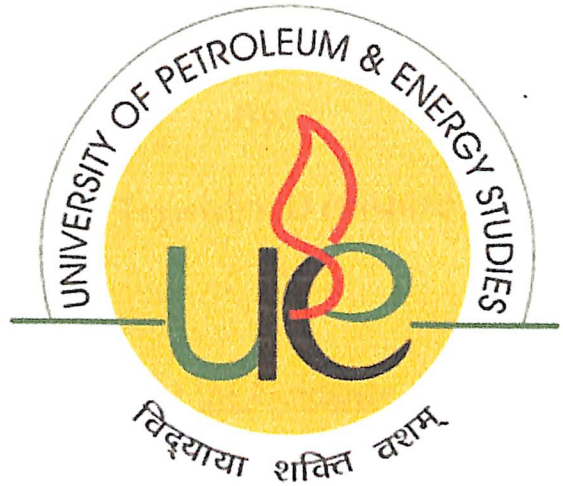
MAJOR PROJECT REPORT

ON

DESIGN OF CITY GAS DISTRIBUTION



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DESIGN OF CITY GAS DISRIBUTION

A thesis submitted in partial fulfilment of the requirements for the Degree of Bachelor of Technology (Applied Petroleum Engineering)

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CERTIFICATE

This is to certify that the work contained in this thesis titled "Design Of City Gas Distribution" has been successfully carried out by Ms. Lakshmi Tejaswini. D, student of B.Tech Applied Petroleum Engineering final year under my mentorship and has not been submitted elsewhere for a degree.

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I am privileged to extend my sincere thanks to all the faculty members and library section of UPES.

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ABSTRACT

City gas distribution is the process of supplying the gaseous fuel in the form of PNG (pipeline natural gas) and CNG (compressed natural gas) to the domestic, commercial, industrial and transportation sectors.

The City Gas Distribution accounts for 4-6MMSCMD in the country. It is going to be increased to 20MMSCMD in the next four years. The City gas distribution in the country is increasing at a rapid rate for the usage of PNG for the domestic, commercial, industrial and CNG for transportation. The two big factors that will drive this growth are increase in domestic gas production (from the KG basin) and the development of infrastructure (both at the local and cross-country level).

This project covers studies on various equipments used in city gas distribution system like DRS, CGS, Regulators and Meters and laying of pipeline network.

Gas distribution system is a connected pipeline system that carries natural gas from a source such as a city gas station (or) regular station to customer premises. A typical gas distribution system consists of assets such as main pipes & service pipes to distribute gas, valves, and regulator device to control and regulate the flow, joins and fittings to join different pipes and meters to measure the inlet and outlet of gas.

The project also covers the design of the city gas distribution for Rajahmundry city, by considering the quantity of the gas required for domestic commercial and industrial areas.

The design involves the calculation of volume of gas required by the city, design of steel and PE pipelines, design methodology of pipe sizing and proposing the network required for the city. The topic CNG Station includes discussions on various types of CNG stations, parts and equipments involved at a CNG Station like the compressor, dispenser, the gas meter, storage cascade, pipes, valves & fitting, control panel , safety accessories etc.

This project also focuses on all aspects safety and regulations considered for designing the city gas distribution network.

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ABBREVIATIONS

CGD – City Gas Distribution

CNG – Compressed Natural Gas

PNG – Piped Natural Gas

LPG – Liquefied Petroleum Gas

LNG – Liquefied Natural Gas

KG Basin – Krishna Godavari Basin

CGS – City Gas Station

LDO – Light Diesel Oil

SKO – Superior Kerosene Oil

BCF – Billion Cubic Feet

CH_4 – Methane

CO_2 – Carbon Dioxide

UHC – Unburned Hydro Carbon

CO – Carbon Monoxide

NOx – Oxide of Nitrogen

SO_X – Oxide of Sulphur

HC – Hydrocarbon

MDPE – Medium Density Poly Ethylene

DRS – District Regulating Station

RPD – Rotary Positive Displacement

ECU – Electro fusion Control Unit

MEK – Methyl Ethyl Ketone

SDR – Specific Diameter

CV – Calorific Value

MMSCMD – Million Metric Standard Cubic Per day

P, V, T – Pressure, Volume, Temperature.

CHAPTER-I

INTRODUCTION

City natural gas distribution network means an interconnected network of gas pipelines and the related equipment used for transporting natural gas from a bulk supply high pressure transmission main to the medium pressure distribution network and subsequently to the service pipes supplying natural gas to domestic, industrial or commercial premises and Compresses natural gas (CNG) stations for transportation purpose.

The City gas distribution accounts for 4-6MMSCMD in the country. It is assumed to increase to an amazing 20MMSCMD in the next four years. The City gas distribution in the India is increasing at a rapid rate for the usage of PNG for the domestic, commercial, industrial and CNG for transportation. The two factors that will drive this growth are increase in gas production (from the KG basin) and the development of infrastructure.

1.1 CITY GAS DISTRIBUTION IN INDIA

Oil India Limited (OIL) was first to start distribution of gas in Assam in the 60s. In Gujarat, Oil and Natural Gas Corporation (ONGC) started selling its associated gas to the neighboring industries in the 70s. With the find of Oil / Gas at Mumbai high, supply of gas commenced to industrial consumers around Mumbai like MSEB, Tata and RCF. The gas pipeline networks were laid / owned by either ONGC or the customers.

With the gas discovery in south bassein of Mumbai shores, the first cross country pipeline in India was conceptualized with Hazira as the landfall point in Gujarat. Gas Authority of India (GAIL) was formed in 1984, to act as a nodal agency for natural gas in India. GAIL constructed and operated this pipeline, which ran from Hazira to Jagdishpur via Bijaipur. This pipeline supplied gas to the fertilizer and power sector. Thereafter, entire existing assets of ONGC and development of new networks were transferred to GAIL.

As a pilot project first city gas distribution project was taken up with the help of ONGC at Vadodara city in 1972. Historically, due to lack of natural gas demand, the supply of gas to cities did not build up. Though studies were conducted in 80s for cities like Mumbai and Delhi, projects did not take off in absence of adequate gas allocation.

Gujarat Gas Company Limited (GGCL) was the first commercial city gas distribution project in India. GGCL currently under British Gas management developed distribution network in the Bharuch and Ankleshwar cities. Subsequently, they expanded their network to Surat.

Mahanagar Gas Limited (MGL) started city gas distribution to domestic, industrial and commercial customers in Mumbai in 1995. The focus of the company was to supply gas to domestic households and in an event of surplus cater to the industrial demand.

Similarly in 1998, Indraprastha Gas Company Limited (IGL) started city gas distribution in Delhi. The focus of IGL was to provide CNG to the transport sector in view of Supreme Court judgment making CNG compulsory.

In addition to these, city gas distribution in limited scope is present in Sibsagar (Assam) and Agartala (Tripura) mainly for the domestic users.

Natural gas is generally used by various industries for fuel requirements as well as feedstock in the manufacturing process. The major industries identified as natural gas consumers are the power plants and the fertilizer companies. In addition, chemical & petrochemical units, glass manufacturers, textile process houses, sponge iron units and pharmaceutical units are also natural gas consumers in the state.

Natural Gas scores high over other competing fuels such as naphtha, furnace oil , LDO, SKO, etc on account of being a clean fuel, non polluting and economical. Gas being easy to handle, the handling cost of gas is comparatively lower. Usage of gas also improves operational efficiencies.. As a result of the above, gas is a preferred fuel.

With the successes of IGL & MGL, CNG has become the most sought after fuel in the transport sector. Use of CNG not only checks the air pollution but also provides immense savings to the user.

Internationally as well as domestically, the use of natural gas has been increasing steadily for several reasons viz. price advantage, fuel diversification and/or energy security issues, environmental concerns, market deregulation (for both gas and electricity) and overall growth in the economy.

With the likely improvement in availability of gas and related pipeline infrastructure, several city gas distribution projects are likely to come up in near future. This shall get further boost with the pro-active stand taken up by the Supreme Court of India in relation to the deteriorating air quality in major cities of the country. Delhi & Mumbai have witnessed

significant improvement in air quality after the court made mandatory use of CNG in public vehicles.

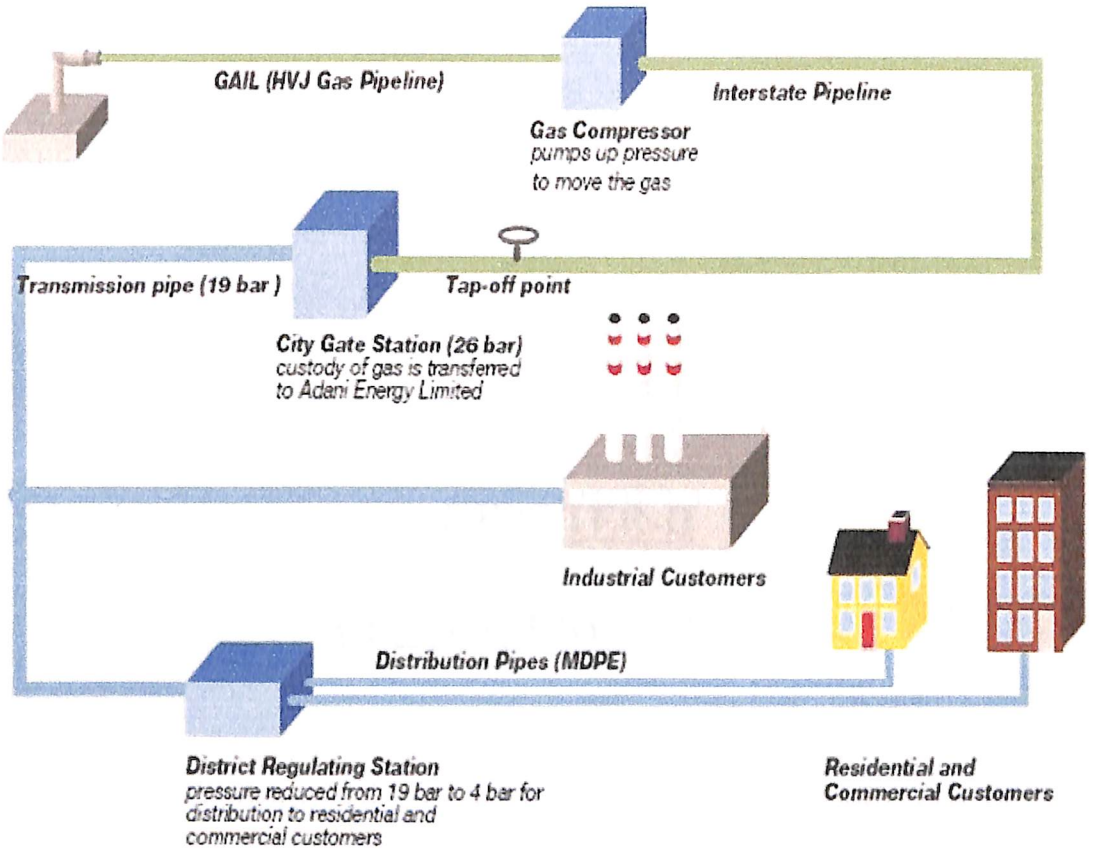


Figure : Example of city gas distribution

CHAPTER-II

LITERATURE REVIEW

NATURAL GAS – FUEL OF THE CENTURY

Globally natural gas is the fastest rising component of the total energy consumption. Use of Natural gas is ever-increasing around the world for a variety of reasons including economy, fuel diversification and energy security issues, environmental friendliness, market deregulation for gas & electricity, etc.

Global Natural gas consumption which stood at 87 trillion cubic feet in 2001 is expected to double to 182 trillion cubic feet by 2020 with an average yearly growth rate of 3.2 %. Significant rise in gas consumption is expected in Asia and Central and South America. The share of natural gas is likely to go upto 28 % by 2020 from the current levels of 16%

Gas consumption is expected to grow by 2.5 % per year in the industrialized countries. Natural gas is likely to account for largest increase in energy use for power generation over next two decades as compared to others. In developing countries also similar trends are likely for the natural gas consumption. As per estimates natural gas consumption would grow by an average of 5.2%, more rapidly than any other fuel, up to 2020.

The increase in usage of natural gas can be attributed to the increasing sensitivity to environment issues and need to improve the environment performance. Besides the environment advantage, natural gas also provides efficient combustion, economy and convenience.

India is a large country with a population of over one billion (16% of world population). To provide a better quality of life for the people, the energy needs are enormous. Constant economic development and population growth are motivating energy demand faster than India can produce it. India consumes 12.18 quadrillion Btu (Quads) of energy, or just about 3% of the world's total energy consumption. During the last 50 years the Government of India through National Oil Companies has developed a reliable energy production and distribution system. However, energy consumption in India, despite growing at a rapid pace, is still much below the world average.

Natural gas in India is becoming more popular as a primary energy source since the last two decades. It is primarily used in fertilizer, power, petrochemicals and steel sector. Consumption of natural gas is dramatically increased from 629 billion cubic feet (bcf) per year in 1995, to 800 bcf in 2004. In India Natural gas will become a bigger part of the energy picture, mainly as a way to reduce dependence on foreign oil and also to meet the stringent environmental regulations because of the absence of sulfur dioxide and reduced levels of nitrogen oxide and carbon dioxide.

As per the Hydrocarbon Vision 2025 of Government of India, share (%) of natural gas in future Energy Supply in India is as shown in table.

Table : Energy supply in India

Year	Coal	Oil	Gas	Hydel	Nuclear
1997-98	56	35	7	2	1
2001-02	50	32	15	2	1
2006-07	50	32	15	2	1
2010-11	52	30	14	2	1
2024-25	50	25	20	2	3

Source: Hydrocarbon Vision 2025 of Government of India

Over the last one and half decade the Indian gas market has made significant advancements and is now ready of take off on much wider coverage of the country the next 10 years or so. The Indian gas market, at present, is supply constrained, however number of supply side initiatives have been taken by Govt. of India to increase the gas supply to the market from the domestic resources as well as through imports. The policy framework has been put in place to support development of gas import projects as well as to intensify exploration in the country to improve the base of recoverable gas reserves in coming years. Similarly major steps have been taken to undertake study and commercial exploitation of unconventional gas resources.

Some of the recent initiatives of Government of India for augmenting the gas supplies are: Iran-India gas pipeline project, Myanmar-India gas pipeline, Petronet LNG Project, Coal Bed Methane projects and attracting private capital for exploration and production of the Oil & Gas fields.

The predominance of Natural Gas as a fuel for city energy purpose internationally is primarily due to three reasons. Firstly, it is more economical alternative. Comparing natural gas with fuels against which it will be competing in various customer segments within cities namely fuel oils for industrial segment, petrol/diesel for transport segment and LPG for commercial and domestic segments, this can be clearly bought out. In the transport segment (refer figure) the fuels are compared based on running cost, CNG is almost three times as economical as the traditional fuels.

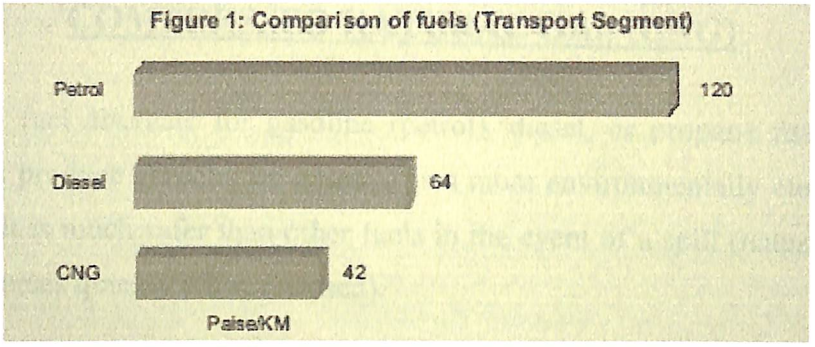


Figure : Comparison of fuels (Transport Segment)

Source: www.crisil.com

For the commercial, industrial and domestic segments the fuels are compared on the basis of total expenditure incurred to create one million Kilocalories of energy (refer figure)

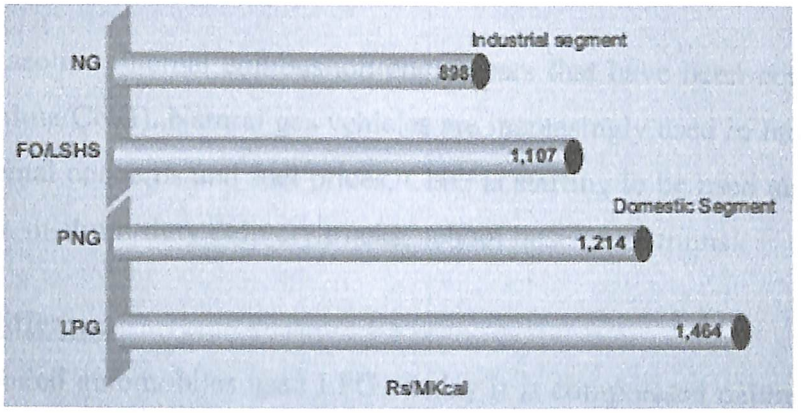


Figure : Comparison of fuels (Industrial & Domestic segment)

Source: www.crisil.com

For industrial customers natural gas offers a 21% cost benefit in energy terms while for the domestic segment Piped Natural Gas (PNG) presents a savings opportunity of almost 16% on the monthly bill. Secondly, natural gas is a clean fuel. When natural gas burns it creates lesser pollutants as compared to traditional fossil fuels.

COMPRESSED NATURAL GAS (CNG)

CNG is a fossil fuel alternate for gasoline (petrol), diesel, or propane fuel. Although its combustion does produce greenhouse gases, it is a more environmentally clean substitute to those fuels, and it is much safer than other fuels in the event of a spill (natural gas is lighter than air, but disperses quickly when released).

CNG is made by compressing natural gas (which is mainly composed of methane (CH_4), to less than 1% of its volume at standard atmospheric pressure. It is stored and distributed in hard containers, at a normal pressure of 200–250 bar, usually in cylindrical or spherical shapes.

CNG is used in gasoline internal combustion engine cars that have been converted into bi-fuel vehicles (gasoline/CNG). Natural gas vehicles are increasingly used in India. In response to high environmental concerns and fuel prices, CNG is starting to be used also in light-duty passenger vehicles, medium-duty delivery trucks, school buses, and trains..

CNG – Making difference

In the past, gas fuelled automobiles used LPG. Today it is compressed natural gas that is in use. Methane is the prime component of CNG while LPG is a blend of Propane, Butane and some other chemicals.

Table : Typical composition of CNG:

COMPONENT	PERCENTAGE RANGE
Methane	90.5% – 91.5%
Ethane	3% - 4.2%
Propane	0.3% - 0.5%
CO_2	3.5% - 4.2%
Others	0.012% - 0.212%
Total	100%

Physical properties

Non-toxic: Natural gas being sulphur/lead free, its use substantially reduce harmful engine emission. When natural gas burns completely, it gives out carbon dioxide and water vapour- the very component we give out while breathing.

Lighter than Air: Natural gas which is being lighter than air, will rise above ground level and disperse in the atmosphere, in the case of leakage.

Colourless: Natural gas is colourless.

Odourless: Gas in its natural form is odourless, however, ethyl mercaptant is later added as odorant so as to detect the leakage

Fuel vs. Emissions (gm/100 Km)

Table : Fuel vs. Emissions

Fuel /Emissions	CO_2	UHC	CO	NO_X	SO_X
PETROL	22,000	85	634	78	8.3
DIESEL	21,000	21	106	108	21
LPG	18,200	18	168	37	0.38
CNG	16,275	5.6	22.2	25.8	0.15

Benefits of CNG

- Environment friendly and hence better health
- Economical.
- Safer
- Very low particulate emission
- Low emission of air borne toxins
- Negligible emission of oxide of sulphur(SO_X)
- More quiet operation, having less vibrations and less odour than the corresponding diesel engines.

Limitations of CNG

- Non availability at all locations.
- Higher conversion cost of vehicles.
- Higher Infrastructure cost.
- Lack of knowledge about CNG.
- Requires high pressure to increase storage energy density.
- Requires high pressure cylinder for storage
- Shorter self-sufficiency (but there is dual fuel option available).
- Boot space occupied by cylinder.
- Much more expensive distribution and storage
- High vehicle cost
- Shorter driving range
- Much heavier fuel tank

Pollution reduction in CNG fuelled vehicles

The use of CNG in vehicle leads to considerable reduction in air pollution as is evident from the following data:

A. Auto rickshaw – Bajaj Three wheeler

Table : Fuel vs. Pollutants for Auto rickshaw

Pollutants/Fuel	Petrol	CNG	% Reduction
HC	3.26	1.26	63.19
CO	5.48	1.57	71.35
CO_2	47.44	27.60	41.82
NO_X	0.25	0.20	20.00

(Source: Bajaj Auto manufacturer of three wheelers)

B. Passenger car:

Table : Fuel vs. Pollutants for different types of cars

Type of car	**Pollutants/Fuel**	Petrol	CNG	% Reduction
Maruti Omni	CO	19.78	0.55	97
	HC	1.14	1.02	11
Maruti Gypsy	CO	4.94	0.59	88
	HC	1.86	1.42	24
Premier Padmini	CO	18.36	0.94	95
	HC	2.83	2.03	28
Ambassador	CO	52.16	0.78	98
	HC	6.37	4.33	32

Source: Emission test conducted by GAIL (INDIA) Ltd.

C. **Diesel Buses**: Ashok Leyland

Table : Fuel vs. Pollutants for Ashok Leyland bus

Pollutants/Fuel	Diesel	CNG	% Reduction
HC	1.68	1.4	16.67
CO	4.5	3.77	19.37
NO_X	13.73	8.0	41.77
Particulate Matter	0.125	0.0029	97.68

Source: Ashok Leyland the manufacturer of buses

PIPED NATURAL GAS (PNG)

The second category of the gas in the CGD is the PNG. The major difference between the CNG & PNG is that, the PNG which is supplied through the MDPE from DRS, the pressure is 2-4 bar.

Applications of PNG

Following are the applications of PNG

- Cooking purpose
- Heating/ furnace
- Air conditioning
- Gas fire places
- Hotels, restaurants, hospitals.
- Industrial

PNG – Convenient fuel

The PNG is called the convenient fuel due to the following reasons,

- Continuous supply of gas.
- Necessity of changing the cylinders are not required.
- Useful during the emergency.
- No problem of space occupancy as cylinders.
- The payment is after consumption based on how much consumed.
- It is totally combustible containing 94% of combustible material and does not leave any residues.
- It does not darken the vessels.
- It contributes to a cleaner society.

Comparing the PNG & LPG.

- PNG is comparatively cheaper than LPG.
- The billing is done based on the consumption by the customer.

PNG is safe as,

- The property of natural gas is that it catches fire when it forms a mixture of 5-15% mixture with air, whereas LPG is combustible when at its 2% mixture with the air.
- Since natural gas is lighter than air, in cases of leak, it just rises up and disperses in to the air. Comparing LPG, it being denser than air settles down in case of leakage, which is highly hazardous. The technical factor involved in this is the flammability limit of the gas.
- Large quantity of LPG i.e. around 14.2 kg of LPG is compressed into the LPG cylinders. Whereas, the PNG installation inside the premises is very less and is only at pressure range of 21mbar.

CITY GAS DISTRIBUTION SYSTEM

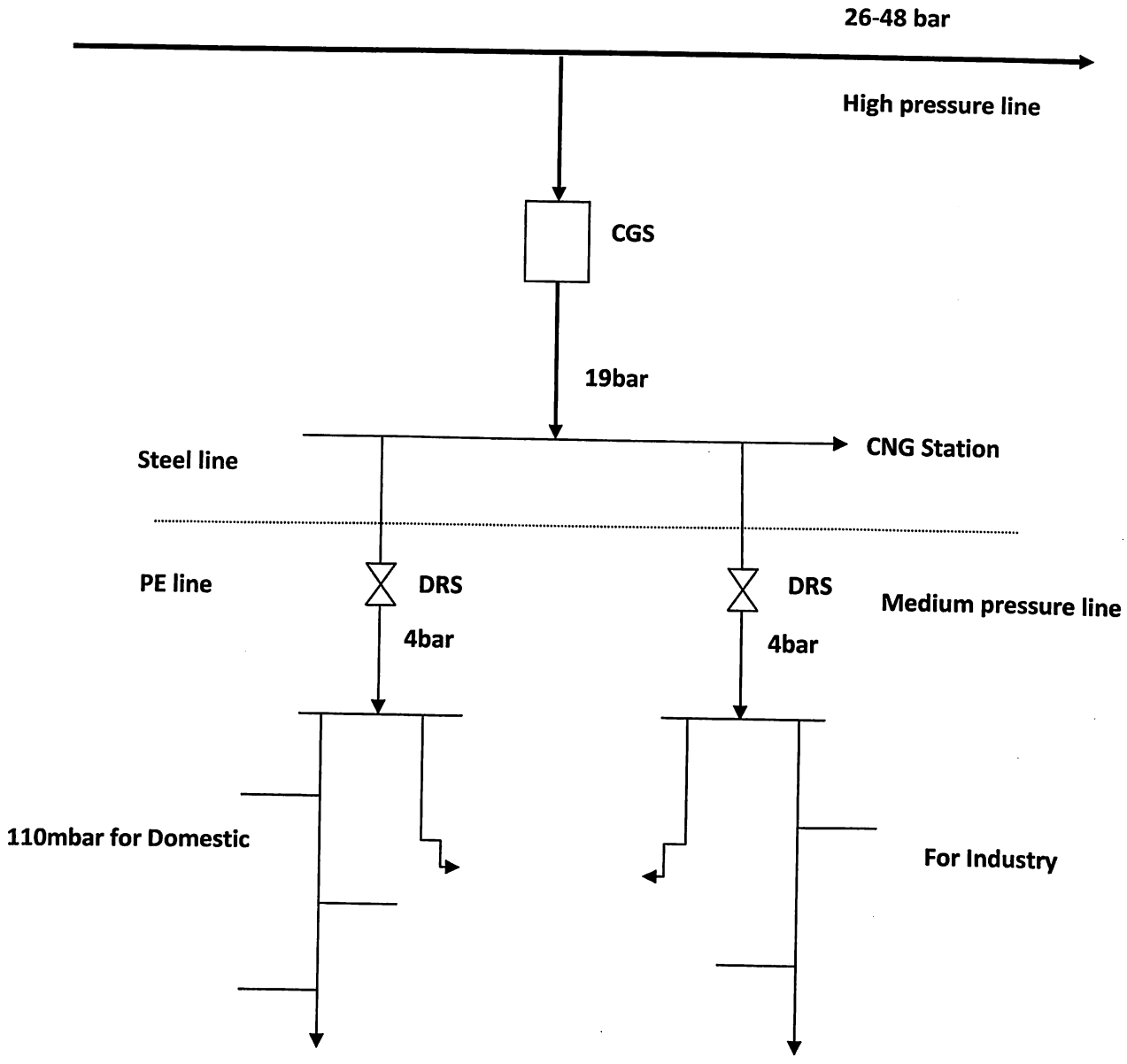


Figure : City Gas Distribution System

The system consists of

1. City Gate Station (CGS)
2. Odorization unit
3. District Regulating Station (DRS)
4. Service regulator
5. Meters.
6. Pipeline system.

City Gate Station

CGS is the starting point of the city gas distribution system; it receives the natural gas from the supplier based on the demand. This consists of configuration.

- Filter skid
- Regulating skid
- Metering skid.

- **Filtration skid**

The skid has been designed in such a way as to accept a single stream only. High efficiency filter separators are used for the removal of liquid and solid particles from the incoming gas stream over the entire operating range. The gas outlet from the processing industry is cautiously maintained at free of impurities, the filtration skid ensures the pure gas distributed to the line. The filter is normally designed to withstand a pressure in the range of 30-49 bar.

- **Pressure Reduction skid**

The pressure reduction skid is installed to reduce the pressure of the incoming gas from the source from the range of 30-49barg to 26barg.

- **Flow metering skid**

Flow meters are installed to for a single stream. The normal flow meters used in the CGS is orifice plates. Orifice flow meters finds its use as a large pressure drop is required. The various parameters such as temperature in the various sections of the line, pressure at the inlet and outlet joints, flow inlet and outlet are controlled by the SCADA systems in the control room

Therefore the gas is passed through the filter for removal of liquid and solid particles and then it is passed through the regulating skid to reduce the pressure of the gas from 26-30 to 19 bar, after this the gas with this pressure is sent to the main metering skid for the purpose of measuring.

Oderization unit

One of the measure safety factors is Oderization of the natural, which is going to be used by the customer. For the safe distribution of the gas some smelling identification is required for leak detections. In this a single odorant or combination of two can be used. The unit consists of a pressure vessel filled with odorant and a special injection pump which pumps these chemicals into the natural gas line by considering flow rate. The odorant generally used is ethyle mercaptant. The odorizer injected should be of 12PPM as per the Indian standards.

District Regulating Station

DRS is the next setup of the CGD. It is a device used to reduce the pressure from 19 barg to 4barg. It is the interface between the steel grid network and the medium pressure network. The location of the District Regulation Station mainly depends on the requirements and demand. The various components in the DRS includes

- Slam shut valves for controlling the flow.
- Filtering skid
- Pressure reduction skid

The normal range of pressure in the District Regulation System is inlet: 19-26barg, outlet: 2-4barg. The maximum allowable flow inside the DRS is in range of 5000-10000SCMH. The inlet to the DRS is from the steel line and the outlet is also the steel line, where its joined to the PE line using the Steel – PE converter.

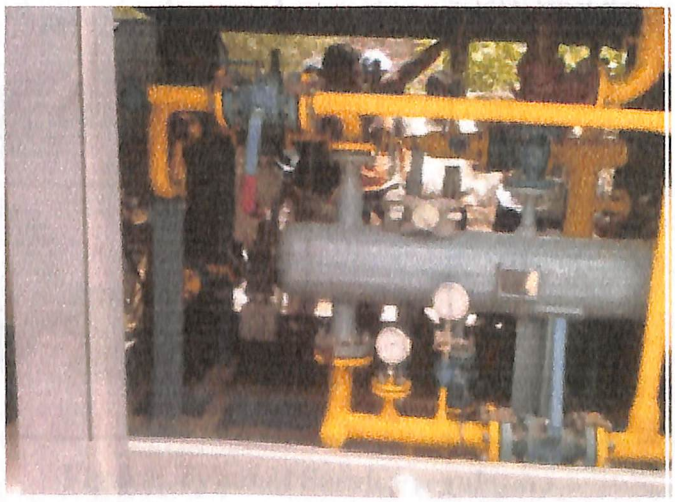


Figure : District Regulating Station Source: Adani Energy Ltd.

Service regulators

These are installed before tertiary PE lines, generally located at customer premises for maintaining supply pressure and designed to maintain safe condition even in the event of rupture in the regulator downstream section. It reduces the pressure from 4 bar to 110 mbar to the service line. These regulators maintain the required maximum and minimum pressure with shutoff device. The types of regulators that are used generally depend on the number of connections. According to this various types of regulators are available as shown in Figure 5.3

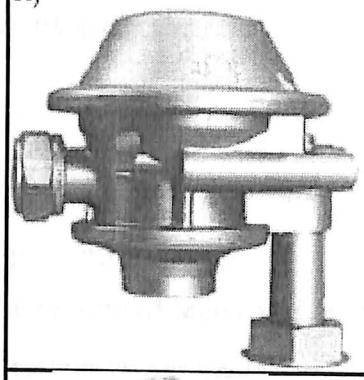
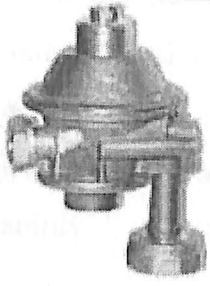
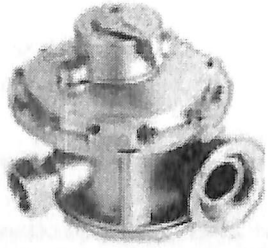
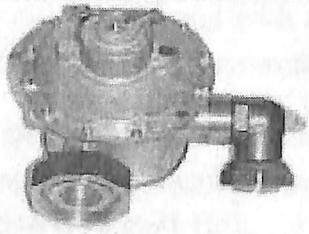
S.no	Type	Flow rate	Max. Capacity
a) 	B-6	6m3/hr	1-8 domestic connections
b) 	B-10	10m3/hr	1-20 domestic connections
c) 	B-25	25m3/hr	1-30 domestic connections
d) 	B-50	50m3/hr	1-75 domestic connections

Figure: Types of Service regulators

Source: Adani Energy Ltd.

Metering

Meters are the important part of the CGD. It decides or gives the information about the amount of gas sold to the customer. Billing of gas is usually done based on the standard conditions i.e. SCM. Meters are used based on the type of the customer and his requirements.

Meter used for the domestic customer is of diaphragm meter, which is having a flow range of 0.017 to 2.6 m^3/hr. with maximum operating pressure of 0.1bar.

For Industry purpose both diaphragm and RPD (Rotary Positive Displacement Meter) or turbine meters are used. It depends on the demand and accuracy needed for billing.

Selection of meters

Following criteria shall be considered for the selection of meters

- Rangeability or Turndown ratio
- Accuracy required
- Suitability of meter with quality of gas available
- Pressure requirement
- Calibration & maintenance requirement
- Size & weight
- Installation and maintenance constraints
- Operability
- Cost
- Gas quality

Turndown ratio

It is a flow measurement term which indicates the range of a specific flow meter, or type of meter that is able to measure with acceptable accuracy. It is also called as rangeability. It is significant when choosing flow meter machinery for a specific application.

If a gas flow to be measured is expected to vary 100000 m3/day and 1,000,000 m3/day, the specific application has a turndown ratio of at 10:1. Therefore a meter requires a turndown ration of at least 10:1.

The turndown ratio of each type of meter is limited by theoretical considerations and by practical considerations. For example, orifice meters create a pressure drop in the measured fluid proportional to the square of the velocity. Therefore the range of differential

pressure can become too large and compromise accuracy. It can also create process problems such as hydrate formation, and in the case of measuring the discharge of a compressor, there is a limit to how much pressure loss is acceptable.

Turndown ratio is one of a number of considerations in choosing a meter type for an application. Some other considerations are price, maintenance cost, accuracy, the fluid type and the velocity of the flowing fluid.

- Diaphragm meters are considered to have a turndown ratio of **80:1**.
- An orifice plate meter has a practical turndown ratio of **3:1**. This means that if an orifice meter with a design flow rate of 20,000 m^3 per day is installed, the flow range that the meter can measure accurately will be between 10,000 m^3 per day and 30,000 m^3 per day.
- Turbine meter has a turndown ratio of **10:1**.
- Rotary displacement meters have a turndown ratio of between **10:1** and **80:1**, depending on the manufacturer and the application.
- Multipath ultrasonic meters often have a stated rangeability of **50:1.**

Meter selection matrix

Table : Meter selection matrix

SN	Type of Meter recommended	Working pressure (bar)		Flow range m^3/ hr		Type of customer	Limitations
		Min	Max	Min	Max		
1.	Diaphragm Meter	0.0	0.2	.016	30	Domestic Commercial & Small scale Industry with pressure requirement less than 75 mbar only	a) Bigger Sized, b)Expensive for high flow c)No Pressure & temperature compensation
2	Rotary Positive Displacement Meter	0.0	16	30	1000	Commercial & Industrial	Requires: a) 50 micron filtration Gas Quality

							b) Lubrication Maintenance
3	Orifice Meters With Single Transmitter	1.5		200	none	Large Industrial customers with flow Turn down ratio within 3:1	a) In- accuracies b). Regular calibration. c) Long straight length of pipe
4	Orifice Meters With Double Transmitter	1.5		200	none	Bulk customers & Transportation custody transfer meters	a) In- accuracies. b).Regular calibration. c) Long straight length of pipe
5	Turbine meters	2bar		500	40000	Large Industrial customers	Hi cost, gas quality.
6	Ultrasonic Meter	7bar	99	1500	none	Bulk customers & Transportation custody transfer meters	

Diaphragm meter:

This is a kind of meter which uses a diaphragm i.e. a synthetic fabric called reinforced nitro rubber, which simultaneously fill and discharges the gas with a fixed volume to measure the quantity of gas passing through it. It is simple process of alternately inflated and deflated by the pressure of the gas.

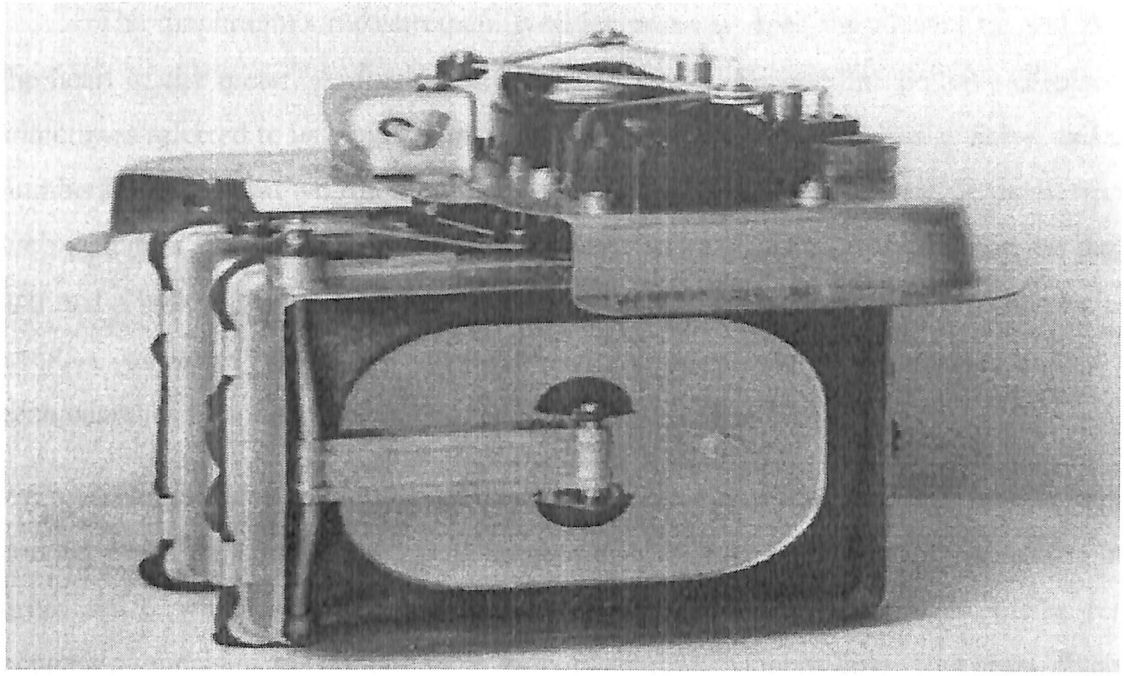


Figure: Diaphragm Meter

Source: Fundamental Principles of Diaphragm Meters by Robert Bennet

Theory of Operation

This design basically consists of three major parts, the valves, the diaphragms and the connecting mechanisms. The diaphragm meter and its components can be referred to as both an engine as well as measurement apparatus.

The engine duties of the diaphragms are exactly that, to drive the meter and ultimately the index registration. The slightest differential pressure across the diaphragm membranes will cause movement from the higher pressure area towards the lower pressure area. This differential pressure is what actually causes the meter to move and the index to register. Differential pressure is created by consuming metered gas at the downstream outlet of the meter, and the higher unmeasured inlet pressure in the cover. When a stove, furnace or hot water tank comes on, the gas is discharged to the atmosphere (burnt) which is lower than the meter outlet and downstream piping pressure. Through passageways and valves, this lower pressure is communicated to one side of the diaphragm, which creates a differential pressure relative to the other side of the diaphragm, which is at a higher pressure. The diaphragm movement is then transmitted through connecting mechanisms to the index for volumetric registration.

The diaphragm's measurement function actually does the measuring and is basically the heart of the meter. A diaphragm meter, which is classified as positive displacement, is sometimes referred to as a bucket meter. If we have a bucket of known volume, and count the numbers of times that we fill and empty the bucket, we can measure larger unknown volumes with a smaller known volume. The diaphragms, and volume created between the diaphragms and meter body, are smaller known volumes. Each time the diaphragm, or chamber, fills and empties, we know how much gas has been used. By simply counting the number of times each chamber fills and empties, we can total the amount of gas used

The linkage or connecting mechanisms transfers the diaphragm movement to the counter or index. The linkage in engine terms is the same as the cranks, connecting rods, and drive shaft, which ultimately transfers the power to the wheels. In meter terms, the connecting mechanisms contain parts such as tangents, tangent links, flag arms, flag rods and diaphragm brackets. These connecting mechanisms not only transfer the diaphragm movement to the index,but also position valves.

Typically, "D" shaped valves open and close passageways to create differential pressures across diaphragm membranes. The opening of one valve and closing of another valve is critical to keeping the meter moving, engine function. Additionally, the precise timing of how long a valve is open or closed affects the measurement accuracy function of the meter. Improper timing in an engine can cause poor performance, possibly component damage, and premature wear. The same is true for valve timing in diaphragm meters.

Putting all of these functions and movements in symphony can create a smooth operating and very accurate measurement device as shown in the following 4 schematics. The 4 cycles of a diaphragm meter are very similar to the operation of a 4cycle engine. The left case, left diaphragm, right diaphragm, and right case create the 4 chambers. All of these areas are sealed from each other. The area in the cover above the valve plate and valves is unmeasured higher pressure gas. The area under the valve plate and valves is typically metered or being metered gas at slightly lower pressures. The left case and left diaphragm are separated from the right diaphragm and right case by means of a partition in the body.

The following figure explains the flow pattern

Step 1

The left valve is positioned such that the left diaphragm is being filled with higher pressure unmeasured gas while the left case is emptying slightly lower pressure measured gas to satisfy the demand. This movement is causing the index to register volume as well as causing the valves to become repositioned for the next cycle. Please note that the right valve is positioned such that there is no activity in the right diaphragm or right case, as shown in figure.

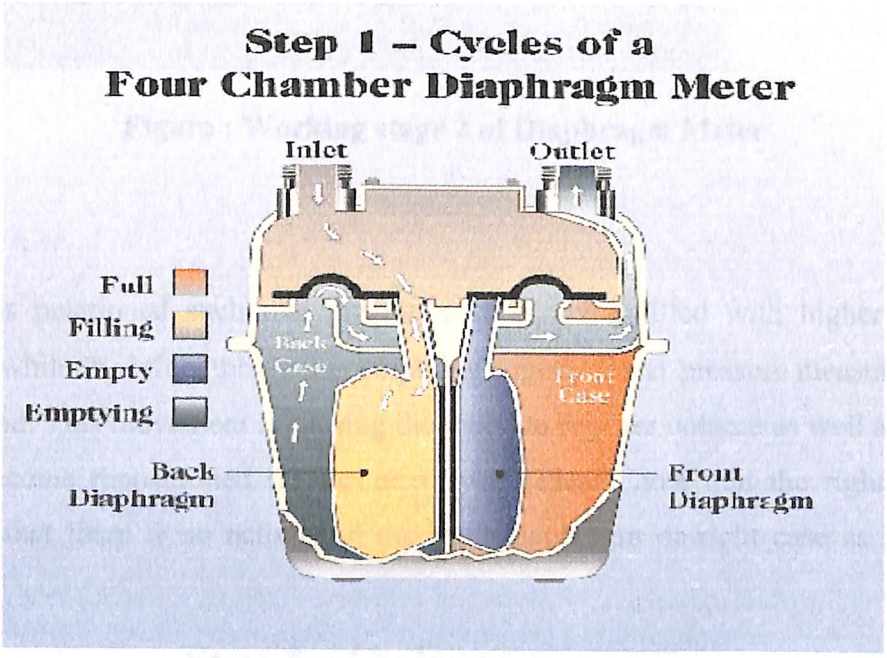


Figure : Working stage 1 of Diaphragm Meter

Source: Diaphragm Meters Applications, Maintenance & Installation by Paul G.Honchar

Step 2

The left valve is now positioned such that there is no activity in the left diaphragm or left case. The right valve is position such that the right diaphragm is being filled with higher pressure unmeasured gas while the right case is emptying slightly lower pressure measured gas to satisfy the demand as shown in figure. This movement is causing the index to register volume as well as causing the valves to become repositioned for the next cycle.

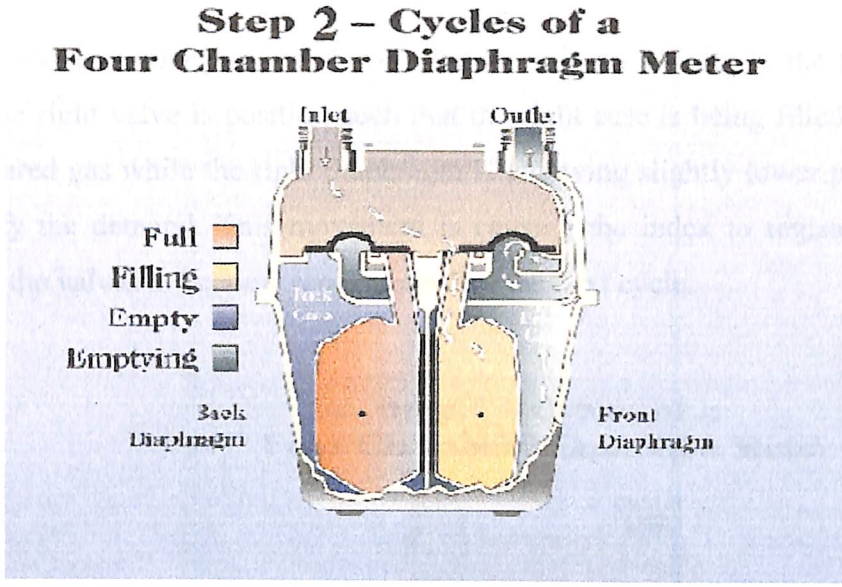


Figure : Working stage 2 of Diaphragm Meter

Step 3

The left valve is positioned such that the left case is being filled with higher pressure unmeasured gas while the left diaphragm is emptying slightly lower pressure measured gas to satisfy the demand. This movement is causing the index to register volume as well as causing the valves to become repositioned for the next cycle. Please note that the right valve is positioned such that there is no activity in the right diaphragm or right case as shown in figure.

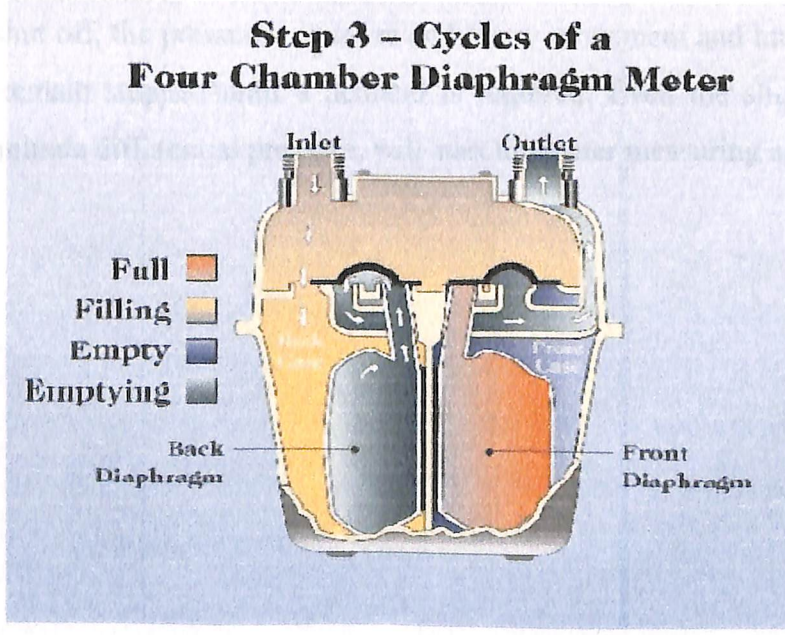


Figure : Working stage 3 of Diaphragm Meter

Step 4

The left valve is now positioned such that there is no activity in the left diaphragm or left case. The right valve is position such that the right case is being filled with higher pressure unmeasured gas while the right diaphragm is emptying slightly lower pressure measured gas to satisfy the demand. This movement is causing the index to register volume as well as causing the valves to become repositioned for the next cycle.

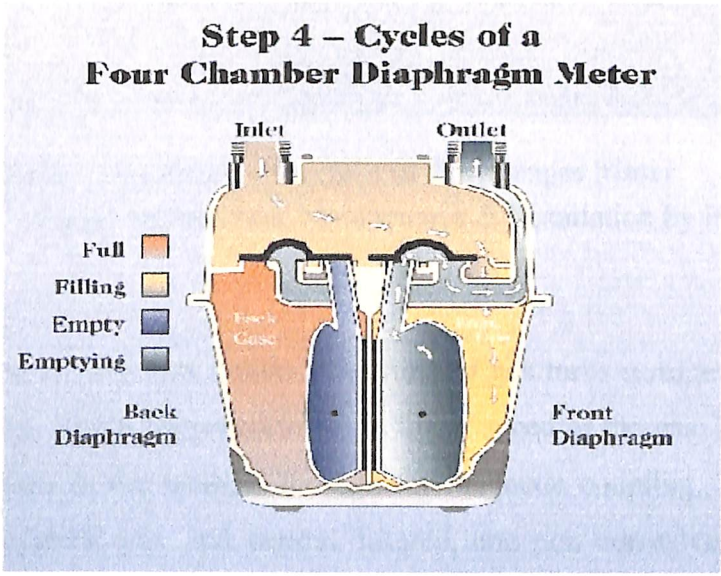


Figure : Working stage 4 of Diaphragm Meter

Source: Diaphragm Meters Applications, Maintenance & Installation by Paul G.Honchar

The cycles will continue and the meter will measure until the demand is shut off. Once the demand is shut off, the pressures equalize and meter movement and measurement stops. The meter will remain stopped until a demand is required. Even the slightest demand, which results in a minute differential pressure, will start the meter measuring again

.

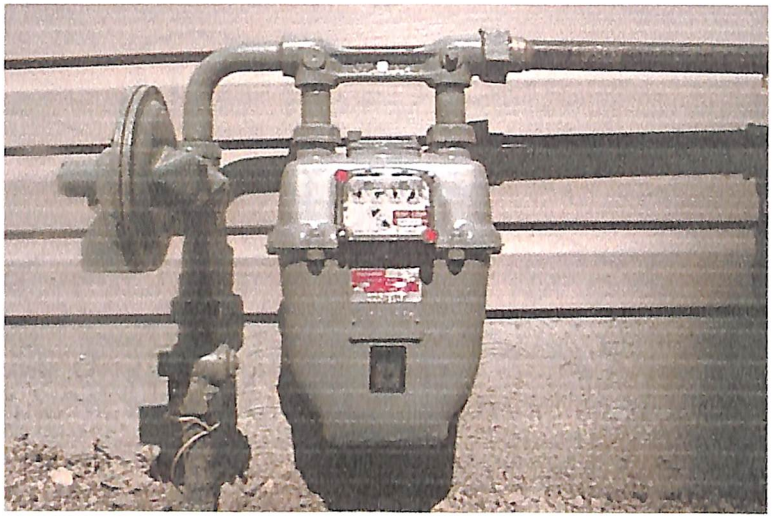


Figure : Typical Connection of Diaphragm Meter

Source: Diaphragm Meters Applications, Maintenance & Installation by Paul G.Honchar

Turbine meter

Turbine gas meters are flow meters. The flow of gas turns turbine wheel, and thus, the rotating speed of the turbine is proportional to linear speed of the gas. The movement is mechanically transmitted to the totaliser through the magnetic coupling. These meters are designed to measure natural gas, and various filtered, and non corrosive gases. They are used to measure medium to high gas flow, at low, medium or high pressure.

Operating Principle

The flowing gas enters the meter through a built-in flow conditioner (1) that conditions the flow profile and increases the gas velocity. The gas continues along the flow channel (2) and enters the turbine rotor. The turbine rotor blading (3) is designed with overlap to give complete guidance to the flowing gas and extract the maximum energy at low gas velocities. The turbine wheel's angular velocity is proportional to the average gas velocity flowing through the meter. The gas exits the turbine rotor through a flow ring and an expanding exit channel to minimize pressure losses. The rotation of the turbine rotor is transmitted via a gear train and transferred from the pressurized meter body to the counter (5) by a gas tight magnetic coupling (4). The follower magnet of the magnetic coupling drives the counter to register volumes metered at the operating conditions.

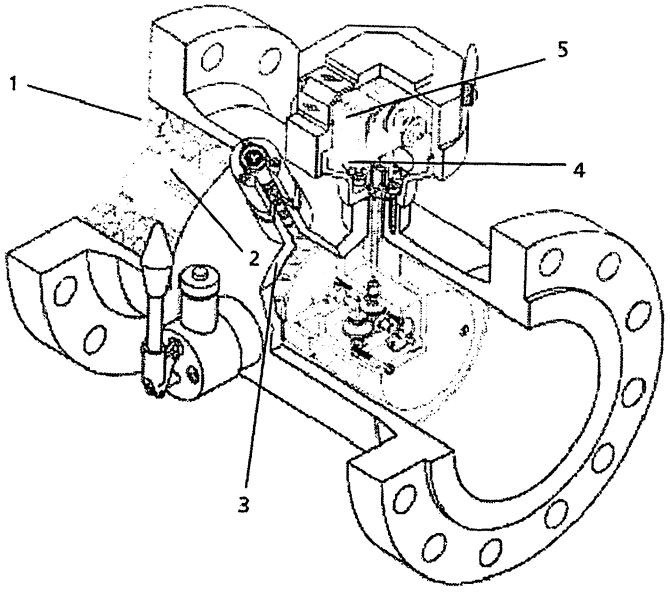


Figure Turbine Meter

Source: Instromet, Inc.

Different types of turbine meters that are available are shown in the table.

Table: Types of Turbine Meters

G size	DN (mm)	Max flow	Rangeability
G 65	50	100	10
G 100	80	160	20
G160	80	250	20-30
G 250	80	400	20-30

RPD METER

RPD stands for rotary positive displacement meter. ***These meters are volumetric meters.***

Working Principle

The flow of gas moves the pistons and each rotation traps and transfers a specific volume of gas. The movement is mechanically transmitted to the totaliser through the magnetic coupling.

Description

A RPD meter is made of 5 main parts:

- A measuring chamber that is limited by the body and the 2 base plates (1).
- 2 pistons, which are synchronized by 2 rears and which rotate in opposite direction (2).
- 2 lubrificant covers (3).
- A magnetic coupling to transmit the movement of the pistons to the totaliser (4).
- A totaliser to register the measured gas(5).

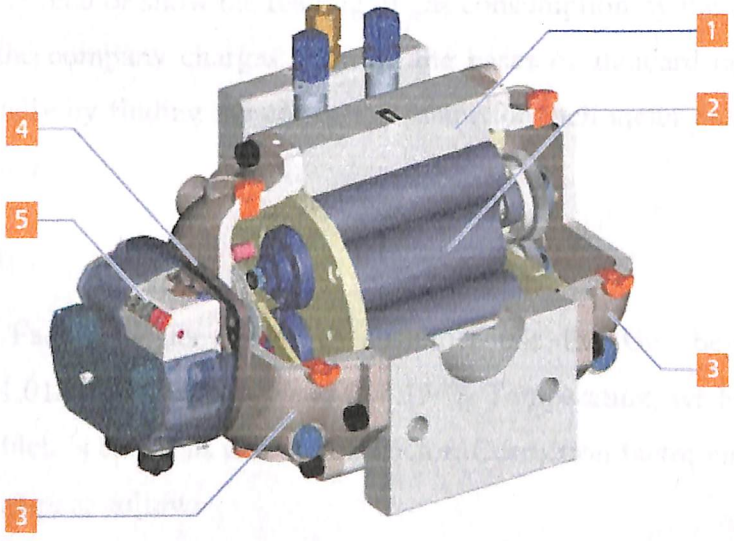


Figure. RPD meter

Source:www.actaris.com

GAS Meter set assembly

The following figure shows how the gas pipe and meter are assembled.

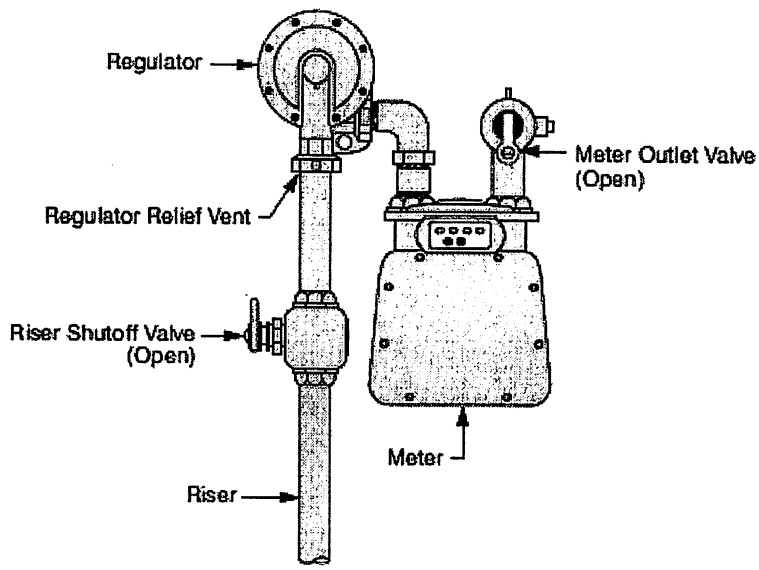


Figure : Gas Meter set assembly

Source: Gas Service Handbook, PUGET SOUND ENERGY

Billing of diaphragm meters

Usually these meters read or show the reading of gas consumption by the customer in normal cubic meter. But the company charges them on the bases of standard cubic meter. This is usually done manually by finding the correction factor for each meter based on the set point of the customer meter.

Correction Factor

Correction Factor means whenever customer use the Gas beyond the Standard Conditions means 1.01325 Bar Pressure and 288.15 ^{0}K Temperature, we have to multiply the m^3/h with factor which is called as Correction Factor. Correction factor can be calculated for a particular set pressure as follows

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$$\frac{V_1}{V_2} = \frac{T_1 * P_2}{T_2 * P_1}$$

Where,

P_1= base pressure,

T_1= base temperature.

V_1 = standard volume.

P_2= operating pressure.

T_2= operating temperature.

V_2= measured volume.

For example for an operating pressure 0.085 barg and temperature 26^0C, the correction factor for this pressure meter is

$V_1/V_2 = (0.085+1.01325)*(15+273)/(1.01325*299)$

$V_1/V_2=1.04401$

So this is multiplied to the obtained the reading as follows

$$Q\ (SCM)= Q\ (CM)*V1/V2$$

Selecting a gas meter location

An approved natural gas meter location is one that is in accordance with regulatory requirements. A good meter location is one where the meter is:

- Easy to read and inspect.
- Accessible for turn-on, shutoff, maintenance, change, or removal.
- Protected against electric sparks, excessive temperatures, flames, and mechanical damage.
- Adequately ventilated.

Required location

It is required that location of the meter should be outside, alongside the building, close to the source of gas supply.

Locations to avoid

The following meter locations present access problems or could expose the meter to accidental damage. It is required to avoid the following locations:

- Public passageways or fire escape routes.
- Under a stairway or walkway.
- On building rooftops.
- Unventilated, confined, or inaccessible places.
- Under openable windows (because of regulator relief).
- Directly adjacent to vehicular driveways, delivery doors, or high traffic areas where the meter may be subjected to vehicular damage

Pipeline System

Pipeline network consists of steel pipeline, polyethylene pipeline, galvanized iron pipeline and finally copper pipeline.

A typical CGD network should consist of the following

Primary network: A medium pressure distribution system comprising of pipelines, gas mains or distribution mains normally constructed using steel pipes and connects one or more transmission Pipeline to respective CGS or one or more CGS to one or more DRS. The maximum velocity in the pipeline network should be limited to 100 ft / sec (30 m/sec) immediately after pressure regulating instrument.

Secondary Network: A low pressure distribution system comprising of gas mains or distribution Mains usually constructed using thermoplastic piping (MDPE) and connects DRS to various service regulators at commercial, industrial, and domestic consumers. The network should be sized for maximum flow velocity of 100 ft / sec (30 m/sec).

Tertiary Network:

A service pressure distribution system comprising of service lines, service regulators and customer /consumer meter set assemblies constructed using a combination of thermoplastic (MDPE) piping and GI /copper tubing components.

LAYING OF PIPELINE NETWORK

Laying of the pipeline starts after the issue of right of issue and the route of pipelines under the City gas pipeline project. Excavation works are performed so as to enable the pipe to be laid in conformity with the levels depths, slopes, curves, dimensions and instructions shown on drawings, specifications.

Detailed Process Of PE Laying.

The detailed process of laying of the PE is handed over to the contractors. The various steps or the technical requirements for the PE laying are as follows,

- PE Excavation.
- PE Trenching.
- PE laying.
- Electro fusion jointing.
- PE Valve chamber.
- PE testing.
- Tap off from in operation gas mains.
- PE route marker.

PE Excavation

Excavation for the PE starts after the issue of right of issue and the route of pipelines under the City gas pipeline project. Excavation works are performed so as to enable the pipe to be laid in conformity with the levels depths, slopes, curves, dimensions and instructions shown on drawings, specifications. It is done under the direction of the company.

• Trail holes refers to the small pits which are generally dug before the actual excavation process for determining the pipe route and locate other underground plant or investigate possible obstruction if any e.g. telephone wires, cables, water lines, pipelines belonging to other companies.

- The trial holes are normally preplanned i.e. the location of between the trial holes is normally at a distance of 25m. They are excavated to a depth of pipe and an addition of 250mm. These holes are not closed immediately. They are protected and fenced. The trial holes are planned in such a way that there are no abandoned trenches and also to avoid insufficient trial holes.

- The excavated trench is maintained on stacked centre line as per the sheets approved and also taking into account of the curves of the pipelines. Proper care is taken while trenching to ensure all underground structures and utilities are disturbed to the minimum. The crossings wherever necessary is provided and maintained for the general public property owners or tenants to cross and also to move any stock from one side of the trench to another.

- Trenching is made in sufficient slopes on sides in order to minimize collapsing of the trench. In places, where there is any danger of landslides the pipeline trench is maintained open for time required to lay the line i.e. the work in that area is completed in less time and covered. The soil stability is analyzed in areas like drainage, ditch etc.

- The bottom of the trench is normally maintained in the square form to the maximum extent with the equipments so as to avoid the hand grading at the bottom of the trench. The bottom of the trench is made free of loose rocks, pebbles and trim protruding routes from the sides of the trench wall. A stretch of 12m is allowed to remain excavated before joining or back filling.

- Any kind of rock which cannot be drilled using sledge hammer, chisel is considered as 'hard rock. Any other Plain cement concrete (PCC) or Reinforced cement concrete (RCC) encountered during excavation are removed in supervision of authorities as the cost of removing those type of obstructions is high.

PE Trenching

Trenching refers to the making of holes i.e. opening the ground wide apart. It is classified into 2 types,

- Open Cut.
- Boring.

Red boring.

Red boring refers to the boring of ground without opening the ground wide apart using the normal tools i.e. by hand.

Machine Boring.

When the boring is not possible by red boring, machine boring is made use of. This happens when hard obstructions are encountered.

The design of the depth of the trench varies for different locations as follows,

- For distribution main 1.5m
- Minor water crossing or canal 1.5m
- Uncased or cased road crossing 1.5m
- Rail or road cased crossing 1.5m
- Normal areas 1.2m

- The above mentioned depths may vary depending on the locality. In case of any difficulties in maintaining the required depth due to unavoidable factors the new depth shall be decided and put in to effect in the particular area only.

- The width of the trench is maintained in wide enough to provide bedding around the pipe and to prevent damage to the pipe inside the trench. The distance between the ground and the bottom edge of the pipe is 50 mm for 63mm diameter pipelines and 100 mm for pipes larges than 63 mm which included the 90 and 125 mm pipes.

- The following clearances are provided between the external wall of the gas pipe and the external surface of the other underground assets in the locality.

    - 150 mm where the gas pipe crosses other assets, other than electric cables where the clearance is 300mm.And 300 where the gas pipe to be laid is on a similar alignment to the other assets.

In places where this clearance cannot be maintained due to various reasons, suitable barrier protections are installed between the pipe and the service line like the electric cable. RCC half round hume pipe is constructed along the trench.

- All the works in the municipal or public roads are required to be executed as per there codes and conduct with a view to cause minimum inconvenience to pedestrian and vehicular traffic. All the trenching works are carried out with proper caution. E.g. before commencing of the excavation the 'caution board' & 'information board' as per the standard size, shape and color are installed at the site. The crown of the backfilled earth is maintained between 50mm and 100mm and is free from sharp edged stones & boulders. The site is maintained neat and clean without causing any nuisance to the public until the completion of the work.

- In case of rain dewatering is done prior to back filling. This is maintained strictly for the protection of the gas pipeline. While back filling the mud or the soil is cautiously done such that there is no extraneous material or hard lumps of soil near the laid pipeline which could damage the line or the coating or leave void spaces in between the fillings. The surplus material is neatly crowned over the trench and adjacent excavated areas on both sides of the trench. Little extra allowance of mud is put over the trench such that it comes to the normal level during settling.

- In cases where rock, gravel, lumps of hard soil or materials are encountered at the time of trench excavation, sufficient sand is placed around and over the pipe to form a protective cushion extending at least to a height of 100 mm above the top of the pipe.

- Thorough and proper compaction is done where in places where the trench is dug like, the drive or road ways. Special compaction methods are adopted.

- Trench excavated in dikes which belonging to the property of railways or which are the part of the main roads are graded and backfilled in their original profile and condition. The backfill materials if required are supplied.

- PE warning grid or mat are placed on the distribution main and on service lines inside premises after backfill of the trench up to a height of 300mm after the sand bedding. The warning mat is unrolled centrally over the pipe section and thereafter the backfilling is done.

- All the excavated material which will be required for backfilling are kept separately and properly. In areas of roads or pedestrian places the refilling are done immediately to avoid inconvenience to the public.

- The back filling is assumed to be complete after the joining of pipes are complete. During the backfilling of the trenches in private society premises, municipal premises and panchayat premises, watering and ramming or mechanical compaction are carried out. Excess soil in the area is cleared off the site and is dumped at suitable location.

- Experienced supervisor is always present at the site to decide on various factors in the required situations. A third party officer is also made to be always available on the site. A prior information of excavation is given to the people in the area where the work is to commence in advance for their prior arrangements.

- Turf is replaced in highly developed grass area. In lesser grassed area top soil are replaced during the restoration process. In areas where the restoration works cannot be completed immediately, alternate arrangements are done temporarily for the traffic and the pedestrians.

Boring

In some areas where the normal trenching cannot be carried out, trenchless technology is carried out which is known as the boring. This is mainly done while the crossing of the roads. The boring is carried as per the requirement. The survey of the underground utilities are done before the boring process so that the other pipelines are not damaged. The cost of boring is costly i.e. 5 times the normal trenching. Hence, the boring is done in required areas only.

- In areas like road junction, front of the society main gates, crossings are done in phases during the night times due to the traffic problems. The works are done so as to finish the work in night itself. If in case any area is left uncovered or not completed by night, steel plates are provided are for the movement of traffic in day time.

PE laying

- The laying of the MDPE pipelines commence only after the ensuring of the proper dimensions and clean surface of the trench. The trench bottom is made to be free from the presence of cuts, stones, roots, debris, stakes and rock projections up to 150 mm below the underside of the pipe and any other material which could make perforations or tearing of the pipe wall. After ensuring of all the above factors, the MDPE coil is uncoiled

smoothly inside through proper process and care inside the trench ensuring no damage to pipe coil during laying.

- It is ensured that the pipe caps are provided before the lowering of the pipeline. The trench after this is released for backfilling leaving adequate lengths open to the ends for joining.
- Before lowering of the pipeline a sand bedding of fine soil is done at the trench bottom. Similarly after lowering of the pipe the trench is filled with sand around and up to 100mm from the top of the pipe.
- Proper inspections of pipes and fittings are done before the releasing of the latter from the store and the defects are reported to store authorities.
- Proper care is taken for PE pipe and fittings after issued from the store till the transporting storing sheltering the pipe near the trench, uncoiling of the pipe by proper process and sufficient man power, lowering of pipe in the trench or pulling of the pipe through the trench such that no external damage is caused to the pipe.

Electro fusion jointing

- Jointing of the pipes is normally carried out by the electro fusion process based on the requirements. Proper care is taken during the EF jointing such that there is no failure of the joint.

Electro fusion

Electro fusion is a simple method of joining PE pipes in circumstances where butt fusion is not practicable, such as where valves, elbows, and tees must be added. Prefabricated fittings are used, incorporating an electrical heating coil which melts the plastic of both the fitting and the pipe, causing them to fuse together.

The characteristics of the fitting to be welded, such as the fusion time, are registered via a barcode on the fitting. On swiping the sensor over the bar code the required setting time and temperature are set and on click of start the process starts. An electro fusion control unit (ECU) supplies the electrical energy necessary to heat the coil. When the coil is energized, the material adjacent to it melts and forms an expanding pool which comes into contact with the surface of the pipe. The continued introduction of heat energy causes the pipe surface to

melt and a mixing of pipe melt and fitting melt takes place, this is vital to produce a good weld. Following the termination of the heat cycle, the fitting and the pipe are left to cool and the melted material solidifies to form a sound joint.

Hot and cold zones, sometimes called melt and freeze zones, are formed after energizing the coil. The length of these zones is particularly important. Each zone ensures that fusion is controlled to a precise length of the socket of the fitting and that the melt pressure is also controlled throughout the entire jointing process. The precisely controlled pitch and positioning of the coil in relation to the inner surface of the socket ensures uniform heat distribution.

The basic fusion parameters: temperature, pressure and time, are controlled by the ECU which is programmed to establish these parameters from the barcode read from the fitting itself. The ECU also provides a permanent record of the procedure followed.

Compact ECUs are now available that allow in-trench electro fusion welding to be carried out safely by just one man.

The effectiveness of electro fusion depends on attention to preparation of the jointing surfaces and ensuring that the surfaces to be welded have satisfactory contact during the welding and cooling cycles. The pipe surfaces to be fused need to be scraped to remove the surface oxidation layer prior to fusion. Pipe clamps or other approved methods of restraining, aligning and re-rounding the pipes during the fusion cycle should be used. To prepare the jointing surfaces the pipe surface must be scraped with an appropriate pipe scraper, as recommended by the pipe or fitting manufacturer, to remove the entire surface of the pipe over the area indicated, to a depth of approximately 0.3mm. Metal files, rasps, emery paper etc are not suitable end preparation tools. Following scraping the scraped surface must be wiped with an authorized Isopropanol impregnated pipe wipe, as recommended by the pipe or fitting manufacturer, to remove any dust residue. Methylated spirits, acetone, methyl ethyl ketone (MEK) or other solvents are not recommended for wiping the scraped surface. The prepared surfaces must completely dry before proceeding. The resulting joint, when properly made, is as strong as the original pipe and can withstand all the loads applied during routine installation and operation. All the fittings related to electro fusion are according to the design standards.

The pipeline is normally flushed with air to remove dust, water mud etc which would have entered the pipe during the laying process. Before jointing the packing sand is placed under the pipes on both the sides of the joint to keep the pipes in line and correct during the jointing process. The alignment clamps with correct size are used whenever necessary to align the pipe during the electro fusion jointing cycle. It is a usual practice to make a joint of electro fusion fitting on the same day of laying.

- The electro fusion joint is inspected before the restoration of the trench so as to ensure the leakage. In case of leakage the joint is redone with a separate coupler to prevent future damages to line.

- The time of electro fusion for the normal 90mm MDPE is around 42secs and a temperature of 48 deg C is to be maintained. This reading is noted from the meter. The various types of the joints which are used in the coupling or jointing of the MDPE pipes are normally 3 types

    I. Coupler

    II. Tee

    III. Elbow

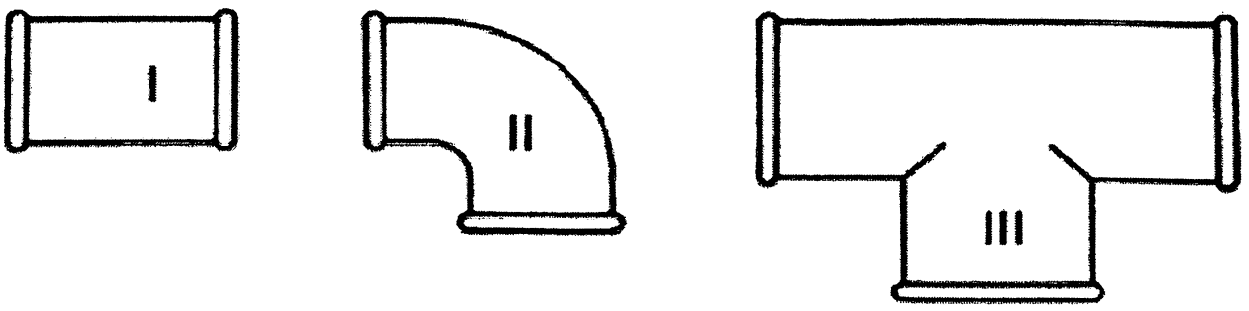


Figure 6.1 Types of Joints used for coupling

PE Valve chamber

- At certain areas the installation of the PE stop valves and the construction of the valve chamber is required. The valve chamber can be constructed in any type of soil. It includes conveying and spreading the stuff embankment within 200mm from the end of the cutting with all required lead and lift to required gradient and chamber.

- The cement, bricks, coarse sand are supplied and the fine gravel (machine crushed). The ratio of cement, coarse and aggregate 40mm is 1:4:8. The necessary PCC work in the annular space is carried between PE pipe and brick wall for sealing.

- The fix heavy duty RCC manhole chamber circular cover with square frame with the desired load capacity and the dimensions mentioned in the designed standard drawing. The remaining PCC work around the precast frame is carried out to fix the precast frame on the chamber to avoid any displacement.

- The PE stop off valves are installed in pipe system operating at the pressure above 110mbarg. The distance between each stop off valve is 1500m approximately for 125mm dia. pipe and 2000m for 90mm dia. pipe. This scope covers the necessary reopening of the charged pipe i.e. providing temporary bypass, squeeze off & cutting of PE pipe, installation of PE stop off valve, removal of temporary by pass, construction of valve chamber as mentioned above.

- In case of delay in construction of valve chamber on any charged or uncharged pipeline, the PE stop off valve is properly wrapped and is backfilled in such a manner that the valve is not damaged.

PE Testing

- Pressure testing is carried out with compressed air or nitrogen gas. The progressive pressure testing for the main pipelines and all the PE 100 pipelines SDR11 are carried out at a pressure of 6barg, for a time period of 24 hours. The reading of pressure is taken for every one hour. The leakages in the pipeline can be found out by this method. Any unaccountable loss in pressure in the line during the test period implies the leakage in the pipe, else vice versa.

- The stabilization period throughout the length of the pipe is normally half an hour which is assumed. All the measuring instruments which are used are totally tested and approved by the company. All the testing are witnessed by the company authorities.

- Purging is also done with the help of nitrogen. The nitrogen cylinders used are checked for their label, certification and tests.

- The testing carried out during the commissioning process includes the testing of the charged line for the composition of the gas. The methane content in the gas is tested using the specified meters. The oxygen content in the line is also checked up. The maximum allowable range of oxygen in the line is 0-2%. Normally the oxygen content in the line is 0.2%.

- The testing is done with all necessary regulators, hoses and connections, which are in good condition and working order.

- A record of all the purging plan before the commencing of the purging work is kept as a reference drawing. The plan includes the provision of the following materials and equipments.

    - Fire extinguisher.
    - Purging adaptor
    - Purge stack with flame trap and gas sampling point.
    - Gas sampling equipment
    - Squeeze off tool.

The design of PE pipe networks should follow conventional network practices with the installation of valves at convenient or critical locations. The valves can then be operated to isolate sections of the pipe network for maintenance.

Additionally however PE pipe networks have the advantage that more localized isolation can be implemented by the use of pipe 'squeeze-off'. Squeeze-off is used in routine and emergency situations to stop or nearly stop flow in PE pipe by flattening the pipe between parallel bars.

PE pipe squeeze-off utilizes the ductility of PE by allowing the pipe to be squeezed together using relatively simple but specially designed squeeze-off tools thus preventing the flow of fluid and isolating the pipe section. It is important that only specifically designed tools are used and that the squeeze-off controls are set for the specific diameter and SDR of the pipe in order to control the degree of compression of the PE pipe and prevent any damage.

The squeeze off tools are generally mechanically operated up to about 125mm diameter and hydraulically operated for larger diameters. However squeeze-off equipment is not readily available for the largest diameters of PE pipe. It is important to follow the manufacturers instructions when using these tools and to use tools appropriate for the pipe diameter and SDR. Also the tools need to be capable of resisting the operating pressure of the pipe, and there are limits to the pressures that they can sustain.

Properly implemented squeeze-off, using the correct tools, is not expected to cause damage to the PE pipe, which regains its circular cross-section after the tool is released. However squeeze-off is not recommended to be done more than once at any location. If repeated flow control is required a valve or an appropriate flow control device should be installed in the system.

Squeeze-off is not intended as a means to throttle or partially restrict flow. Complete flow stoppage may not occur in all cases. When squeezing larger pipes, particularly at higher pressures, some seepage is likely. When seepage is not acceptable, it may be necessary to vent the pipe in-between two squeezes-offs. Any work performed must be downstream of the second squeeze-off.

Inflatable bag flow stopping equipment can also be used for PE pipes. A saddle fitting needs to be fixed to the pipe, through which the inflatable bags are inserted. It is important that the correct saddle fitting is used compatible with the equipment being used. Reference should be made to the manufacturer's instructions.

Adequate and sufficient trench is provided for commissioning process or providing tap off. The reopening of any trench might be required during the commissioning process. . The maximum trench dimensions which might be required during the commissioning is 2.5m by 1m.

PE Route Marker

- The route marker can be defined similar to a milestone. The PE route marker shows the route of the laid pipeline. This is for the easy reference for finding the route. The Route marking process is to be completed before the commissioning process.

- The route marker is normally laid for lines in which the pressure of the line is greater than 110mbarg. The distance between each route marker is approximately 300m.

- The precast of RCC mix of 1:1.5:3 is required for the route marker stone. The route marker stone is casted as per the design requirements. For easy understanding of the route marker in the diagrams it is represented by the yellow color.

- A 6mm smooth thick cement plastering work is to be done over the projected route marker including scaffoldings, curing etc.

Tap of from charged gas mains

- The taping process from the charged gas line is a tedious and time taking work. This is done in case of emergency purposes. The number of live connections from the charged lines can be minimized by proper planning and synchronizing medium pressure network charging for a particular area.

- The flow stopping devices are used such as squeezers. These are used only on the MDPE lines as they have their property of regaining their after squeezing.

- The method to be used for each connection, the number and type of flow stop devices to be used is to be determined by the company.

Records to be maintained

The various records which is maintained to ensure the proper laying of the line and also the cost of laying is as follows,

- Daily progress report.
- Approval for technical deviation if any.
- Material reconciliation report as in the designed format.
- The testing report of the PE network with reference drawings as per the desired codes
- Employees presence registers on site during the PE laying.
- Other specific documents wherever necessary.
- Organizational chart before the starting of the work.
- Details of tools resources and tackles before start.

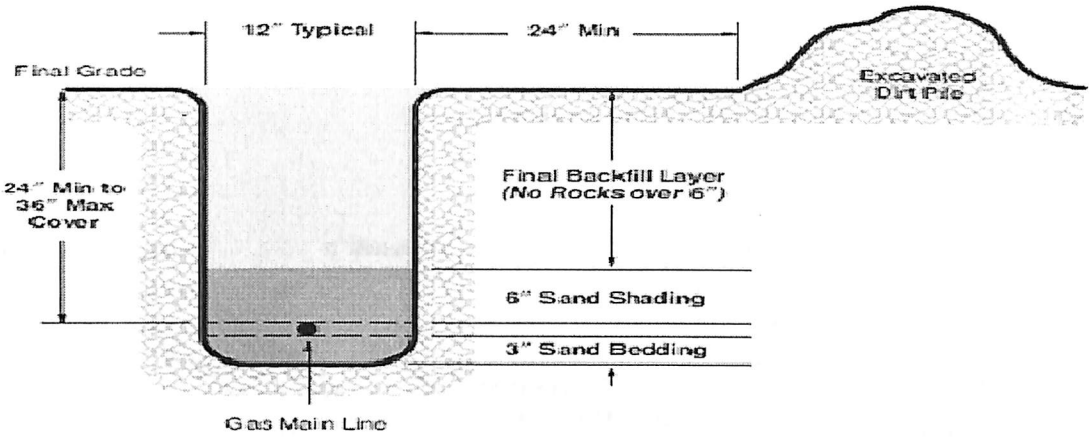


Figure: Typical commercial gas main line trench Source: Gas Service Handbook,

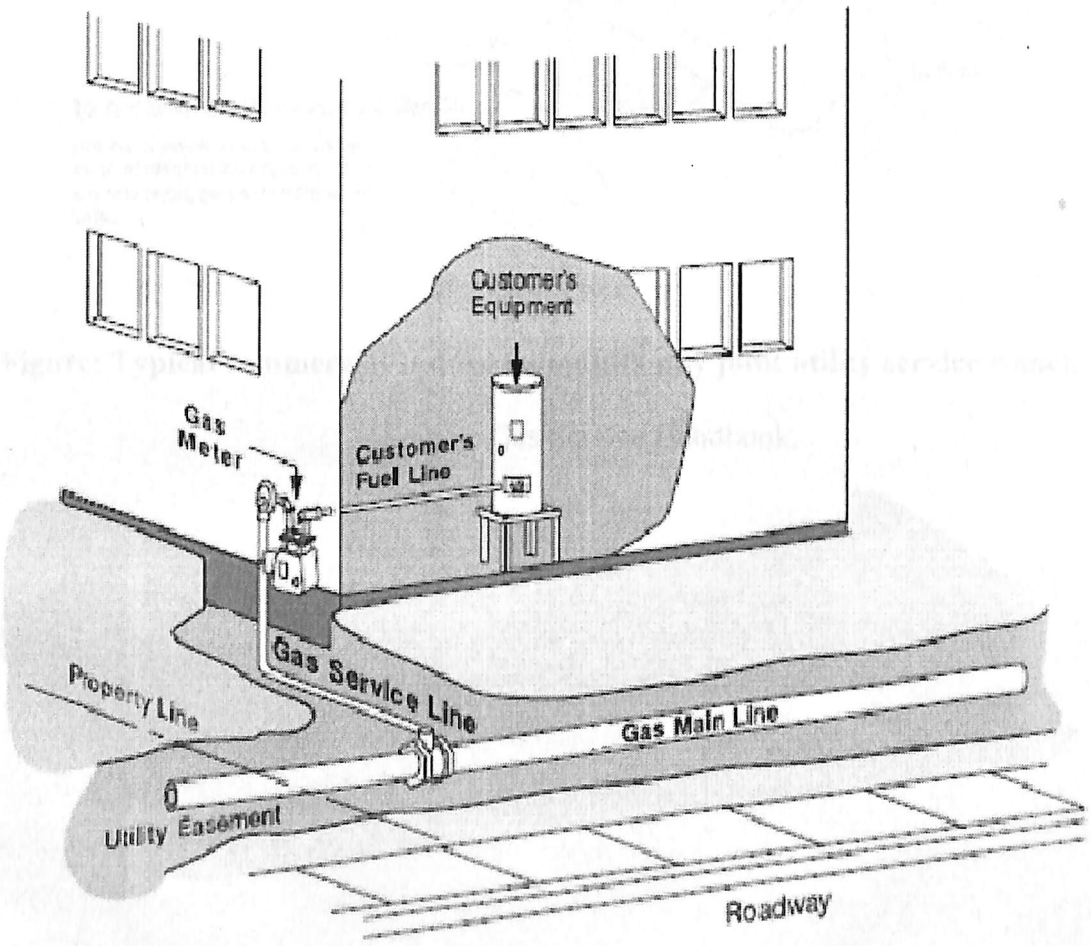


Figure: Typical gas system components

Source: Gas Service Handbook.

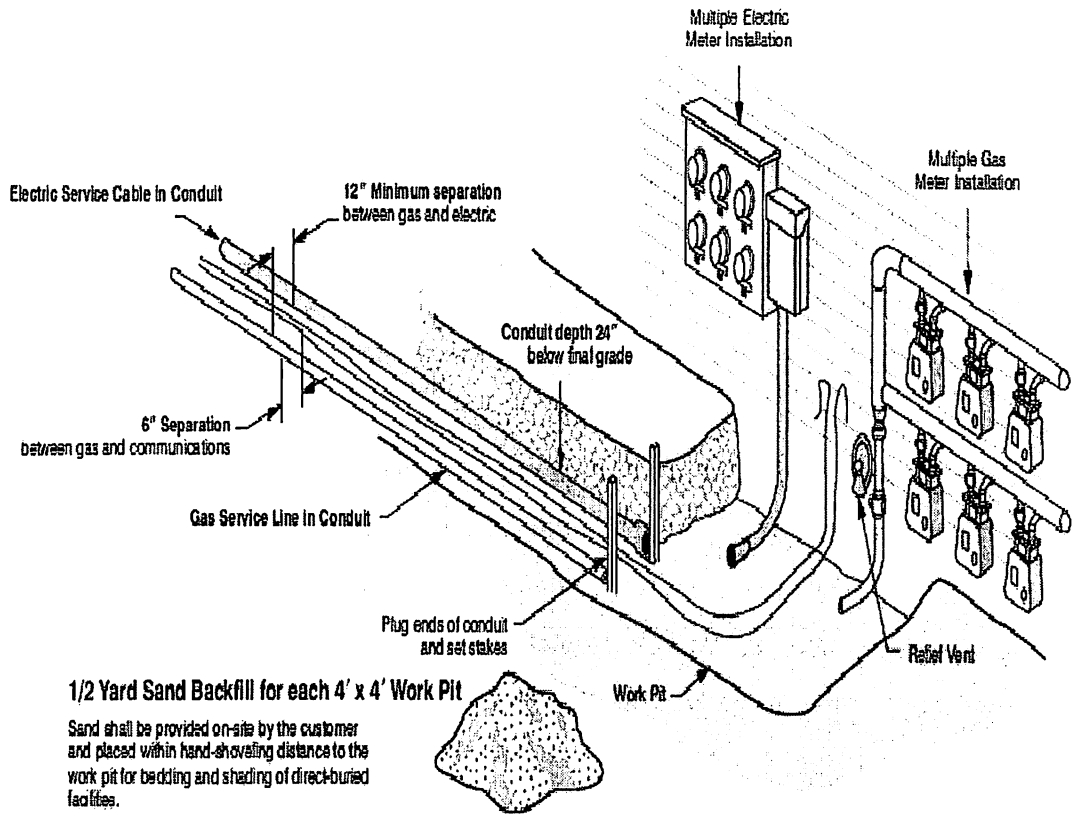


Figure: Typical commercial/Industrial/multifamily joint utility service trench

Source: Gas Service Handbook.

CRITICAL ASPECTS OF CITY GAS DISTRIBUTION PROJECT

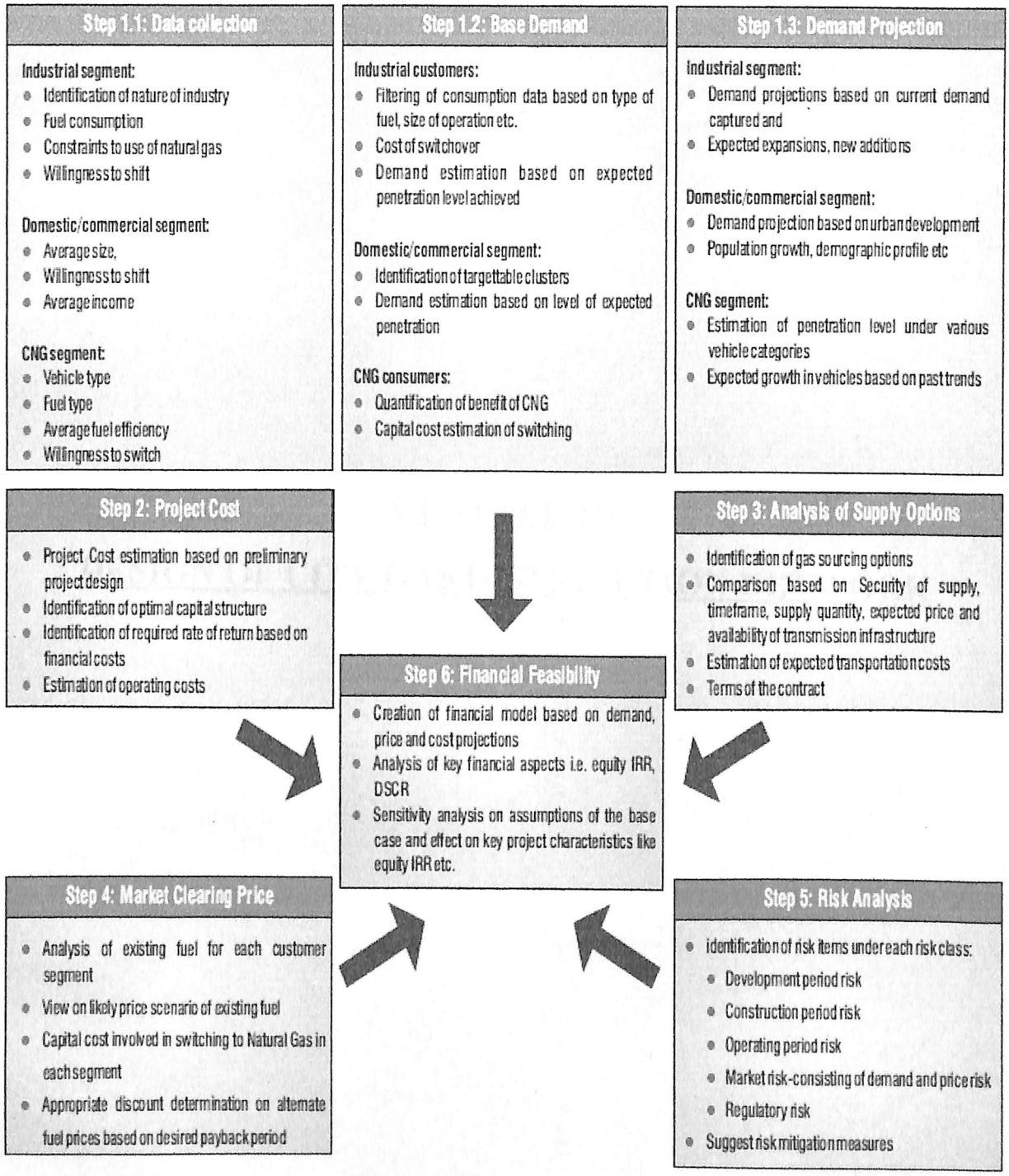
With a growing demand base and increasing supply options City Gas Distribution networks offer a tremendous investment opportunity. However in order to tap this opportunity the developers need to analyze several critical aspects of the project.

- **Demand build-up** - For a city gas distribution project the industrial segment provides the "base load" demand, which can be captured in a shorter time frame. In contrast, build-up of demand in the commercial, transport and residential segments provides better margins but has a higher gestation period. The project roll out must therefore be planned to capture an optimal mix of demand from these segments.
- **Supply** - Input gas price and its terms and conditions are critical for the viability of the city gas distribution project. Existence of Natural gas networks passing by or in proximity of the supply sources from the city limit enhances the project feasibility by reducing the capital and input gas costs.
- **Pricing of delivered gas** - The delivered gas must be priced in such a manner so as to secure a minimum level of profitability for the promoters, while providing adequate incentive to induce targeted customers to shift to Natural Gas. Keeping this in mind Gas should be priced using the 'alternate fuel linked pricing' methodology where Gas is priced at an appropriate discount to alternate fuel prices. For example in PNG the fuel should be priced at a discount to LPG so as to provide the customer with a payback period of less than three years on the expenditure on setting up the connection.
- **Risk factors**- The feasibility of a city gas project is highly sensitive to the demand the company is able to capture, and is thus exposed to **demand risk.** The project is also exposed to **price risk** due to the probable mismatch in the movement of input gas price and selling price. Moreover the Indian Gas sector does not have a well-developed regulatory framework. Uncertainty exists over issues such as licensing for setting up distribution networks, exclusivity of operator within a distribution zone and role of regulator in pricing of gas. This exposes projects to **regulatory risk.** The project could also be exposed to the residual risk created by the difference in terms and conditions of contracts with the suppliers and the buyers.

Challenges for implementation of City Gas projects

- Availability of Gas.
- Long build up period.
- Trunk line connectivity.
- Capital intensive – high initial investment as cities are geographically dispersed.
- Huge infrastructure required.
- Support from Authorities

Feasibility of City gas distribution project:



CHAPTER-III

DESIGN OF CITY GAS DISTRIBUTION NETWORK

CHAPTER-IV

RESULTS

CHAPTER-V

CONCLUSIONS

In this project studies on various City Gas Distribution systems like City Gate Station, District Regulating Station, Regulators, Metering equipments like Diaphragm meter, Turbine meter, Reciprocating Displacement meter, laying of Polyethylene pipeline network and Compressed Natural Gas stations were carried out.

During the course of project it was found out that the total natural gas requirement for Rajahmundry city is 3,04,300 SCMD, with 45000 SCMD for domestic purpose,7300 SCMD for commercial sector, 27000 SCMD for transportation sector and 2,25,000 SCMD for industrial sector.

The steel pipeline connecting main pipeline and City Gate Station is designed and found the diameter of the pipeline is 12 inches considering future requirements and thickness of the pipeline is found out to be 4.38 mm for pipe grade of X42.

The Polyethylene pipe connecting District Regulating Station and meter is designed and found out that the required Standard Dimension Ratio (SDR) is 11 and the corresponding Maximum Operating Pressure(MOP) is 7 bar.

CHAPTER-VI

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CHAPTER-VII

APPENDICES

APPENDIX

List of specifications of piping materials used in the CGD network

Steel pipe[2]

API 5L:	Specification for line pipes.
ASTM: Service	A106 Seamless Carbon Steel Pipe which is for High Temperature
ASTM: Service	A333 Seamless and Welded Steel Pipe which is for Low-Temperature

Galvanized iron pipes

IS 1239 (Part-1):	Steel tubes and other Wrought Steel Fittings.

Valves

API 6D:	Pipeline Valves
ASME B16.34:	Flanged valves, threaded and welding end
BS 5352: mm &	Specification for globe valve, steel wedge gate and check valves 50
	smaller for the petroleum, petrochemical and allied industries
BS 5351:	Specification for steel ball valves for the petrochemical, petroleum and allied industries
BS 1873:	Specification for steel globe, globe stop and check valves (flanged and butt-welding ends) for the petrochemical, petroleum and allied industries.

Fittings

ASME B16.9:	Factory-Made Wrought steel butt welding fittings
MSS SP-75:	Specification for high test, wrought, butt welding fittings
MSS SP 97:	Integrally reinforced forged branch outlet Fittings - Socket welding, threaded and butt welding ends
IS 1239:	Steel tubes, tubular and other wrought steel fittings

Gaskets

ASME B16.20:	Spiral-wound metal gaskets and metal jacketed gaskets for use with raised face and flat face flanges.

Copper tubes

BS EN 1057:	Copper and copper alloys. Seamless, round copper tubes which are used for water and gas in sanitary and heating applications.

Pressure safety equipment

EN 334:	Gas pressure regulators for inlet pressures up to 100 bar
EN 14382:	Safety devices for gas pressure regulating stations and installations
API 526:	Flanged steel pressure relief valves

Copper fittings

BS EN 1254:	Copper and copper alloys. Fittings with ends for capillary soldering or capillary brazing to copper tubes.

Plastic pipes

ISO 4437:	Buried polyethylene (PE) pipes for the supply of gaseous fuels.

Plastic Valves

ASME B16.40:	Manually operated thermoplastic gas shutoffs and valves in gas distribution systems.

Brass Ball Valves

BS EN 331:	Manually operated ball valves and closed bottom taper plug valves for gas installations in buildings