devices and transferring that data to a central database for billing, troubleshooting, and analyzing
- Saves utility the expense of periodic trips to each physical location to read a meter

https://lancasteronline.com/business/new-gadget-reads-your-gas-meter-from-street/article_7c35f2f0-92bf-56f4-94f6-c7939a14a0f9.html

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Automatic Meter Reading (AMR)

- Billing can be based on near real-time consumption rather than on estimates based on past or predicted consumption
- Provides customers better control over gas usage
- AMR technologies include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF)

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Meter Pros and Con's
… From Experience

Diaphragm

- Pros
  - Most common
  - Inexpensive
  - Very accurate
- Cons
  - Flow limitations
  - Pressure limitations
  - Cause pressure drop

Rotary

- Pros
  - Don't have pressure limitations like diaphragm
  - Much higher flows than Diaphragm
  - Very accurate measurement
- Cons
  - Easily stopped with weld slag or debris in new installations
  - Needs to be maintained regularly (oil check)

Turbine

- Pros
  - Allow large volumes of throughput
  - No pressure limitations
- Cons
  - Expensive meter
  - Pilot loads lost
  - Tends to run fast when less than 20% of rated capacity


Thank You
Consider taking the on-line test while
course material is fresh in your mind
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