Final Project Report
(STUDY OF SAFETY ASPECT IN CONSTRUCTION OF CITY GAS DISTRIBUTION NETWORK)

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STUDY OF SAFETY ASPECT IN CONSTRUCTION OF CITY GAS DISTRIBUTION NETWORK

A thesis submitted in partial fulfillment of the requirements for the Degree of
Master of Technology
(Health, Safety & Environment)

By
(Amit Mishra)

Under the guidance of

... Internal Guide .....
... Dr D.V.L Rewal.....
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Approved

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Dean

College of Engineering
University of Petroleum & Energy Studies
Dehradun
April, 2010.

APPROVAL SHEET

This is to certify that the project titled

"Safety Aspects in construction of city gas distribution network"

Has been satisfactorily completed by the **Amit Mishra-R070208002** of M. Tech HSE course at the University of Petroleum & Energy Studies during the academic year 2009 - 2010

This report has been submitted in partial fulfilment of the requirement

For the degree of

Master of Technology (HSE)

As prescribed and approved by the University of Petroleum & Energy Studies.

Dr.D.V.L Rewal

University of Petroleum & Energy Studies,

Dehradun

ACKNOWLEGEMENT

- I am writing this final evaluation report during the Final Year Project 2010 in the program of Master of Technology at the division of HSE (Health, Safety and environment Engineering) at UPES , Dehradun.

- One person without his help and continuing support i can't pursue my project is my project guide **Dr.D.V.L Rewal** Thank you sir for continuous advice, Mentoring and kind support.

- And of course University of Petroleum & Energy Studies, Dehradun both staff for all their help and support.
  Thank You All!

AMIT MISHRA

DECLARATION

I **Amit Mishra** hereby state that this final evaluation report has been submitted to University of petroleum & energy studies in partial fulfilment of the requirement of Final Year Project in **M.Tech (Master of Technology)** program class of 2010.

The empirical information of this project is based on my experience in Final year project.Any part of this project has not been reported or copied from any report of the university and others.

Amit Mishra (R070208002)

PREFACE

- This is the final evaluation report for Final Year project commenced from the 1st of January 2010 and will formally close on May 2010.The duration of the project is approx. 5 months.

- In this report intern is totally free to share all his/her experience during Project, good and bad both. So this report reflects originality, the whole truth about intern's working. And i am also putting these all things in this report.

ABSTRACT

City Gas Distribution (CGD) Sector, by its nature is a hazardous Sector. Transportation of large volumes of hazardous Piped Natural Gas(PNG) involves inherent risks of Fires, Explosions, Toxic Releases and environmental pollution & if adequate precautions are not taken during the design and operation of petroleum installations, it may lead to destruction of whole installation.

This project report gives information of Technical details about City Gas Distribution Network and regulatory compliances and provide knowledge about pipeline construction, inspection procedures and operating practices. It also provides safety measures for the equipment and employees and recommend corrective actions based on appropriate state-of-the-art technology.

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1. 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.

Example of City Gas Distribution:

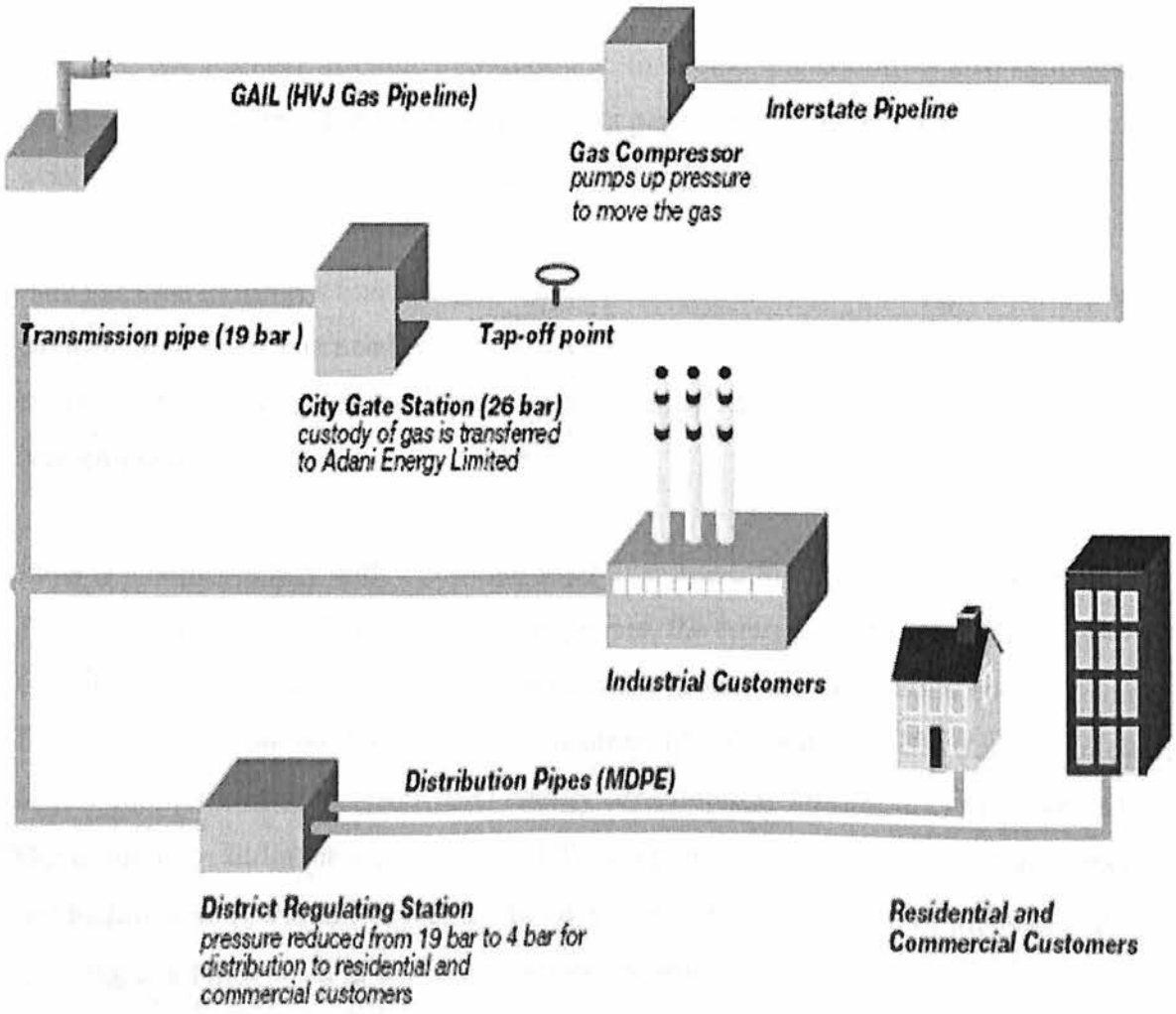


Figure 1.1: Example of city gas distribution

2. 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 2.1,

Table 2.1: 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

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.

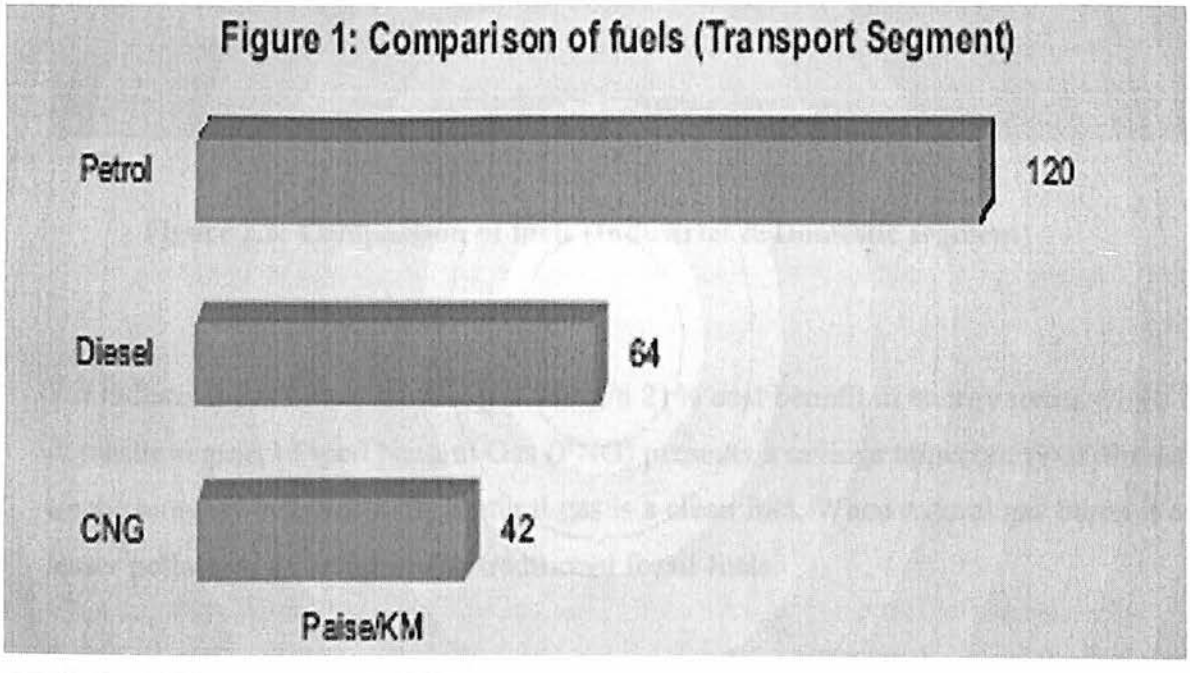


Figure 2.1: Comparison of fuels (Transport Segment)

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

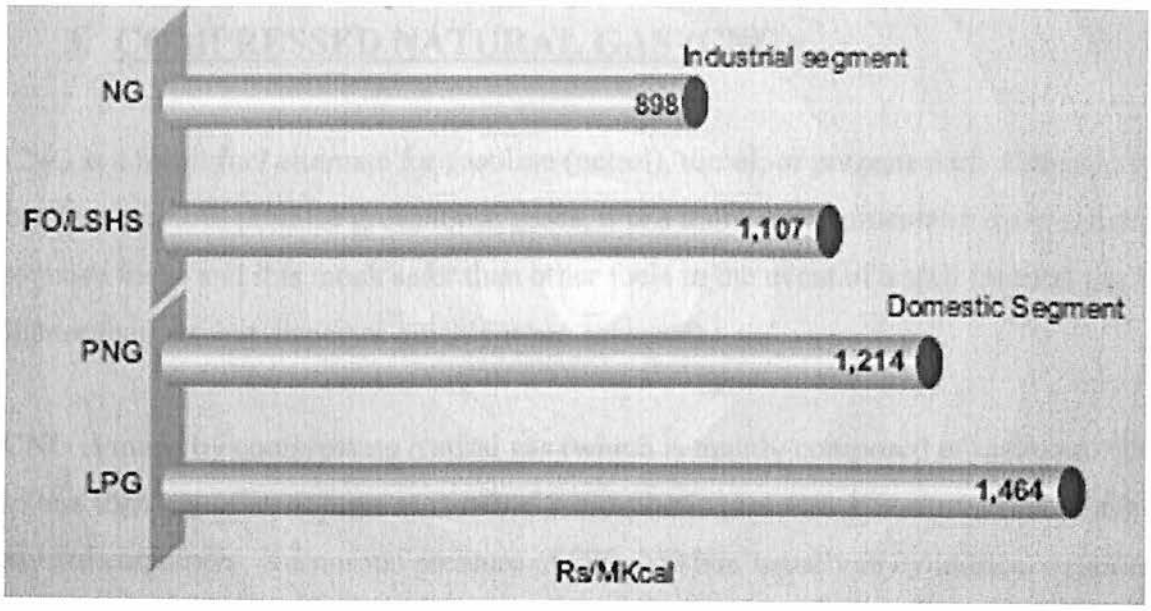


Figure 2.2: Comparison of fuels (Industrial & Domestic segment)

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

Environmental comparison of fuels:

(Pounds of pollutants produced per Billion BTU of energy)

Table 2.2: Environment comparison of fuels

Pollutants/Fuel	Natural Gas	Diesel	Oil	Coal	Petrol
Carbon Dioxide	117000	135250	164000	208000	285700
Nitrogen Oxide	92	1632	448	457	4081
Sulphur Oxide	0.6	1121	1122	2591	204
Particulates	7	1021	8.4	2744	40.8

3. 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 (CH4), 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.

3.1 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 3.1: Typical composition of CNG:

COMPONENT	PERCENTAGE RANGE
Methane	90.5% – 91.5%
Ethane	3% - 4.2%
Propane	0.3% - 0.5%
CO2	3.5% - 4.2%
Others	0.012% - 0.212%
Total	100%

3.2 Physical properties:

Non-toxic: Natural gas being sulfur/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, ethyle mercaptant is later added as odorant so as to detect the leakage

Fuel vs. Emissions (gm/100 Km)

Table 3.2: Fuel vs. Emissions:

Fuel /Emissions	CO2	UHC	CO	NOX	SOX
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

3.3 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(SOx)
- More quiet operation, having less vibrations and less odour than the corresponding diesel engines.

3.4 Limitations of CNG:

- availability Non 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

4. 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.

4.1 Applications of PNG:

Following are the applications of PNG:

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

4.2 PNG – Convenient fuel:

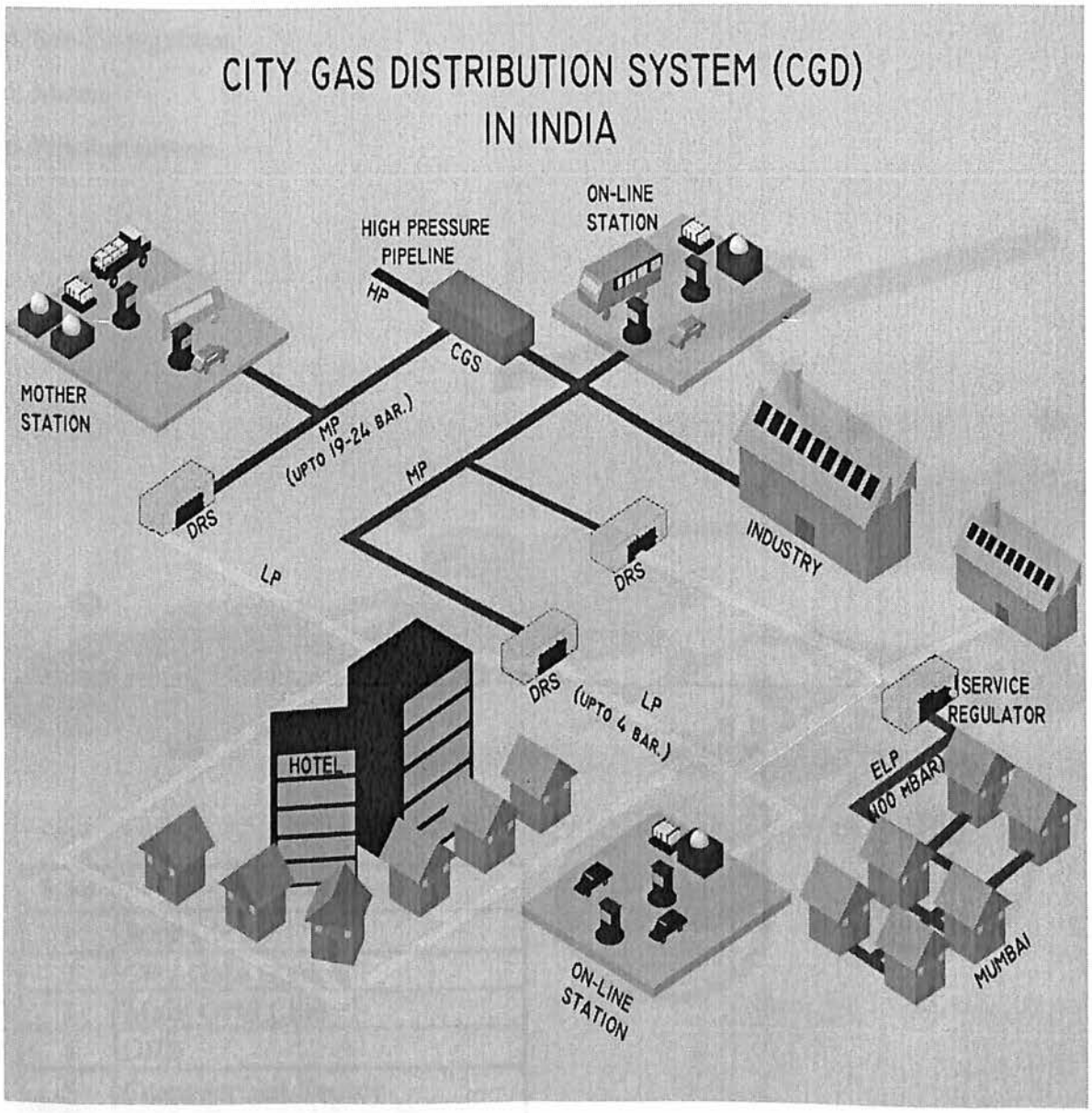
The PNG is called the convenient fuel due to the following reasons,

- 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.

4.3 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

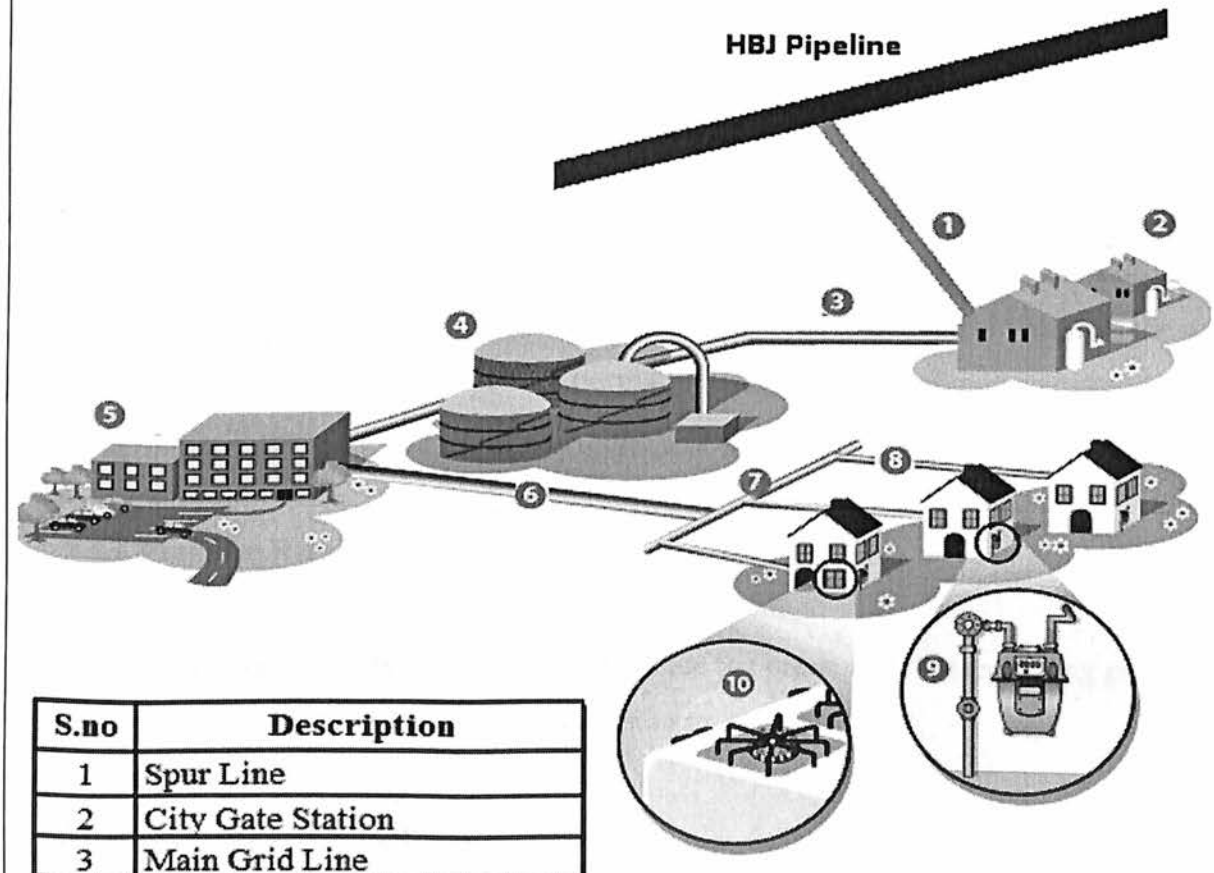
CITY GAS DISTRIBUTION SYSTEM IN INDIA



5. CITY GAS DISTRIBUTION SYSTEM IN INDIA:

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.



S.no	Description
1	Spur Line
2	City Gate Station
3	Main Grid Line
4	DRS
5	Commercial Sector
6 & 7	Distribution Main Line
8	Distribution Service Line
9	Meter Regulatory System
10	Appliances

5.1 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.

5.1.1 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.

5.1.2 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.

5.1.3 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.

5.2 ODOURIZATION UNIT:

One of the measure safety factors is Odorization 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.

5.3 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,

a) Slam shut valves for controlling the flow

b) Filtering skid

c) 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.

5.4 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.

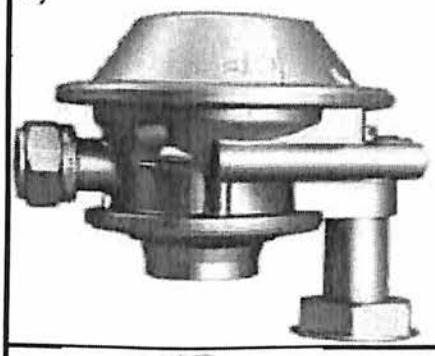
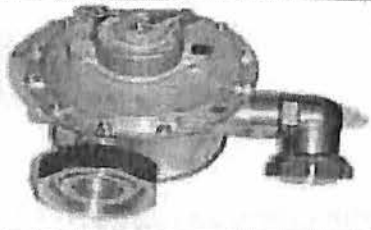
S.no	Type	Flow rate	Max. Capacity
a) 	B-6	6m3/hr	1-8 domestic connections
b) 	B-10	10m3/hr	1-20 domestic connections
c) 	B-25	25m3/hr	1-30 domestic connections
d) 	B-50	50m3/hr	1-75 domestic connections

Figure5.1: Types of Service regulators

5.5 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 m3/hr. with maximum operating pressure of 0.1bar.

5.6 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:

5.6.1 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.

5.6.2 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).

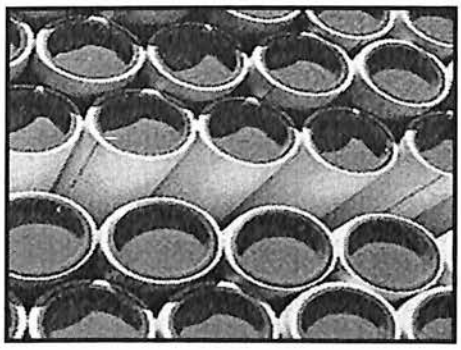
5.6.3 Tertiary Network:

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.

5.6.4 Tubing / Hose pipe for connecting consumer meter set assembly and consumer appliance:

The connection between consumer meter set assembly and gas appliance (provided by consumer) may be made by GI pipes or copper tubing or steel reinforced rubber hose. Steel reinforced rubber hose shall conform to IS: 9573

5.7 MDPE Pipeline:



A high pressure gas distribution system requires high strength and reliability from the pipe. These all qualities are associated with the Polyethylene pipes. So, these are extensively used for gas distribution applications.

The MDPE and HDPE gas distribution pipes are specially designed and produced for natural gas distribution system applications. The properties that favour their usage are

- Crack resistant
- Impact resistant
- Chemical resistant
- Corrosion resistant,
- Weather ability
- Strength combined with ease of handling
- Lightweight, flexible and heat fusible for easy installation

Polyethylene pipe provides long-term resistance to different service conditions like abrasion, temperature variation, bending, internal pressure, direct burial, and point loading and squeeze-off. These are manufactured to exceed all industrial needs under ASTM D2513.

Polyethylene pipes do not fail due to temperature variation for the following reasons

i). Polyethylene has a lower modulus of elasticity; the internal stress build up is considerably less than the long-term strength of the material.

ii). The passive resistance of the soil prevents some movement when the pipe is direct buried.

6. DETAILED ROUTE SURVEY FOR THE PIPELINE:

6.1 Selection of the Route :

In consideration of the Environment requirements, construction methodology, design and engineering factors, availability of the logistic support during construction, operation and maintenance of pipelines various feasible alternatives were identified based on the desktop study of the relevant topographic maps of the areas.

After the desktop study of the route, reconnaissance study of the route was carried out for the collection of the various details of the route. After collection of the field data once again desktop analysis of data were carried out for arriving at the optimum route. For the final route selections followings factors are considered.

- Maximum reach to potential demand centres with minimum length.
- Use of existing defined pipeline corridors by respective authorities.
- Minimum disturbance to agriculture land.
- Compliance with environmental regulations.
- Safety of people and property.
- Shortest possible route.
- Minimum number of bends.
- Favourable ground profile for construction.
- Accessibility of the pipeline for the operation and maintenance
- Location of pipeline facility and access there to.
- Avoidance mining area as far as possible.
- Avoidance forest area as far as possible.
- Minimum number of road, canal crossing.
- Avoidance of rocky terrain.
- Flexibility for future expansion.
- Avoidance of the notified forest as well as thick plantation area.
- Avoidance of the area reserved for the future development.
- Avoidance of archaeological and sensitive area.

On completion of the above exercise final route is selected for the pipeline network. After selection of the route, detailed survey for the final route is carried out. During the detailed survey pipeline alignment is decided. The main purpose of the detailed survey is to prepare drawings and report for the pipeline construction.

The details of the topography along the identified routes are surveyed and marked on the base map. The running distance from the starting point is also indicated. The main obstructions like culvert, road cuttings, Nala/drain, power line, pylons and buildings are recorded. Areas like flyover/canal crossings are avoided wherever possible. Main consideration is given for position of PNG filling station for sketching the position of DRS and PNG station. Suitable sites for PNG are selected specially on road bends. The feasible routes are marked on the existing base map and the best possible route amongst them has been indicated.

6.2 Optimum route is based on the following factors :

- Shortest length of the pipeline grid.
- Least topographical variations and minimum obstacles in the form of rail/road/river/canal crossings.
- Minimum cost of the system layout.
- Density of traffic flow.
- Minimum number of turning points.
- Availability of sufficient space on both sides of the road.

7. GETTING PERMISSIONS FROM THE RESPECTIVE JURISDICTIONS:

After marking the optimum and feasible route for the pipeline, before construction, the company should obtain permissions from the respective Jurisdictions through which the pipeline route is passing.

The following are the Jurisdictions through which a pipeline may traverse

- National Highways Jurisdiction
- Nagar Nigam Jurisdiction
- Irrigation Department Jurisdiction
- Rajya Sampatti Jurisdiction
- Railway Department Jurisdiction
- Private Property
- Social Forestry
- Public Works Department (P.W.D)

8. 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.

8.1 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.

Safety Features of PE Excavation:

• 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.

8.2 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.

8.2.1 Red boring:

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

8.2.2 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.

Safety Features of PE Trenching:

• 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.

8.2.3 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.

8.3 PE LAYING:

Safety Features of 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.

8.4 ELECTO 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 44 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.

Safety Features of PE Electro Fusion Jointing:

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.

8.5 PE VALVE CHAMBER:

Safety Features of 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.

8.6 PE TESTING:

Safety Features of 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.

8.7 PE ROUTE MARKER:

Safety Features of 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.

8.8 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.

8.9 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.

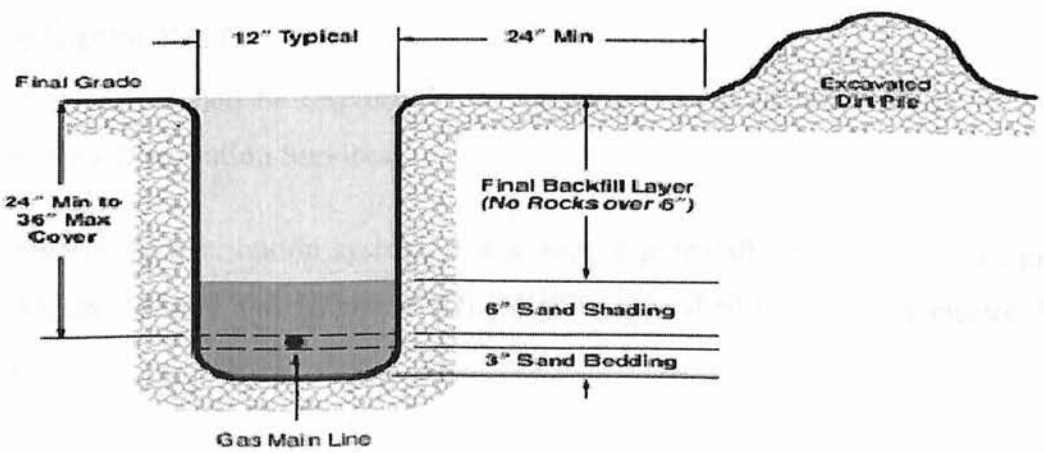


Figure 8.1: Typical commercial gas main line trench

9. CONSTRUCTION ACTIVITIES OF THE PIPELINE:

MDPE Network

For commercial and domestic consumers it is recommended that low pressure [4kg/cm2(g)] underground network shall be provided for safety reasons, as it is safe for inhabited areas, easy to lay and economical.

It is recommended that the distribution system in the city be constructed from MDPE at 4bar pressure.

The polyethylene fused joints are as strong as the parent pipe, ensuring the integrity of the pipe system. The polyethylene compound used in the manufacture of pipes shall be free from cadmium & visible water and shall confirm to the weathering requirements for thermal stability and hydrostatic strength.

The pipeline shall have 180mm, 125mm, 63mm, 32mm and 20mm diameter pipes to form the complete distribution reticulation system.

The system is divided in two broad categories, namely

A) Distribution mains

B) Distribution Services

A) Distribution Mains

Distribution Mains shall be responsible for carrying the gas to the colonies for further distribution by Distribution Services.

To standardise the distribution system, it is proposed to install only four sizes of pipes – 32mm, 63mm, 125mm and 180mm (OD). MDPE pipes shall be fused by electro fusion coupling.

Safety Features of Distribution Mains:

All MDPE pipes shall have minimum cover of one meter and shall be back filled with sand around it to protect the plastic material.

Emphasis shall be placed on utilizing modern construction techniques to install the distribution system. This shall include, wherever possible, avoiding disruption / damage to road and footpaths by boring and drilling. Large crossing, such as canals, major roads, etc., shall be carried out using Horizontal Directional Drilling (HDD).

It is proposed to have valves on the distribution and transmission networks at strategic locations to ensure security of supply (two valves for every 5 KM of distribution mains).

It is proposed to install plastic protection strips (warning tapes) 300mm above the MDPE pipe, to warn any agencies digging the area well ahead of reaching depth of MDPE pipe.

To ensure system integrity and safety, prior to commissioning, the MDPE pipes shall be pneumatically tested.

B) Distribution Services :

Distribution Services service lines are laid underground to connect customers from the Distribution Mains up to the customer premises, then laid vertical to rise above the ground level just below the proposed regulator point.

Safety Features of Distribution Services:

The few centimetres of the MDPE pipeline that rises above ground shall be protected by GI pipe sleeve. Since most services must cross roads/footpaths to reach the customers, they are usually installed by boring to reduce restoration costs.

Open excavation is required only at the connection to the main as well as at the service.

Warning tapes shall be installed all along the route where open cut is used for pipe laying.

10. GAS FOR GREEN GAS LIMITED(GGL):

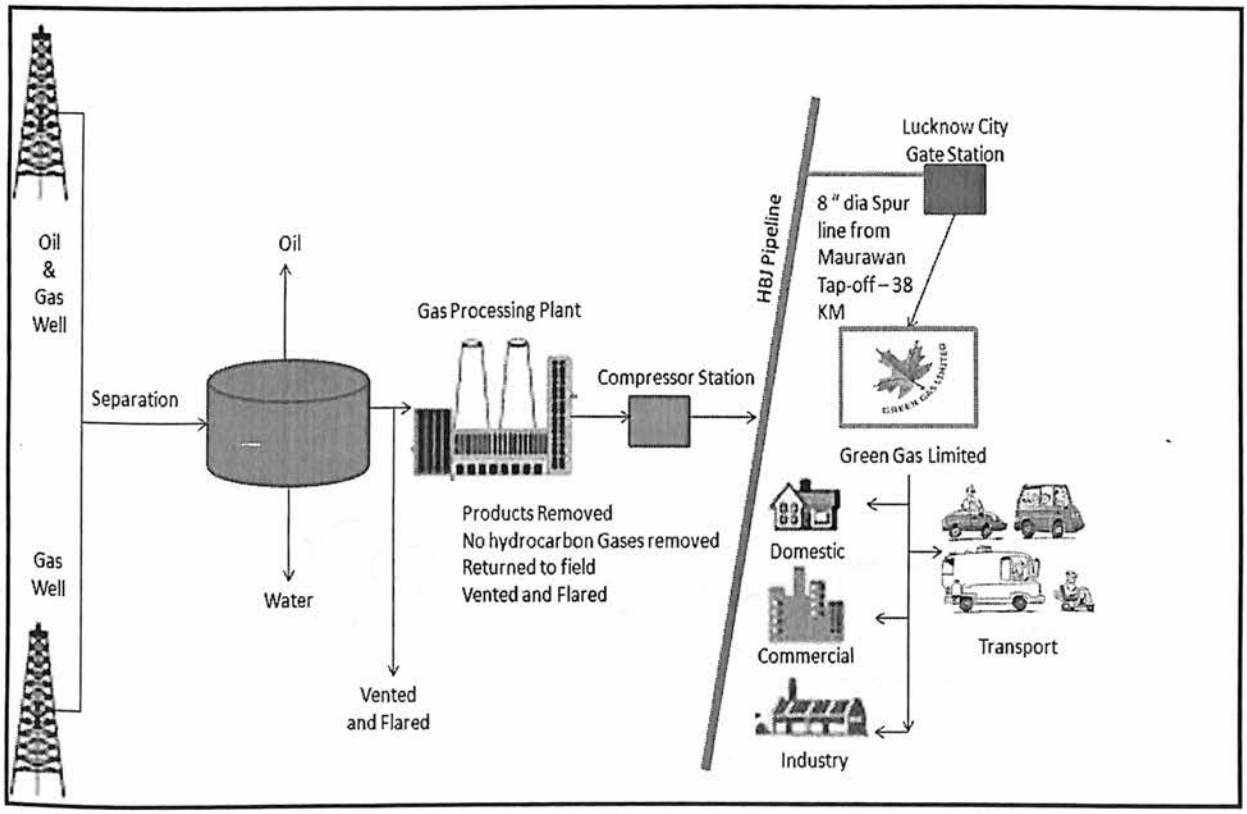


Figure 10.1: Overview of Gas Distribution

Gas for GGL, Lucknow is obtained from the GAIL-HBJ Pipeline tap off at Intermediate Pigging Station (IP-2 Station) near Maurawan from the existing 18" HBJ Pipeline. The spur line from Maurawan to Lucknow is dia 8"

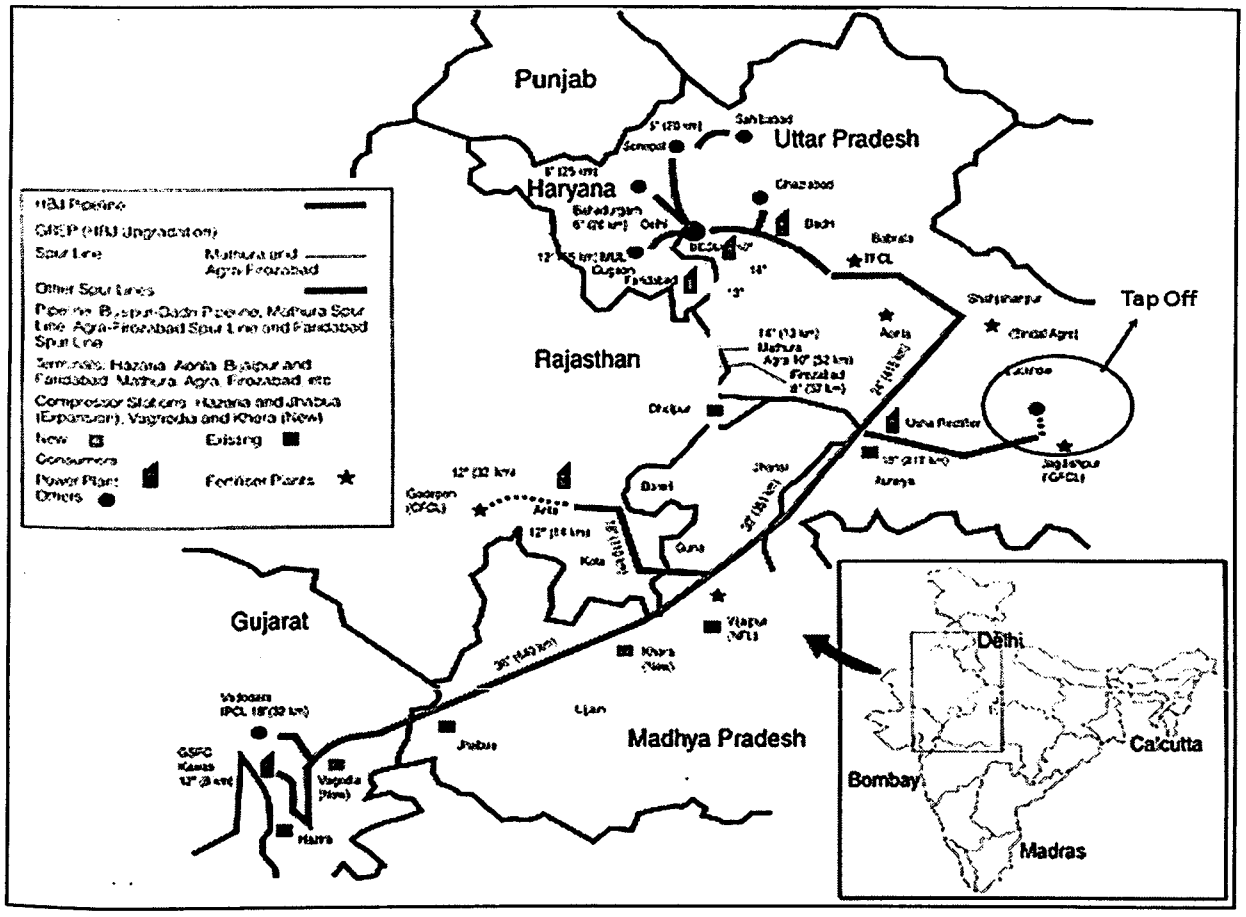


Figure10.2: HBJ Pipeline Network

The feeder line (8") length is approximately 38 Km from the tap off point to the City Gate Station(CGS) near Amousi.

11. GGL PIPELINE NETWORK PLAN IN LUCKNOW:

Meeting the demand of natural gas in Lucknow City for Automobiles, Commercial sectors (hotels, restaurants), Industrial and Domestic Sector it is planned to complete the steel main grid line of 12'' diameter, length around 66 km and pressure 19 kg/cm^2 around the city forming a closed loop. The Layout of the steel main grid line is shown on the Diagram No. 1 attached with this report.

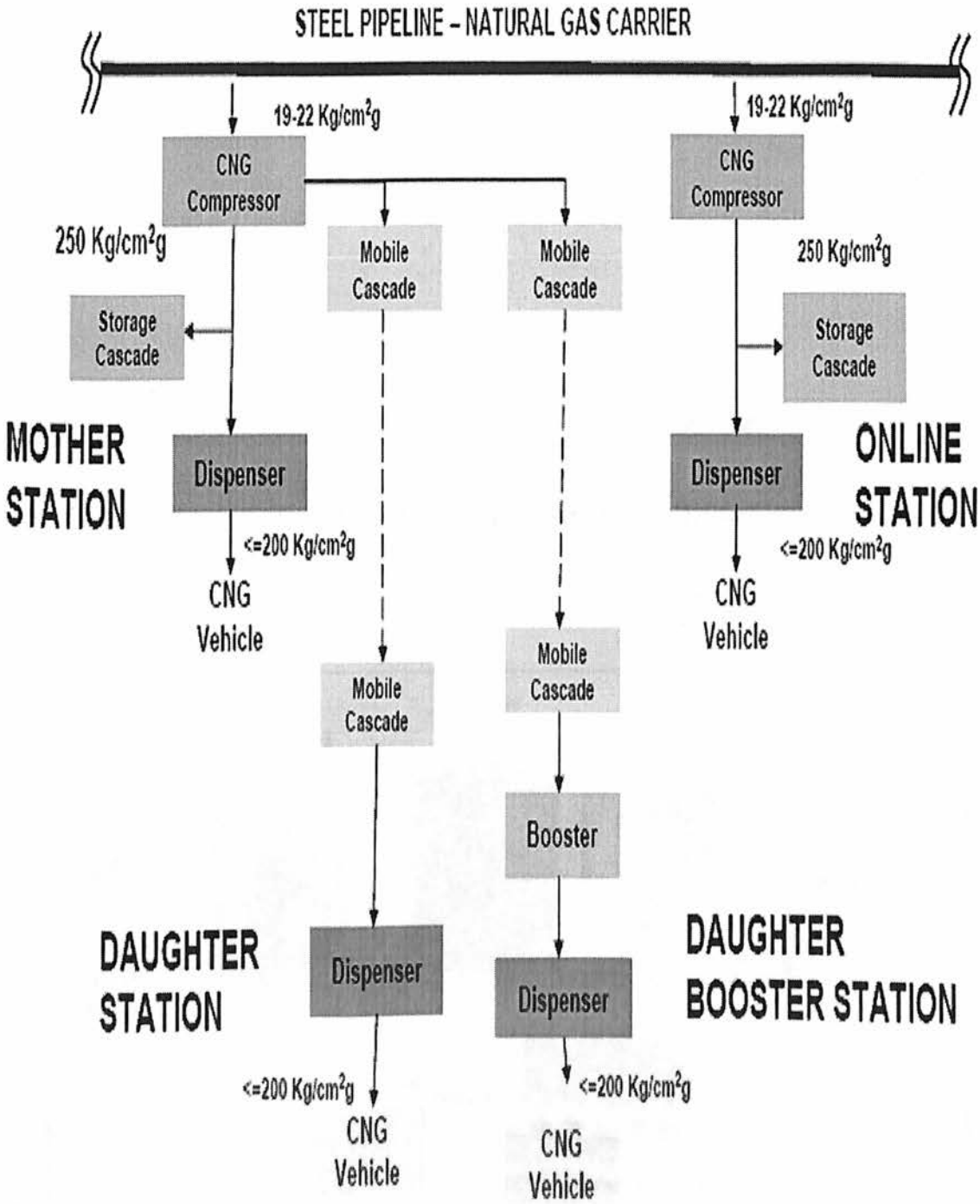
Main Grid Design Parameters:

Considering the demand load, supply pressure and future requirements for all consumer sectors and inlet pressure at City Gate Station (CGS), the City Grid has been designed.

The main grid line has been designed based on the following design parameters

Design Pressure	19kg/cm^2
Specific Gravity of Natural Gas	0.65
Density of Gas	0.788 kg/SCM
Design Temperature	
Buried	45^{0}C
Above Ground	65^{0}C
Design Factors	
Joint Factor	1
Temperature Factor	1
Population Density Factor	Class – IV
Design Life	30 Years
Pipeline Specifications	
Pipeline Material	
For 8" size P/L	API 5L Gr.B, 7.0 mm WT
For 4" size P/L	API 5L Gr.B, 6.4 mm WT
Corrosion Allowance	0.5mm
Pipeline Efficiency	0.9

12. CNG NETWORK IN LUCKNOW:



12.1. CNG MOTHER STATION:

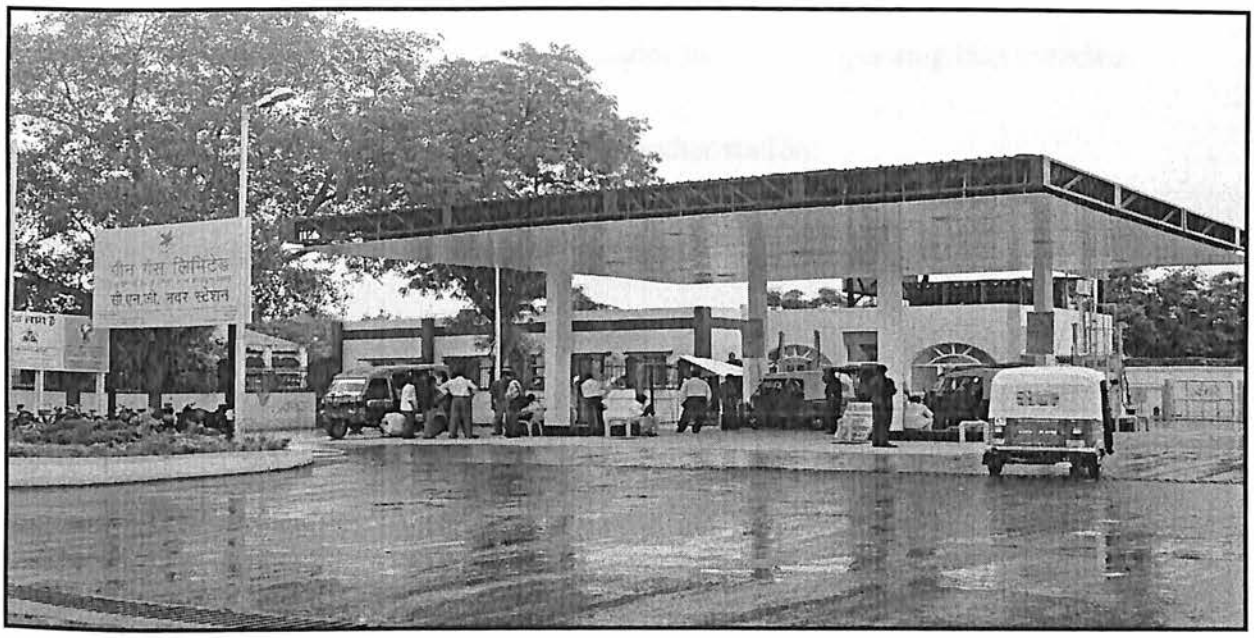


Figure12.1: CNG Mother Station, Amousi, Lucknow

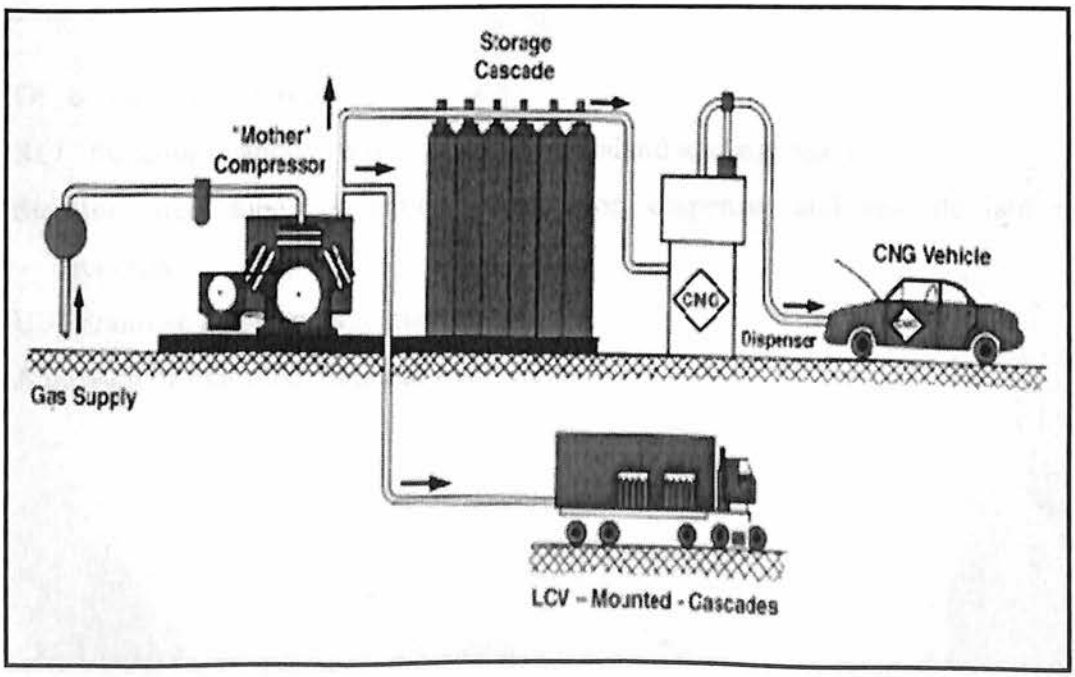


Figure 12.2: CNG Mother Station Process Flow

CNG MOTHER STATION

CNG facility connected to natural gas pipeline and having a compressor meant primarily to fill mobile cascades for 'daughter' stations. Such facilities, in addition to act as 'mother' station can also fill stationary cascades for CNG dispensing into vehicles.

The following units have been envisaged in mother station:

Main equipment:

a) Mother compressor along with auxiliaries
b) Dispensers for buses
c) Dispensers for car and three wheelers
d) Stationary cascades
e) Mobile cascades
f) Loading facility for mobile cascade
g) DG sets, UPS and Battery bank, Electronic control panel
h) Instruments for air and water facilities
i) Fire fighting equipment and safety side

Other facilities:

a) Office-cum-control room
b) RCC forecourt, canopy/roof over dispenser island and signage's
c) Stainless steel tube connecting compressor, dispenser and cascade laid in U/G trenches
d) U/G drainage and sewerage network
e) Approach or exit road, boundary valve etc.

Safety features of compressor:

- 3-stage reciprocating compressor with console type air cooling and safety relief valve at each stage, after cooler at final discharge along with all services lines, tubing, valves, instruments and auxiliaries.
- All mother compressors shall have mass flow meters both at suction and discharge to avoid separate metering skids for the stations.
- Gas engines with air and coolant or water based cooling system; gas flow meters with electronic volume corrector, totalized and associated equipment.
- Control system will ensure unattended safe operation in automatic mode. The priority fill system will ensure maximum flow rate by filling of vehicle, storage cascade and mobile cascade in assigned order.
- Entire compressor equipment shall be mounted on one skid and packaged in an acoustically insulated housing.
- The engine and compressor will be housed in the same package unit with a partition wall. The housing will provide a degree of protection equipment to IP 44 as per ASI 939.
- The housing will be flame and fire proof and provided with forced ventilation, flame arrestor, Infrared flame detection and alarm system, automatic shutoff, automatic co_2 flooding and other fire retardant
- The compressor will be provided with the required control system using PLC; air compressor for start up and pneumatic control; instrumentation and controls; emergency shutdown device and electrical supply system.
- The entire compressor system shall be earthed.

12.2. CNG DAUGHTER BOOSTER STATION:

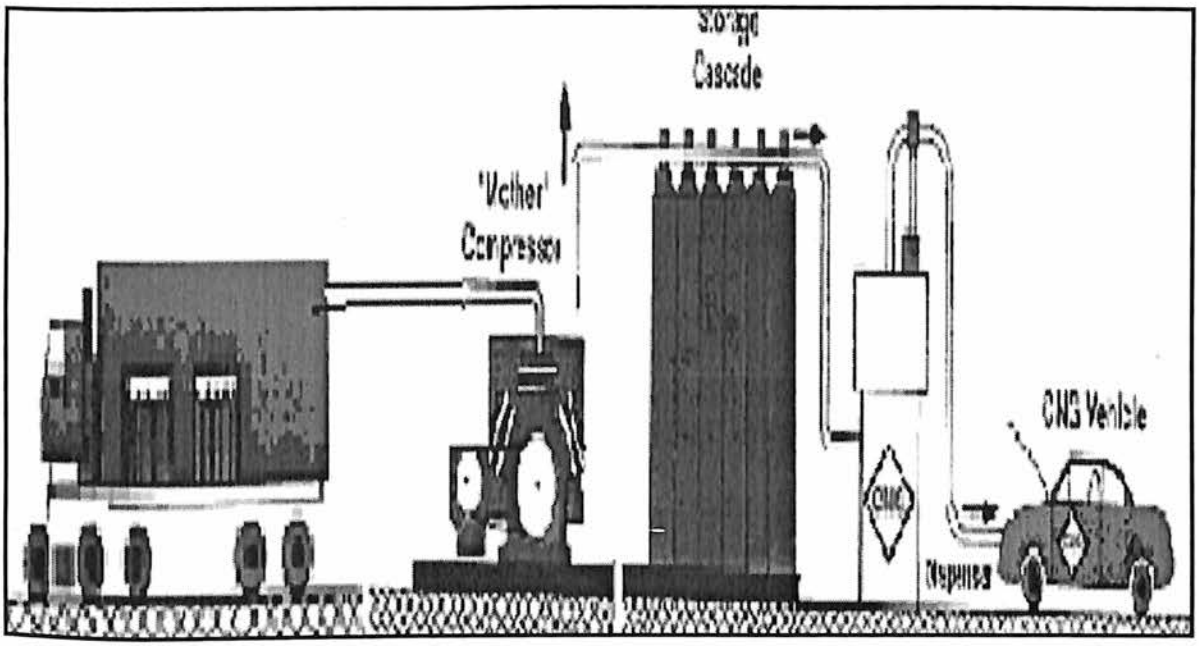


Figure 12.3: Daughter Booster Station Process Flow

The CNG facility that is not connected to the natural gas pipeline and has facilities for dispensing CNG to vehicles (s) from mobile cascades after boosting the gas pressure using booster compressors.

The following units are installed in the Daughter Booster Station

I). Main equipment:

i). Booster compressor

ii). Dispensers for Cars and three wheelers

iii). Stationary cascades

iv). Dg Set, UPS & Battery Bank, Automatic Voltage Stabilizer (AVR), Electrical Control Panel

v). Instrument air and water facilities

vi). Fire Fighting equipment

vii). Unloading facility from mobile facility.

II). <u>Other Facilities:</u>

i). Office cum control room

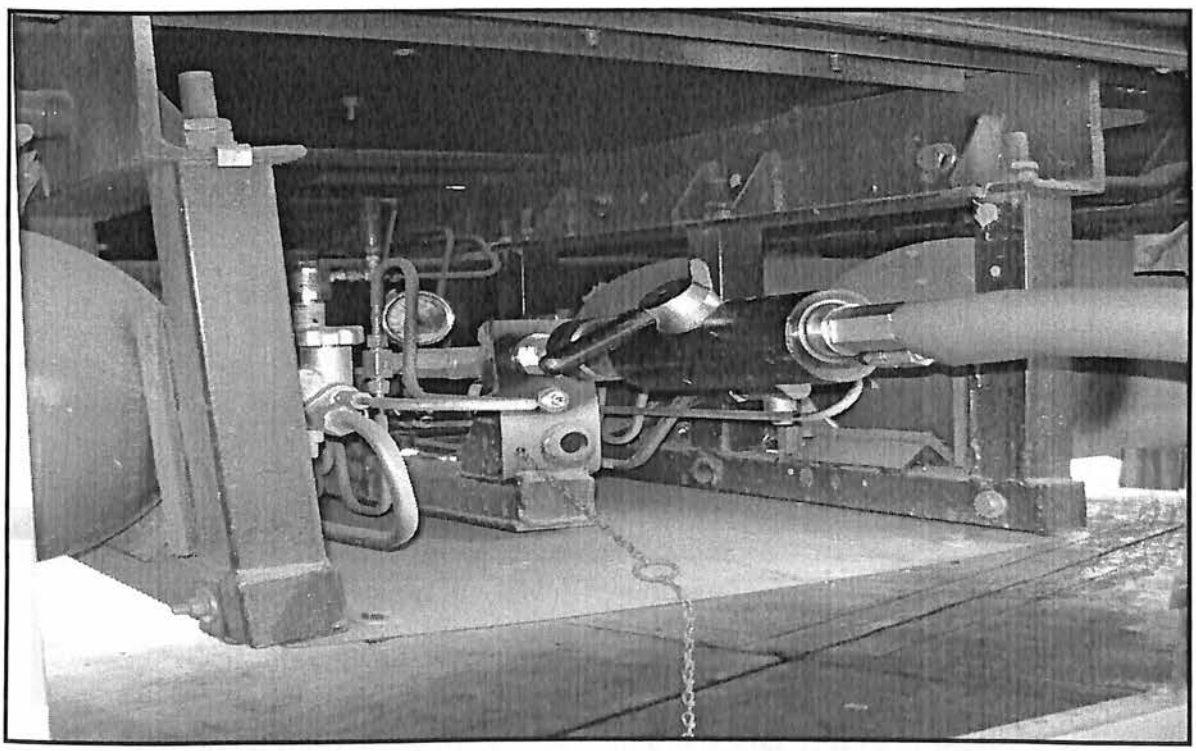
ii). Stainless tubing connecting the equipment

iii). Underground drainage and sewage network

12.3. DISPENSERS:

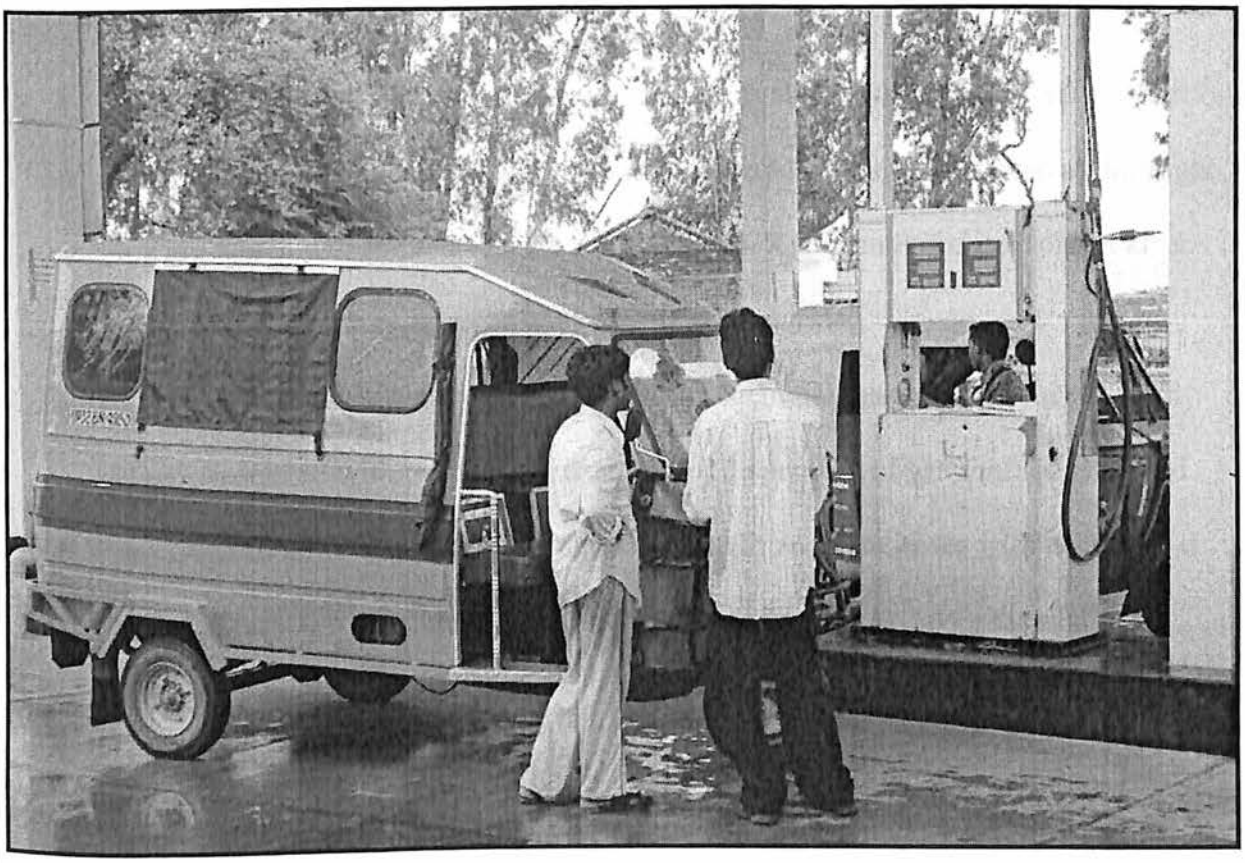
Compressed natural gas from compressor or cascade shall be dispensed to NGVs (natural gas vehicles) such as cars, 3-whelers, buses ,etc, through dispensers. Following two types of dispensers have been envisaged.

12.3.1. Bus dispenser:



To meet the requirement of bus filling at mother stations, single arm bus dispenser, each of capacity 80 kg/min has been envisaged. The system shall be designed in such a way that when compressors are in operation, the bus dispenser will take about 65 kg/min gas from cascade and about 15 kg/min gas from compressor.

12.3.2. Car dispenser:



To meet the requirement of car and three wheeler filling at mother, online and daughter stations, double arm type car/auto dispenser each with a capacity of 15 kg/min have been envisaged.

Safety features of dispenser:

- The car dispenser shall have two arms and bus dispenser shall have one arm for dispensing the gas.
- 'Coriolis' true mass flow metering system or equivalent with necessary sensor and electronics shall be provided with provision of liquid crystal backlit display for night viewing which will show unit wise of CNG in Rs./Kg, quantity of gas sold in kg & total sale in Rs. A temper proof totalizer shall be provided
- PLC based sequencing software and controller including hardware along with ball valves associated with pneumatic actuation for dispensing of gas shall be provided.
- Two CNG flexible electrically conductive twin fill and vent hoses with two NGV-1 Type-2, Class-A fill nozzle with captive vent including three way vent shall be provided
- All dispensers shall be earthed.

12.4. CASCADE:

This is a group of gas cylinders with a total water capacity not exceeding 4500 Litres, contained within a length of 5.5M, a height of 1.6M and a width of 1.2M in case of cylinders kept vertical, or 5.5M, 1.6M and width of 1 cylinder up to 2M in case of horizontal cylinders. Either arrangement used shall be interconnected by high-pressure piping to form a single gas storage unit referred as stationary cascade and,

The cascade which is used for transportation of CNG in the structural container having facility for lifting and placement is called as mobile cascade.

Following two types of cascades have been envisaged.

12.4.1. STATIONARY CASCADE:

Cascades are used to store the CNG at high pressure, to absorb the surge of reciprocating compressor, frequent start and stop of compressor and to supply additional gas when dispensing rate is more than the compressor capacity. Compressor will start if pressure in cascade falls below 210 Kg/cm^2 (g) and stop at pressure 255 kg/cm^2(g). For a pressure range of 220 kg/cm^2(g) to 255 kg/cm^2(g), in cascades of 4500 litre & 2200 litre capacity, about 135 Kg & 65 Kg respectively, of CNG can be stored. The cascade shall supply gas to bus as well as car/auto dispensers.

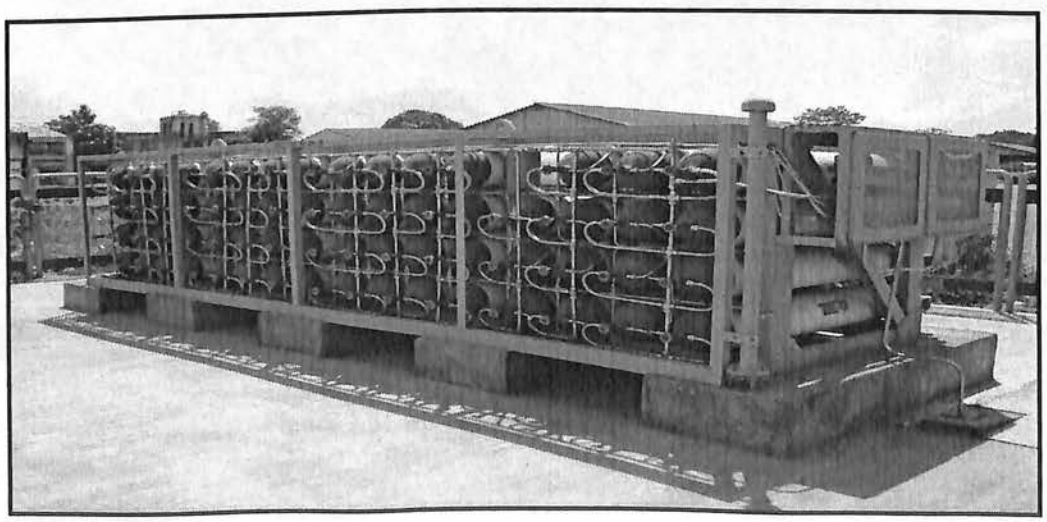


Figure12.4: Stationary Cascade

Safety Features of Cascade:

- Cascade shall be made of group of cylinders fixed with structural steel frame having facility of lifting placement.
- The cylinder and their neck threading shall be designed as per IS: 7285-1988 and IS: 3224-1979, respectively and approved by chief control of explosives (CCOE) approved.
- The cylinder shutoff valve shall be with fusible disc confirming to requirements of IS: 3224-1979 are CCOE approved.
- All end connections for quick release couplings, pressure gauges, valves and fittings of cascade shall be within tamper proof enclosure. This shall be on one side of the cascade for ease of operation.

12.4.2. MOBILE CASCADE:

Figure 3.5: Mobile Cascade mounted on LCV

2200 litre water capacity cascade shall be fitted in light commercial vehicle (LCV). The mobile cascade will be filled at mother station up to 255 kg/cm2 (g) pressure. Mobile cascade at pressure 255 kg/cm2 (g) will be sent to the daughter booster station (DBS) for gas dispensing up to a pressure of 30 kg/cm2 (g) at DBS. Empty mobile cascade at pressure lower than 30 kg/cm2(g) shall come to mother station for refilling. Approximately 335 kg/cm2 (g) gas can be transported from this cascade. The entire assembly shall be CCOE approved.

Suitable loading facility at mother station and unloading station at DBS has been envisaged along with sun/rain protection shed.

Loading facility for Mobile Cascade:

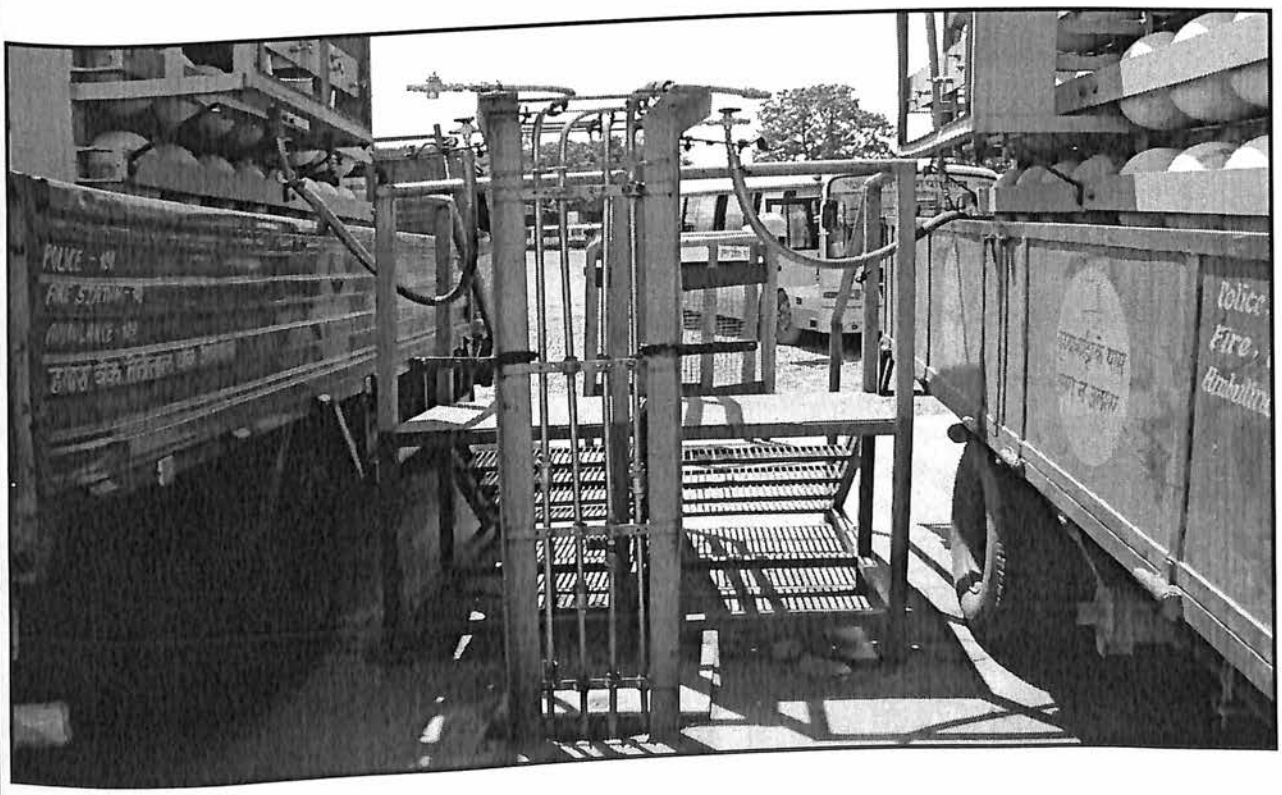


Figure 12.6: Filling of Mobile Cascades

12.5. FIRE FIGHTING EQUIPMENT AND SAFETY SIGNS:

Fire fighting facilities need to be carefully planned after considering the availability of municipal fire tenders etc. However, at least the following Portable fire extinguishers shall be positioned:

Location	Type of Extinguishers
Dispensing Unit	1 x 10 kg. DCP(Dry Chemical Powder)
Compressor (on-line)	1 x 10 kg. DCP
Compressor (mother station)	1x 75 kg DCP
CNG Storage	1 x 10 kg. DCP
Cascade refuelling area	1 x 10 kg. DCP
MCC/ Electrical Installation of 25 m^2 area	1 x 4.5 kg CO2

Office-cum-control room and other facilities:

This shall be an RCC framed structure of suitable size to house office, control room, electrical room, cashbox and toilet. The front side shall have glazed partition for viewing dispensing operation. The floor will have ceramic tiled finish and synthetic emulsion paint on walls and ceilings have been considered.

- The station shall be enclosed with 2.1m high boundary wall on three sides
- The fore court shall be made of high riding quality RCC pavement with wearing resistance surface
- The Stainless Steel tube trenches and drainage shall be covered with heavy duty precast SFRC (steel fibre reinforced concrete) covers of suitable design and manufacture.
- GI conduits shall be laid for cabling work
- Properly designed dispenser island with safety guards shall be provided.
- Structural steel canopy shall be provided over the dispensing area for providing sun and rain protection. The canopy shall have provision of roof drainage, illumination and signage's
- The station shall be provided with approach roads, entry and exit ways, parking bay, operation area fence, safety barbs, road signs, station drainage system etc
- The station shall be provided with corporate traffic and safety signage's using state of art techniques and landscaping
- The station shall be provided with safety and fire fighting equipment, earthing pits and safety instructions

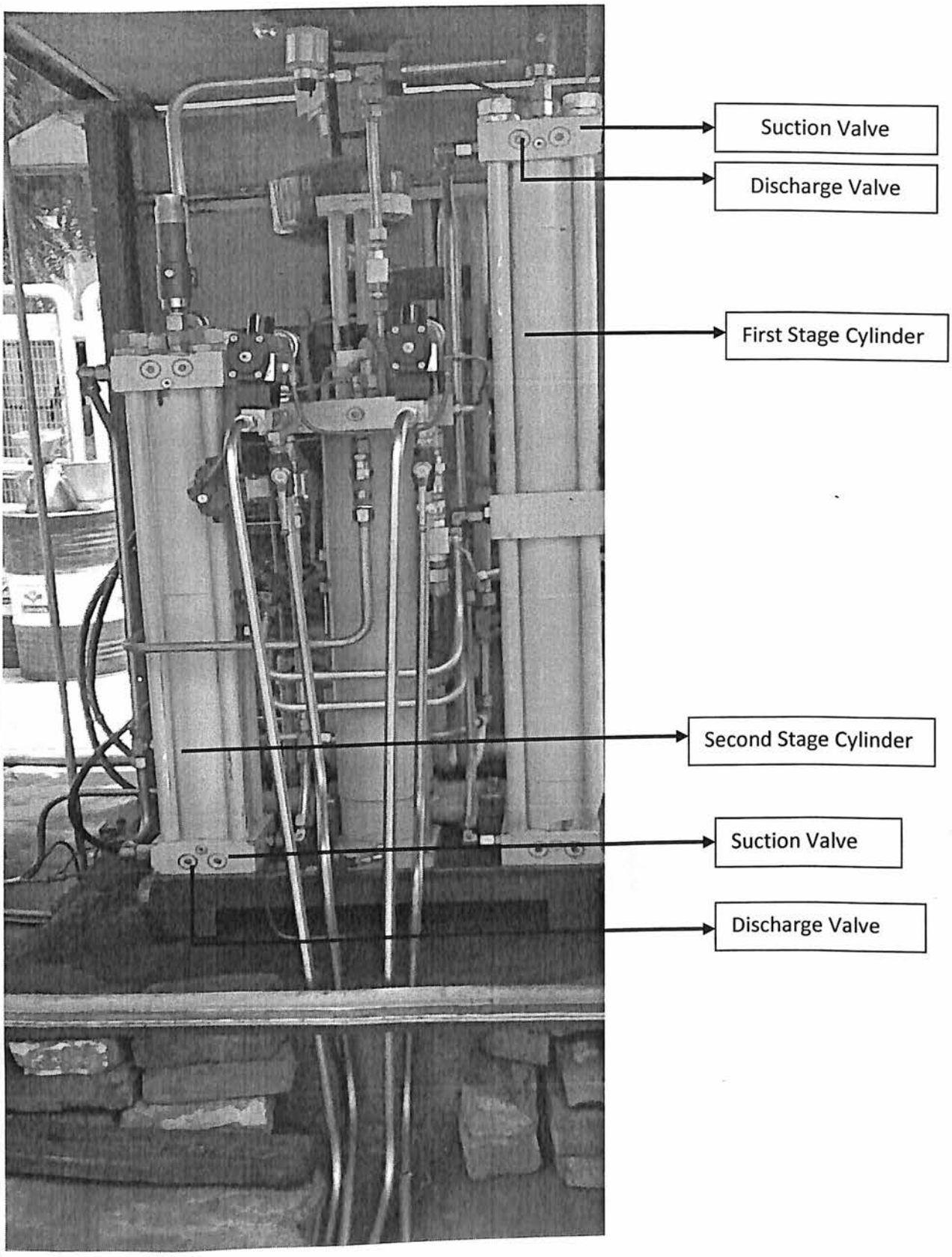


Figure 12.7: Parts of compressor

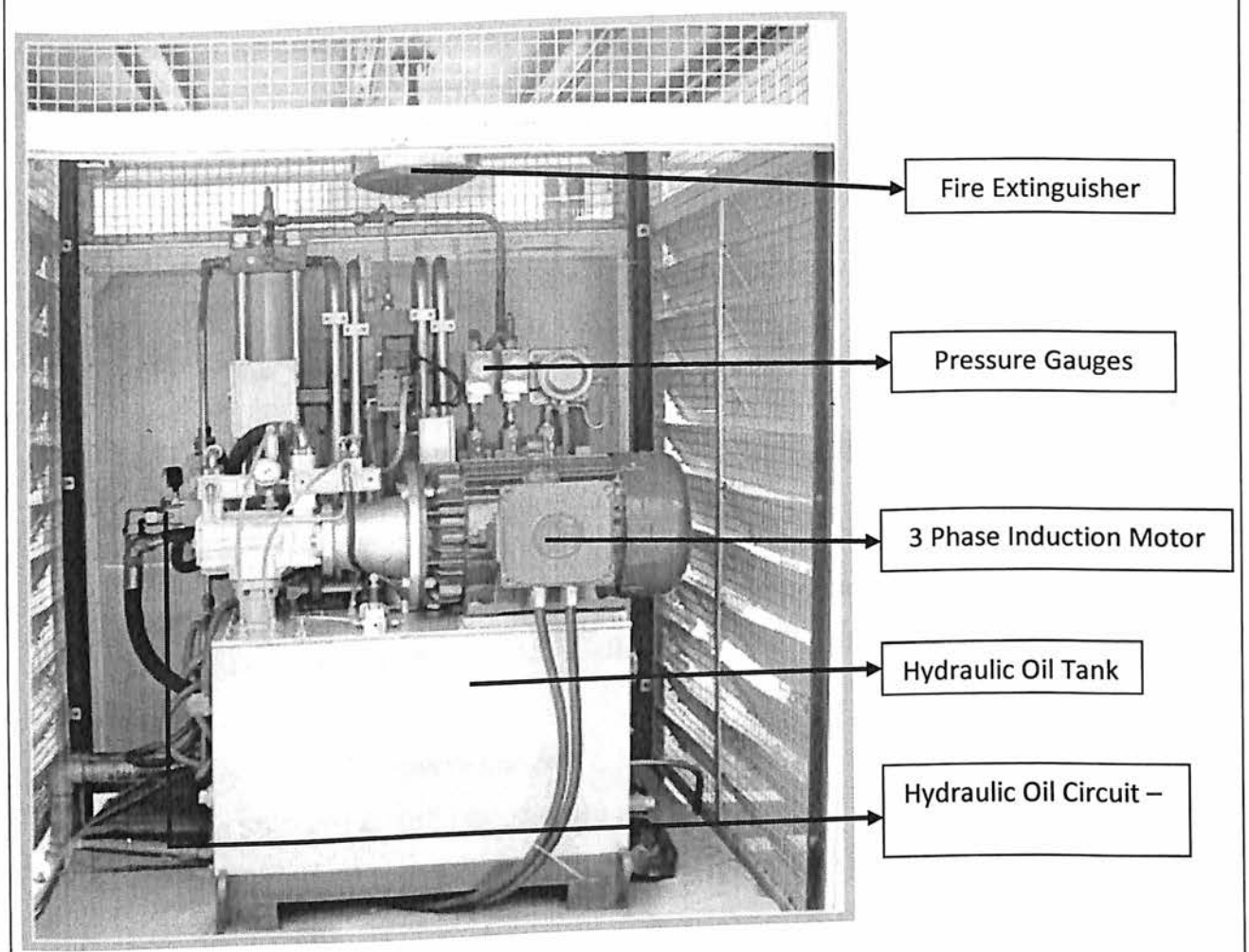


Figure12.8: Parts of compressors

12.6. COMPRESSOR OPERATION:

The Compressor Schematic as shown above will includes the following main components,

Tank and its accessories

Pumping assembly

Hydraulic exchange assembly

First stage pumping unit

Second stage pumping unit

First and second stage water and air cooling assembly

Safety and Monitoring Devices on the Compressor unit:

- Intake gas filter
- Gas Safety Relief valves on each stage of the Compressor
- Inter Stage and Delivery Pressure Gauge
- Gas Thermostat
- Hydraulic Circuit pressure gauges
- Visual Indicators of Oil Temperature and level
- Electric Oil Level Indicator
- Oil Thermostats
- Maximum Oil Pressure relief valve

Cooling System:

Air- Water Cooling System:

At the outlet of Each Stage the gas is cooled in Water- Gas Heat Exchanger

Water – Oil Heat Exchanger:

The Hydraulic oil is cooled by means of a Water-oil Heat Exchanger

13. CONCLUSION:

- As observed the risk assessment of site construction activities are a must for prevention of incidents or any untoward accident. Prima facie prior to start of any activity the risk assessment and corresponding respective control measures shall be established and necessary implementation of measures are to be ensured.

- The understanding of these control measures should percolate down the stream i.e. from staff working at top to the work force down at the bottom of the hierarchy. The goal of achieving HSE objectives/targets as laid down by the company can be accomplished only upon successful implementation of stringent & safe working practices