"CITY GAS DISTRIBUTION SYSTEM FOR DEHRADUN"

Dissertation Submitted to

University of Petroleum & Energy Studies

In partial fulfillment of the requirements

For the award of the degree

Bachelor of Technology

in

Applied Petroleum Engineering

Specialization in Gas

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UTTARAKHAND

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CERTIFICATE

This is to certify that the project report titled **"City Gas Distribution System for Dehradun"** is being submitted by **Swetabh Gautam** and **Tarun Dey Ramola**, in partial fulfillment of the requirements for the award of the degree of BACHELOR OF TECHNOLOGY (Applied Petroleum Engineering-Gas Specialization) of U.P.E.S. Dehradun. This is a bonafide record of the work carried out by them under our guidance and supervision. Further this work has not been submitted elsewhere for the degree.

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DECLARATION

We hereby declare that the entire work presented in this report was carried out by us under the guidance of **Mr. Rajeshwar Mahajan** (Assistant Professor-COE UPES) and no part of this report has been submitted for any degree or diploma in any institution previously.

In keeping with the general practice of reporting scientific observations, due acknowledgements have been made wherever the work described is based on the findings of other investigators. Any omissions, which might have occurred by oversight or errors in judgment, are regretted.

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SWETABH GAUTAM

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NOMENCLATURE

AGA: American Gas Association

ANSI: American National Standard Institute

API: American Petroleum Institute

ASME: American Society of Mechanical Engineers

CCOE: Chief Controller of Explosives

CGS: City Gas Station

CNG: Compressed Natural Gas

DCEP: Direct Current Electric Power

GAIL: Gas Authority of India

GI: Galvanized Iron

GIS: Geographical Information System

ISO: International standard Organization

LNG: Liquefied Natural Gas

MN: Methane Number

MOST: Ministry of Surface Transport

NFPA: National Fire Protection Association

NGV: Natural Gas Vehicle

OISD: oil industry safety directorate

PCV: Pressure Control Valve

PSV: pressure safety valve

SMPV: Static and Mobile Pressure Vessels

SV: Sectionalizing Valve

SM3: Standard Cubic Meter

Sox: Sulfur Oxides

Tcf: Trillion cubic feet

ABSTRACT

CNG has become the most convenient and economical fuel today as compared to that of other fuels in the market. It is considered to be an environmentally "clean" alternative to other fuels. It is made by compressing purified Natural Gas. This compression is done at CNG Station where the Natural Gas is converted to CNG.

Mother stations are outlets to the CNG pipeline networks running (existing / proposed) throughout the length & breadth of a city / high way. These stations also provide Cascade filling facility (at 250 bar g), used to fill gas in small cascades and transport gas to Daughter Stations. CNG vehicle storage cylinders need to be filled at a pressure of 200 bar (g). Natural Gas from main line comes at 19-26 bar (g) pressure to CNG Station. Here, first it passes through a Metering skid to measure the volume of Gas consumption and record the pressure of Gas. Then it goes to the compressor which is the heart of any CNG station .The purpose of compressor is to compress the Natural Gas from 19-26 bars to 250 bars in three stages of compression. The compressed gas is stored in specially built cylinders/tanks called cascades. There are two types of cascades, stationary and mobile cascades (LCV). The purpose of Stationary Cascade is to store the compressed Natural Gas when ever cascade is on higher priority and the dispenser at this time is in off position. The purpose of LCV is to carry CNG to daughter stations. When a vehicle arrives and needs to be filled the gas goes in the dispenser, so as to dispense the CNG to the vehicle and record the volume of gas dispensed. The gas flow in this whole system is controlled by the Priority panel. It is the function of the Priority Panel to direct the CNG flow to the Dispenser/Stationary/ LCV Cascade based on their priority. The priority panel directs the gas flow from the compressor to the High bank, Medium bank or Low bank of the storage cascades, depending on demand.

The project deals with introduction to natural gas and CNG, mother station designing, equipments present at a CNG station and their description, compressor statistics and calculations, compressor maintenance guidelines, codes and standards followed at a CNG station and the problem of lube oil carryover and suggestions to overcome this problem.

CHAPTER 1
INRODUCTION

1.1 CITY GAS DISTRIBUTION IN INDIA

In the early stage, the city gas was only started on experimental basis, primarily to utilize the locally produced gas. Such locations had been Duliajan, Moran, Nazira, Sibsagar in Assam, and Baroda in Gujarat. The structured use of Natural Gas in domestic sector in Assam, started after formation of Assam Gas Company in 1962. In addition, the metros of Mumbai and Kolkata used Coal Gas for City Gas Usage way back since pre-independence. The coal gas which is also known as Synthesis Gas did not find a commercial business model and abandoned in Mumbai way back in 1981. In Kolkata this concept is still working after the original company the Oriental Gas was succeeded by Greater Calcutta Gas Supply Corporation in 1987, however it is on the retardation phase.

The development of City Gas in India remained localized for quite long time. It was only in 80's when structured development of City Gas took place in India. The Gujarat Gas Company is the example of this initiative when Govt. of India allocated gas for development of City Gas in Ankleshwar and Bharuch.

In early 90's Supreme Court on a PIL filed by Sh N.C. Mehta directed that the City Gas should be implemented in Delhi, Mumbai and Baroda by GAIL (I) Ltd. In pursuant to this direction, the CNG was introduced in all these three towns in 1993. In Mumbai a JV of GAIL, BG and Govt. of Maharashtra was formed to pursue City Gas Business. A company was registered in 1995 as Mahanagar Gas Limited. This company has been performing very successfully since then.

In Delhi after continuing its activities for 5 years, GAIL formed a JV with Bharat Petroleum Corp. Ltd. and Govt. of NCT of Delhi and created a new company in 1998 by the name of Indraprastha Gas Limited.

Subsequently, there have been various initiatives in the City Gas Distribution (CGD) Projects. As of now, the numbers of companies operating in CGD are as under:

- Assam Gas Company Ltd, Duliajan, Assam
- Tripura Natural Gas Company Ltd, Agartala, Tripura
- Gujarat Gas Company Ltd (GGCL), Surat, Gujarat
- Baroda Municipal Corporation Ltd, Baroda, Gujarat
- Charotar Gas Sehkari Mandali Limited
- Great Eastern Energy Corporation Ltd.
- Mahanagar Gas Ltd (MGL), Mumbai, Maharashtra
- Maharashtra Natural Gas Company Ltd, Pune, Maharashtra
- Indraprastha Gas Ltd (IGL), Delhi
- Bhagyanagar Gas Ltd, Hyderabad, AP
- Green Gas Ltd, Lucknow, UP
- Central UP Gas Ltd, Kanpur, UP
- Avantika Gas Ltd. MP
- Gujarat State Petroleum Corporation Ltd, Ahmedabad, Gujarat
- Adani Energy Ltd, Ahmedabad, Gujarat
- Sabarmati Gas Ltd, Gandhinagar, Gujarat
- Kolkata City Gas Co. Kolkata WB
- Haryana City Gas Limited, Gurgaon, Haryana
- Sity Energy Limited, Delhi
- Reliance Industries Ltd
- Reliance Energy Ltd
- Krishna Godavari Gas Ltd (JV of GSPCL & Govt of AP)

The major players among above companies are MGL, IGL and GGCL. Their major achievements in regard to market penetration and infrastructure are as under:

Traits	MGL	IGL	GGCL
Domestic Connection	3,17,000	95,000	2,12,000
Vehicle Conversion	1,83,000	1,75,000	58,000
CNG Outlet	127	154	22
Gas Sold (MMSCMD)	1.26	1.55	0.31

1.2 WHY NATURAL GAS

With the hydrocarbons finds in India way back in 1889 in upper Assam, the journey for exploring hydrocarbons reserves continued. There had been Oil & Gas finds in various regions at various times. The major gas finds of Bombay High and South Basein change energy consumption pattern in India. Natural gas is most eco friendly fuel among the hydrocarbons group and next only to solar energy, wind energy, hydel energy and hydrogen. The Indian Energy Basket has a share of Natural gas touching 9% as against 24% of the world average.

The most benign use of Natural Gas is in City Gas Application. This sector comprises of:

Domestic household use

Commercial use in hotels, hospitals, restaurant and offices

Transport sector use in Three wheelers, buses, trucks and cars

Industrial Sector use in the Small Scale Industry including Power generation.

The Household use of gas has picked up in India especially when multiple use of Natural Gas in the houses was demonstrated. The gas can be used for cooking, water heating, space heating, air conditioning, refrigeration, power generation and fuelling the vehicle. The concept of a single switch solution in the household sector is picking up momentum. This concept provides that a household could be self contained gas users to meet its all energy needs at one go that means once the gas supply is switched on, all these services can be secured which are all gas based of course selectively or need based.

In the commercial sector the city gas has found to be very useful in the application like cooking, air conditioning, power generation. In fact a concept of Combined Heat & Power (CHP) is getting popular in India. This system has much higher thermal efficiency as compared to other conventional services.

The use of Natural gas in the transport sector has contributed to a great extent to contain the pollution due to vehicular exhaust emissions. Apart from this natural gas as CNG has been able to replace high priced hydrocarbon commodity like petrol and diesel. This has further helped India to reduce its Oil Import Bill. As a matter of fact, the international Gas Price is always 10-15% less as compared to crude oil price in energy terms.

Natural gas supply to industries in and around a city or local area has considerably helped reducing pollution in the cities apart from providing ease of operation and fuel handling to the industries.

1.2 NATURAL GAS & ITS COMPOSITION

Natural gas is the cleanest burning environment-friendly conventional fuel. World over today, it is recognized as the fuel of the future - its demand is growing faster than any fossil fuel. A naturally occurring hydrocarbon containing mainly methane and ethane, natural gas is a colorless, odorless and nontoxic fuel with distinct advantages over other alternative fuels.

1.3 GAS COMPOSITION

Composition of Gas considered as below.

Component	Range mole %		Design case mole %
Methane	84.50	98.77	89.00
Ethane	0.69	9.00	5.00
Propane	0.03	4.00	1.50
Butane	0.00	2.00	0.50

Pentane	0.00	0.35	0.35
Hexane	0.00	0.15	0.15
Heptane	0.00	-	0.00
Carbon Dioxide	0.00	4.50	3.00
Nitrogen	0.05	1.25	0.50
Total	100	100	100

1.4 Gas Demand in India

Projections	Terminal Year of Plan 2006-2007
Gas linkage committee allocations + Potential Demand by Existing Market	180 MMSCMD
Hydrocarbon Vision-2025	231 MMSCMD
ADB'S Gas Master Plan	185 MMSCMD
Initial Assessment by User Ministries + Other Sectors	135 MMSCMD

The Eternal Demand – Supply

Ever since man began using fuel for energy, supply has played the elusive stance. with India poised as the world's 6th fastest growing economy, the demand for fuel increases at an unprecedented pace.As per the Natural Gas Working Group for the Tenth five year plan, in 2006 – 2007 the estimated gas demand for domestic sector is 179mmscmd. Due to lack of production of natural gas, the demand will be match by importing the LNG from LNG exporter country.

The increasing rate of Natural Gas consumption per five year is summarized in table below;

Year	**Consumption (in TCF)**	Growth rate of consumption (%)
1995	0.8	-
2000	0.92	15%
2005	1.4	75%
2010	1.7	112.5%

Natural Gas makes better business sense than conventional fuels

- Assured uninterrupted and reliable 24-hour supply of fuel.
- Equipments based on natural gas incur lower maintenance cost and downtime - yielding higher productivity & profitability.
- Natural gas is nearly 100% combustible yielding higher efficiency.
- Its clean burning characteristic can help improve end-product quality making your product more competitive.
- calorific value effective prices comparable to other fuels.
- Distributed through pipelines directly at premises - zero spillage, handling & logistic problems.
- Pipeline delivery relatively immunizes you against inflation of transportation costs

- Low pollution emissions Zero solid wastes. Giving you the environment friendly company status.
- Pipeline delivery requires no storage facility thus saving on space.
- A metering device at customer's premises allows custody transfer resulting in zero pilferage.
- No storage at customer's premises ensures high consumer safety. It also easier to control &containing case of emergencies.

1.5 ADVANTAGES OF NATURAL GAS

It is proven manifold that natural gas is a very clean fuel. The world Energy Conference of Tokyo 1996 announced that natural gas is the No.1 alternative because:

- Natural gas has excellent combustion properties,
- Natural gas is a safe fuel (lighter than air, high ignition temperature)
- Natural gas is a clean fuel (no sulphur, no lead, no particles, little Nox, CO
- and HC).
- Natural gas has abundant reserves, wide spread over the globe.
- Natural gas is a strategic fuel,
- Natural gas is cheap if we exclude taxes.

1.6 THE FUTURE OF CGD IN INDIA

With the Petroleum and Natural Gas Regulatory Board in position and good prospects of new gas finds in India the future of CGD Project is expected to see an asymptotic growth. There are proposals for extending the existing transmission pipe line network from nearly 7000 Kms to more than 10000 Kms in the coming years and subsequently to 15000 plus Kms. An exercise done by the one of organizing company indicates that around 130 cities/towns are expected to get city gas project in various stages in next XI – Five Year Plan.

1.7 SALIENT BENEFIT OF THE PROJECT

Benefit to State Government

- Private investment in state for development.
- Directly or indirectly employment local people in the city.
- Revenue to Government in the form of sales tax.
- Network of Natural Gas shall attract more industries hence a growth to economy.
- Earning from Government land by leasing for CNG retail outlet.
- Benefit to public.
- Pollution free environment
- Cheaper Domestic Fuel.
- Cheaper and clean CNG availability for personal vehicles.
- Venus for employment
- Benefit to industrialists
- Cost saving, as natural gas is a cheaper fuel than most of the existing fuel.
- Pollution free hence, no future threat on account of pollution.
- Safe, reliable, clean and user friendly fuel, hence improvement in motivation for employees.
- Improves product quality of industries in many cases.
- Direct supply so no inventory cost.
- Prices of Natural Gas are consistent compared to other Petroleum products, hence better forecast planning.
- Benefit to local commercial transporter
- Cheaper CNG fuel available.
- More Mileage per kilogram of fuel.
- More use of public transport due to reduced tariff.
- No hassles for "for pollution under control" inspection.

1.8 SCOPE OF THE WORK

In this project, the natural gas distribution system is divided in two segments namely:

- PNG Directly supplying gas through pipeline to consumers such as domestic, commercial and industrial units.
- CNG To compress the gas to 250 bar and to fill in the CNG cylinders installed in the vehicles through CNG dispensers.

Benefits of PNG –

- PNG is Convenient
- 24 hours uninterrupted gas supply,
- No changing or handling of gas cylinders,
- No more last minute emergency,
- Simply, do away with cylinders and its associated problems,
- Make payments after you consume, through banks, drop boxes, ECS, Net, etc.,
- PNG is Economical,
- PNG works out to be up to 10% cheaper than LPG,
- 14.2 kg. LPG is equivalent to 18 units of Natural Gas shown in your meter. At present, price of LPG is Rs. 255/- you consume Gas costing Rs. 205/- only, saving Rs. 50/- (approx.) every time. (Above figures are indicative.)
- PNG is Safe
- Natural Gas catches fire only when it forms a 5-15% mixture with air whereas LPG catches fire when it forms 2% or above mixture with air.
- Our supply designs, executions and operations are being done as Per International best Practices.

PNG is Clean

- Being a gaseous fuel, very clean compared to any other fuel with more than 94%.

- Combustible particles.
- Burns with a flame always hence, no blackening of vessels.
- Sulphur content less than 10 PPM.
- Most preferred fuel in vehicles in Mumbai today.
- Contribution for a cleaner society.

PNG is versatile

- Apart from cooking, other appliances like geyser, air conditioner, vehicles etc. can be used on Natural Gas. However, please do not attempt to alter/modify the existing installation yourself or through any unauthorized person. Please call 1917 for assistance.
- PNG is the fuel of choice around the world.

CHAPTER 2
PROJECT DETAILS

2.1 THE PROJECT

The objective of the project is to developed and designs a CNG Infrastructure Development Program for setting up CNG stations in Dehradun city as well as the network system of pipeline to service the natural gas demand of industrial, commercial, domestic and transport sector of Dehradun city. It is proposed that the Gas shall be entering to Dehradun city at CGS through GAIL's transmission grid.

2.2 NETWORK DESCRIPTION

2.2.1 DESIGN BASIS

The project describes the design basis for the facilities downstream of CGS including CNG Distribution Steel Network. It has been considered that NG at an outlet pressure of 19 kg/cm2 (g) shall be made available at the GAIL's CGS for the CNG & city gas distribution in Dehradun. The estimated amount of natural gas for dehradun city is 0.02MMSCMD which will touch the amount of 0.4MMSCMD over the period of 10 years. All the significant demand centre of Dehradun city has been identified in Reconnaissance survey and Detail route survey, and it is proposed that the length for Steel Grid within the city is 35Kms whereas the PE grid is 10 Meters/Customer.

2.2.2 DESIGN PHILOSOPHY:

The design of the primary steel network is based on the demand and peak load. The calculation of pipeline parameters is calculated with the Weymouth formula incorporating the value of efficiency and roughness to be 0.9 and 25.4 micron. The primary network is designed to meet the 30% higher load than the estimated peak load at the maximum liming velocity of 40 m/s.

To cater to the domestic, commercial and small size industrial consumers, a low pressure city gas distribution network consisting of various sizes of MDPE pipeline shall be laid up to the consumer points.

The secondary network system consisting of MDPE pipeline shall be taken from the main Steel Gridline by tapping from steel network and connected to the District Regulatory Station (DRS) which shall reduce the gas pressure 16-19 kg/cm2 (g) to 3- 4 kg/cm2 (g) for onward distribution to domestic, commercial and small size industrial consumers through MDPE pipe network. Pipe sizing is carried out on basis of Weymouth formula with 30% extra load capacity than the estimated capacity with maximum limiting speed 40 m/s.

The PE Pipeline network will provide service mainly to residential customer with some mix of commercial and industrial customer according to their requirements.

The Design philosophy shall be:

- To optimize the use of each component of the system.
- Minimize the use of mechanical parts which can be the cause of the unnecessary pressure reduction in gas or in system.
- Utilize maximum energy associated with he system.
- Enhance reliability by having redundancy in critical component.
- The design philosophy will be achieved by:
- Operating the system at optimum value
- Carefully implementation of mechanical equipment
- Minimize the use of different pressure system.

2.2.3 SYSTEM BASIC CONCEPT

Pressure levels

The concept is based on the pressure levels given in the following sections.

High-Pressure

This applies to the pipelines connecting the Gas transmission System to the "City Gates".

Design data for HP system

The maximum inlet pressure for the City Gate was taken as 49 bar(g) being known as the supply pressure by the GAIL at off-take points.

Medium pressure

1. General

Usually two main pressure are considered for "Gas Distribution Networks"

MPS

- MOP = 19 bar(g) (compatible with ASA Class 150 flanges and fittings);
- Basic Material of Construction - Steel
- Operating Pressure fluctuating between said MOP and level MPS Pressure depending on actual operating pressure and pressure drops.

MPP

MOP = 4 bar(g)

- Basic Material of construction – Polyethylene
- Operating pressure fluctuating between said MOP and the minimum pressure (Pmin) necessary at the inlet to End-Users SC to guarantee MGP to End-users.

City gates are interfacing the High-Pressure system by lowering the pressure to MPS pressure level. Pressure reducing stations are interfacing MPS to MPP.

2. Application to present Projects

The project development considers both MPS and MPP pressure networks.

Major industrial consumers will be directly fed through connection in MPS network. CNG On-line / mother stations will be connected to MPS pressure network. Small scale industrial customers in industrial estates will be provided through connections in MPP network.

Network analysis shall consider that Pmin at the farthest end (end of MPP network) shall not be lower than 1.0 bar under normal operation.

2.2.4 PIPELINE NETWORK

2.2.4.1 STEEL MAIN GRID

Notwithstanding the major advantages of polyethylene (PE), steel pipelines remain necessary and shall be utilized as follows:

1. High & Medium Pressure Mains
Mandatory for all high & medium-pressure design systems.

Peculiar conditions:

- Location class: the design of High pressure mains shall consider requirements as for Location Class 4 (ASME 31.8) to allow timelessness should the environment change in the future.
- Wall thickness: according to ASME B31.8 - Section 841.11 with Design factor of 0.4. In addition, wall thickness shall, in no way, be lower than the values below in function of Nominal Diameter (ND)

- 4 in. and below 3.9 mm;
- 6 in. 4.5 mm

Steel Grade: The Design Concept considers API Grade X42 Steel quality to offer maximum flexibility for line pipes procurement.

- Bend Radius: of 6D to allow pigging under special circumstances

Steel Pipeline Design Parameters

Max. Op. Pressure, $kg/cm^2(g)$	19 kg/cm^2 (g)
Op. Temperature, °C	5-50 Above Ground - 65°C
Corrosion Allowance	0.5 mm
Pipeline Efficiency/ Roughness	0.9 / 45 micron
Design Temperature	Buried – 45°C
Design Life	30 Years

2. MP Steel network

Medium pressure MP Steel network shall be realized in Grade X-42 steel.

3. Above Ground Mains

Polyethylene being forbidden for above ground crossings, if any, steel mains sections are needed at the crossing with PE/steel transition fitting to be buried with the adjacent PE mains.

2.2.4.2 Design of the Main Grid System

The main objective is to develop a grid supply system, which shall carry the bulk gas supplies to the areas of potential demand from GAIL's City Gate Station (CGS) to the City of Dehradun.

The pressure regimes followed for the system design is as below:-

Distribution Network	Pressure Regime	Service pipe
Main Grid Line kg/cm^2(g) (High Pressure System)	19	Steel
Distribution/ Service Line (Medium Pressure System)	4 - 1.5bar	MDPE
Large commercial connection	2 bar	MDPE

Medium & Small commercial Connection	300 mbar	MDPE
Domestic Connection (Low Pressure System)	21 mbar	MDPE / GI

2.2.4.3 MP POLYETHYLENE NETWORK

To cater to the domestic, commercial and small size industrial consumers, a low pressure city gas distribution network consisting of various sizes of MDPE pipeline shall be laid up to the consumer points.

For the city gas distribution, a tapping of 6" / 4" line shall be taken from the main Steel Gridline and connected to the District Regulatory Station (DRS) which shall reduce the gas pressure 16-19 kg/cm2 (g) to 3- 4 kg/cm2 (g) for onward distribution to domestic, commercial and small size industrial consumers through MDPE pipe network.

Three separate MDPE network have been planned to connect the Domestic, Commercial and small Industrial consumer points separately from three separate DRS as per design requirement. Each network of MDPE pipes (one for domestic, one for commercial & one for small Industrial consumers) has been finalised based on simulation of the route/area survey and are enclosed herewith. However, the registrations of all these consumers (as listed in this document) are required to be completed by MNGL before execution of these Networks.

Physical and Mechanical Properties of MDPE(Gas) Pipes

Sr.	Characteristics	Units	Requirements	Test Parameters	Test methods
1	Conventional Density	Kg/c3	>930(base polymer)	23 degree C	ISO 1183, ISO 1872/1
2	Melt Flow Rate	G/10 min		190 degree C/5kg	ISO 4440/1, IS 2530:1963
3	Thermal stability	Min	>20	200 degree C	ISO/TR 10837
4	Hydrostatic Strength(HS)	h	Failure Time>=100h Failure Time>=165h Failure Time>=1000h	PE-80-9.0 MPa - 20C PE-80-4.6 M Pa - 80 C PE-80-4.0 M Pa - 80 C	ISO-1167
5	Elongation at Break	%	>=350		ISO 6259/3

The MDPE network shall mainly comprise of the following.

- District Regulating Station (DRS)
- MDPE pipe from DRS up to the customers' premises.
- Industrial and large commercial connections through Meter regulating Station (MRS) to be installed at the customers' premises.
- Medium/ small Commercial connections through commercial meters and regulators to be installed at the customers' premises.
- Domestic connections through domestic meters and regulators to be installed at the customers' premises.

2.2.4.4 COVER - CLEARANCE - PROTECTION

In accordance with the provisions of API, OISD and other standards the basis for minimum cover requirement for both steel & PE pipelines, shall be 1.0 M. In exceptional cases, where such requirement cannot be physically met, other measures are to be considered and more stringent measures shall be applicable.

City Gas Distribution System

The city gas distribution network shall receive gas from DRS at a pressure of 4 bars for onward distribution to domestic and commercial consumers. The distribution system shall comprise of:

- District Regulating Station
- MDPE pipe network
- GI pipe network
- Office-cum-Control Room for operation and maintenance.

2.2.4.5 SECTIONIZATION

The Sectionalizing Valve station shall have following features:

- Sectionalizing valve
- Tap-Off on upstream
- Cold Venting facility

The purpose of sectionalizing of mains by the valves to:

- Isolate a section for works

- Isolate a section in case of up-set
- Depressurize the isolated section through safe venting
- Ensure the safety of the system

It can be manually operated or by remote operated. There will be some critical valve which will be remotely operated in case of suddenly accident.

The location and number of sectionalizing valve will be defines by network design and analysis.

Mainline valves shall be installed to isolate sections of pipe for safety reasons and maintenance and repair.

For mainline valve stations installed at specified intervals along the pipeline, the cost of facilities can be specified as a lump sum figure that includes

- Mainline valve and operator
- Blow down valves and piping
- Other pipe and fittings that constitute the entire block valve installation

2.2.5 STATIONS

The stations of distribution plan are bifurcated by the interface pressure levels. This section describes the purpose and different component of the stations located at a pressure level interface is tabulated below:

Station	Interface between
The city gate	HP and MPS
The district pressure reducing station	MPS and MPP
The service connection	Network and end user pressure

2.2.5.1 CITY GATE STATION (CGS)

The proposed CGS to be installed at ISBT in Dehradun city shall have a designed capacity of 0.4MMSCMD and deliver an outlet pressure of 19 kg/cm2 (g).

The city Gate Station shall have following major facilities:

- Gas actuated Isolation Valve
- Cartridge Filters
- Pressure regulators
- Slam Shut Valve
- Mass Flow Meter
- Flow Control Valve with by-pass valve
- Pressure Safety Valve
- Control Room with UPS, Battery Bank, Control Panel and SCADA provision.

Two Cartridge filters (1 working + 1 standby) shall be provided to remove all the dust and foreign particles larger than 5 micron size.

One pressure regulator in each stream with one Slam shut valve upstream of regulator is provided to regulate the gas pressure so that the gas supply to main grid line remains constant. The regulators are fall open type and Gas actuated. High and low indications are also provided to indicate malfunction of regulators. In the event of high pressure at downstream of pressure regulator, the upstream slam shut valve closes with an alarm for closure. The set pressure of slam shut valve shall be kept slightly higher than set pressure of Pressure control valve. The set pressure of standby Regulator shall be kept slightly higher than set pressure of the operating Regulator. The stand by Regulator is closed under normal operation and becomes operative automatically in the event of failure of the operating Regulator.

Mass flow meter of Turbine type will be provided to measure mass flow rate. Flow, temperature, pressure and density shall be telemeter through SCADA.

The selection criteria for metering system will be:

- Accuracy and reliability of the device.

- Range of flow rate – maximum and minimum
- Range of flow temperature and pressure
- Maintenance requirement
- Expected life of the device, and its initial and operating cost.

One number Flow control valve with bypass arrangement shall be provided. The function of flow control valve is to regulate gas flow requirement of the main grid line.
Provision is be made for safe flow down of gas in to the atmosphere through QOEC. A vent pipe of minimum 3 m height above ground and located at a suitable safe distance from the valve assembly is provided.

Cathodic Protection (CP) System

For efficient and satisfactory functioning of the main grid line system, both from safety and economic point of view, the pipeline must be protected against corrosion.

External protection shall be provided for prevention of pipeline corrosion. This external protection shall be a combination of corrosion coating and cathodic protection techniques. Conventional coating of pipelines by 3 layer Polyethylene (PE) coating is used as "passive" protection.

Complete corrosion protection cannot be achieved practically by coating, as it is impossible to fully avoid minor defects such as pores or cracks in the coating. Welded pipelines are particularly subject to corrosion at coating holidays because of their low longitudinal resistance, i.e., they practically do not resist the flow of current through the pipeline. At these holidays, dangerous pitting corrosion is initiated. Because of the high corrosion current density, this phenomenon often causes rapid corrosion failure.

Cathodic protection is a method for protecting the pipe reliably even at undetected coating holidays. The protective current supplied electrons to the structure to be protected.

Based on the experience and other relevant data as well as indigenous availability, PE coating shall be provided as external corrosion coating for the pipeline.

Salient features of the CP system proposed for Feeder Line/Main Grid Line are described as follows:

The proposed main grid line shall be catholically protected by an impressed current CP system as a permanent facility.

- Necessary measures shall be adopted to mitigate stray current interference due to the nearby electrified railway track and the interference along the proposed line and the existing lines (protected and unprotected that may exist in and around the ROW).
- Temporary Cathodic Protection (TCP) shall be provided during construction phase of the proposed line by suitable means.
- All the cased road crossings shall be provided with proper insulating separators, end seals and vent pipes. The casings shall be coated. Carrier portions inside the casings shall be independently protected by sacrificial anodes, wherever necessary.
- Minor crossings need not be insulated but extra care in their protection shall be exercised.
- For monitoring purposes, test stations shall be installed at approximately 1 km interval. In addition, test points shall be provided at all crossings and near insulating joints. Central monitoring station shall be located at the CGS through a Remote Terminal Unit (RTU).
- Interference effects, wherever suspected or observed shall be duly investigated and remedial measures provided, wherever necessary.
- Insulating joints shall be provided on the proposed line at all necessary locations where electrical insulation is desirable such as at CGS and DRS. The grounding cells will also be installed at each location.

SCADA System

SCADA System shall be provided to ensure effective and reliable control, management and supervision of the pipeline from a centralized location using remote terminal units (RTUs) located along the pipeline at suitable locations.

- The pipeline is monitored and controlled from central SCADA System Control centre located at the CGS.

- The cost of SCADA facilities range from $2 to $5 million or more depending on pipeline length, number of compressor stations and number of mainline valves and meter stations.
- It is also estimated as the percentage of the total project cost, such as 2 to 5 %
- The SCADA System Control Centre shall be inter-locked through fibre optics cable with remote terminal units (RTUs) located along pipeline. RTUs will be used for scanning and telemetering of pipeline parameters such gas flow, temperature, pressure, valves status, CP parameters, etc., to update the computer data.

Odorization:

The natural gas in the existing HBJ pipeline is unodourised and therefore it will be necessary to install odorizing plants. The odourisation shall be done at the flow rate of 15 ppm. The odorant usually consists of sulpher based chemical compounds and ethyl mercaptan.

PHYSICAL DATA

PHYSICAL STATE	LIQUID
ODOUR AND APPEARANCE	WATER WHITE LIQUID, GASSY OR MERCAPTAN ODOUR
ODOUR THRESHOLD	0.4 PPM
SPECIFIC GRAVITY/DENSITY (G/ML)	0.839 @ 20°C
VAPOUR PRESSURE:	535 HPA @ 20°C CALCULATED
VAPOUR DENSITY (AIR=1)	2.1
VOLATILITY/VOL(%)	100
SOLUBILITY IN H20	6.8 G/L @ 20°C
EVAPORATION RATE	NE
BOILING POINT	35°C
FREEZING POINT	-148°C

FIRE AND EXPLOSION HAZARD

FLAMMABILITY	EXTREMELY FLAMMABLE
CONDITIONS	HEAT, SPARKS, OPEN FLAME
MEANS OF EXTINCTION	WATER SPRAY, CARBON DIOXIDE, FOAM, DRY CHEMICAL
FLASHPOINT	-54°C (CC)
UPPER EXPLOSION LIMIT (% V)	18
LOWER EXPLOSION LIMIT (%V)	2.8
AUTO-IGNITION TEMPERATURE	300°C (572°F)
HAZARDOUS COMBUSTION PRODUCTS	OXIDES OF CARBON, SULFUR OXIDES
EXPLOSION DATA	NE

2.2.5.2 PRESSURE REDUCTION STATION

The pressure reducing stations interfaces MPS with MPP pressure network.

The main component of pressure reduction station are;

- Inlet service operating valve
- The purpose of this valve is to isolate the station from upstream. This valve is manually operated. It is not control and monitor by installed SCADA system.
- Filtration
- Pressure control system
- At this station, along with the active regulator there must be pressure safety device (non venting type).
- Outer header

The pressure reduction station control the flow of gas to the distribution network after reducing the pressure to suit the MDPE Pipe. The DRS work as pressure reducing facility with all relevant precautions as per prevailing codes & standards. It is designed to bring down the pressure from 19 kg/cm2 (g) to 3- 4 kg/cm2 (g).

The pressure reduction station broadly comprise of:

- Pressure reduction
- Cold venting facility
- Filter separator at the inlet of each run of the pressure reduction assembly.

2.2.6 SERVICE CONNECTION:

It is the interface between MPP and MDPE operated at 4bar(g) and the gas end user.

1. Residential connection

The consumer whose desired flow rate is lower than 10 SCM/H will be connecting through MDPE pipes from a designated DRS. The residential Meters shall also be of diaphragm type (designated as diaphragm meters).

2. Commercial connection

Connection applies to that customer whose demanded flow rate is 10SCMH.The turbine flow meter will be used for metering of flow rate of gas.

3. Industrial connection

Based on demand survey the industries along with the gas demand have been identified for providing PNG connections. The PNG supply will be directly through the DRS or through MPS network. For high demand customers, supply of gas will be through the MPS steel network by dedicated MRS.

2.2.7 REGULATIONS, PIPELINES CODES AND STANDARDS

Regulations:

The petroleum Rule 1976:

This is an Act to consolidate and amend the law relating to the import, transport, storage, production, refining and blending of petroleum and natural gas. In this rule it is mendatory that approval of CCE will be require before the construction activities begin.

Factory Act:

The factories act make the occupier of a factory fully responsible for providing and maintaining the plant and the systems of work that are safe and without any risks to the health and safety of the workers and general public.Inspection, testing, examination and certification of equipment and vessels etc. by competent persons approved by CIF. Approval are requires before construction and following to the installation before commissioning.

Highway Authorities:

Approval from highway authorities is required for laying of pipeline crossing the highway.

Pipeline Codes and Standards

a) American Society of Mechanical Engineers (ASME)

ASME B31.8 : Gas Transmission and Distribution Piping System
ASME B16.25: Flanges & Fittings with Butt Welded Ends
ASME B16.9 : Factory – Made Wrought Iron Steel Butt-Welding Fittings
ASME B31.3 : Process Piping

b) **American Petroleum Institute (API)**

API Spec 5L : Specification for Line Pipe

API RP 1102 : Recommended Practice for Liquid Petroleum Pipelines Crossing Railroads and Highways

API Std 1104 : Standard for Welding Pipeline and Related Facilities

API RP 1110 : Recommended Practice for the Pressure Testing of Liquid Petroleum Pipelines

c) **Buearеu of Indian standards.**

IS 14885: Specification for manufacture of Polyethylene pipes

IS 1239 (Part-I): Specification for manufacture of Carbon Steel Pipe.

IS 1239 (Part-II) : Specification for manufacture of carbon Steel Fittings.

2.2.8 SYSTEM PLANNING ASSUMPTIONS

The gas which is available by GAIL for the city gas distribution network will be generally above 30 bar (g). This high pressure shall be regulated to a medium pressure of 26-19 bar (g) at City Gate Station (CGS). The gas would be transported from the tap off point on GAIL's main network to the CGS through an underground steel pipeline. This CGS will also serve the purpose of custody transfer of gas from gas Transmission Company to gas Distribution Company.

The downstream pressure of the CGS will be in the range of 19-26 bar (g). The odorants before distribution shall be add at CGS.

The gas supply to major industrial customers will be directly from the primary steel pipeline networks. From here, the gas is taken through industrial pressure reduction station (IPRS) or district pressure reduction station (DPRS) based on the nature of downstream demand profile. As the pressure above 4 bar makes it an unsafe pressure for direct reticulation to domestic consumers. For the purpose of Piped

Natural gas distribution to Domestic, Commercial & Industrial customers, the medium pressure is further regulated to low pressure of 4 bar (g) though the District Regulating stations (DRS). The distribution network downstream of DRS comprises of Medium Density Polyethylene (MDPE) pipelines network which is laid right up till the customer premises. It is at this point that the 4 bar distribution pressure is further reduced to service pressure of 2 bar-21 mbar based on the customer's requirement of natural gas making it safe to use inside customer premises. MDPE material, apart from having commercial benefits over steel pipeline network also has the advantage in laying in city like conditions. MDPE is also recommended to standardize the distribution system as much as possible. Further, it is proposed to have only three principal distribution pipe sizes of nominal outside diameters of 63 mm, 90 mm and 110 mm. This material is recommended for distribution pressure of up to 4 bar (g); and for the distribution pressure above 4 bar (g) steel pipes of 4" size will be used.

To connect customers, service network is required. These will be installed by fusing a tapping saddle at the top of the distribution main for supply of gas to consumer's premises. At the end of each service, a metal up stand will be installed upon which an isolation valve, regulator and meters will be connected. 21 mbar pressures is recommended for domestic customers, however, pressure for commercial and industrial customers is regulated as per the pressure requirement for that unit. Services are also proposed to be MDPE, with the standard diameters of 20 mm and 32 mm for domestic consumers.

During the detailed design phase of the project, the routes will be refined and selected in detail, to ensure safety, ease of construction and minimal obstruction of other buried services. In addition, during the detailed design the exact location of the CGS and DRS will be nominated, as well as issues such as "Risk Factors with respect to third party system" and "Interruption management".

The principal international standards proposed for the distribution project is ANSI / ASME B 31.8, Gas Transmission and Distribution Piping Systems'. In addition, guidelines specified in the American Gas Association (AGA) publication, Volume III Distribution, Book D-1 'System Design' are adopted.

Three principal design variables are nominated for the safety and reliability of a gas distribution system; these are:

- **Use of a looped or radial system:**
  In this system back feed can be supplied during interruption.

- **Placement of Valves:**

  It is proposed to have approximately one valve buried every 2.5 kilometers of distribution main and at every branch off. It can be use as a isolation valve in case of accident. It is operated from the surface.

- **Layout of services (single and branched):**

  To save on infrastructure cost, it is proposed, where ever practical, to have one gas service to supply up to three domestic customers. This will, however, have a minor negative impact on the reliability of the system, The drawbacks of this system that if the service be interrupted, three customers will be affected simultaneously.

2.2.9 PRELIMINARY INFORMATION USED FOR DESIGN

The information used for design is:

- Market size
- Gas requirement (Domestic ,commercial, industrial)
- Topography of the city
- Future expansion of gas market in proposed city.

2.2.10 SYSTEM FEATURES FOR SUPPLY TO CUSTOMERS

1. Supply Method

By calculating domestic, small commercial and large commercial quantity value the optimum supply method was determine. Other factor that includes location of customer, optimum pressure required. topographical feature and existing supply network was also considered.

2. Supply Facilities

The supply facilities include the following:

- HP pipelines
- MP Steel mains
- MP Distribution
- City Gate / DRS
- Service Connections
- Odourisation Facilities

2.2.11 CONSTRUCTIONAL FEATURES OF CITY GATES, DISTRICT REGULATORS AND DISTRIBUTION PIPELINES

2.2.11.1 CITY GATE STATION

The gas transported by GAIL at city gate station will be at a pressure of 25 to 49 bar. The pressure reduction facility comprises two full capacity Class 300 regulator runs, each having an active /monitor regulator, each fitted with 'slam-shut', protection facilities. The pressure reduction and metering equipment will be fitted on a single self-contained skid-mounted frame. This facility will be provided by GAIL as custody transfer would be their property. The downstream pressure after the pressure regulation shall be a max. of 19 bar.

The supply to the distribution system from the City Gate Station will be at 19 bars. However for large industrial customers, this 19 bar maximum distribution pressure will be dropped to 2 bar in a Class 150 'MRS' which will have a pressure reduction as well as a Metering facility.

2.2.11.2 DISTRICT PRESSURE REGULATING STATIONS

For several small industrial or commercial customers and also for a host of household customers, the gas pressure is dropped in two stages. In the first stage the pressure is dropped to 4 bar in a DRS. The DRS will be similar in design to the City Gate, except that the flow capacity is much smaller and that it does not have a metering facility. It would be on a steel frame with a cabinet design, such that the entire installation can be closed & locked. It shall be installed with a fence around it in an area of 4 M X 5 M. The DRS shall be installed 300 mm above HFL on an RCC platform keeping space for operators to open the doors and carry out maintenance/inspection without locking themselves.

Location - The location of DRS shall be finalized during detailed engineering and project implementation stage. The criterion for location of these stations shall be grouping of customers to achieve optimum utilization of pressure regulation.

Safety - Pressure reducing stations need to be secure from vandalism, vehicle damage and other risks.

Cost - There will be no land cost because it will come under acquisition of right of users land.

Standards - ANSI/ASME B31.8 clause 847.2

Current Practice - At the side of lane/road

Design Basis - Pressure reducing stations will be installed on the paved area, side of lane in a metallic lockable cubical. Stations will be unmanned but contain security alarms to detect tampering.

Pressure Regime:

CGS Outlet - Outlet pressure will be 19 Bar.

District Pressure Reducing Stations Inlet - Minimum inlet pressure to individual Pressure reducing stations will be 19 to 4 bar.

District Pressure Reducing Stations Outlet - Outlet pressure of the pressure reducing stations will be 1 to 4 bar for the distribution system.

Over Pressure Protection

Safety - A monitor regulator will be provided down stream of control valve.

Current Practices - Required by code

Design Basis - To avoid venting of natural gas to the atmosphere over-pressure protection will be via monitor regulators. Only token relief valves will be installed. This approach is both safe, environmentally friendly and does not result in undue concern from the public in the event of over-pressure.

2.2.11.3 DISTRIBUTION PIPELINES

STEEL PIPELINES

The Steel Grid pipeline sizes shall be restricted to 6"NB, 4"NB & 2"NB whereas, spur lines shall be of 2"NB & 1"NB.

PIPES

It is proposed that the steel grid is of Electrically welded/seamless steel pipes. The coating is proposed to be extruded polyethylene, with each weld joint coated with either heat shrink sleeves or polyethylene tapes of equivalent properties.

SALIENT QUALITY CHECKS DURING CONSTRUCTION

Prior to the pipelines being put into service, the steel pipeline legs would be non-destructively tested by two methods. Firstly, welds would be 100% radio-graphed and, secondly, the completed pipeline sections would be hydro-statically tested at a higher pressure than its operating pressure (at least 1.4 times higher).

After hydrostatic testing, the pipeline would be dried, purged and filled with natural gas. The testing and commissioning procedures will be detailed during the detailed design phase of the project. To protect the pipeline from corrosion, a cathodic protection (CP) system of impressed current is proposed. During the detailed design phase, the CP capability of the existing transmission system will be investigated to establish if it has the capacity to provide CP to the extension. If it is found that the existing system does not have the capacity, additional CP facilities will be designed.

The steel pipeline grid is proposed to be installed at a minimum depth of 1.0 meter cover, and in accordance with Indian Standards requirements.

2.2.11.4 PE PIPELINES

The sizes of PE pipes are standardized to three typical outside diameter sizes of DN63, DN90 and DN110. The smaller number of pipe sizes for distribution systems will reduce the level of

inventory and minimize the capital and operational cost. Laying pipe sizes larger than DN110, was shown not to be economical viable, when compared to steel pipes. The cost saving of laying PE pipes smaller than DN63 is minimal but-the capacity of the distribution system is reduced substantially.

To standardize the distribution system, it is proposed to install only three sizes of OD pipes - 63mm, 90 mm and 110 mm. It is proposed that all pipe joining is by electro-fusion couplings. The distribution pipe is proposed to be Standard Dimension Ratio (SDR) 11 up to 63 mm & (SDR) 17.6 for above 63 mm. The term SDR is defined as the normal outside diameter (DN) divided by the minimum wall thickness.

It is standard practice in India to have a minimum 1.0 meter cover. This additional depth in a densely populated area would be recommended. All MDPE pipe should be back filled with sand around it to protect the plastic material.

Emphasis will be placed on utilizing modern construction techniques to install the distribution system in line with international trends.

This will include, wherever possible, avoiding disruption/ damage to roads and footpaths, by boring and drilling. Large crossings, such as canals, rivers and other long distance crossings will be installed using Horizontal Directional Drilling (HDD).

Project will have valves on the distribution and transmission networks after every 1.5-2.5 km's distance at strategic locations to ensure security of supply. The key features of the PE network will be:

- All PE pipes being padded with soft soil.
- All PE pipe joints being electro-fusion couplings.
- Cover of 1 meter.
- 25% of pipe being in the roadway, 75% in nature strips.

- 100 m coils for DN 63 and DN 90 and 12 meter pipe lengths for DN 110 pipe, with allowance for 450 and 900 bends and equal tees.

To ensure system integrity and safety, prior to commissioning, the MDPE pipes will be air tested for 24 hours.

2.2.11.5 DISTRIBUTION SERVICES

Distribution services are used to connect customers from the mains. As most services must cross roads /footpaths, to reach the customers, they are often installed by boring, to reduce reinstatement costs. Open excavation is then only needed at the connection to the main and at the service. Where open excavation has taken place, Marker tape is installed.
To standardize materials, it was assumed that 20 mm services will be used to supply domestic consumers, 32 mm services for small and large commercial consumers.

2.2.11.6 BACKFILLING & RESTORATION

Safety: Initial backfilling shall be done in 300mm layer, taking precautions that no stones or boulders will impact or damage the pipe.

Cost: Already excavated material is used for back filling, unless soil conditions make this impractical, then imported material will be used.

Standards: API - 1102, Clause 4.62
Current Practice: As above

Design basis: We will use 20 bar as regulated at CGS.

Back filling shall be done as above practice and area shall be dressed in with the existing level. The restoration of any disturbed works including asphalt and concrete road surfaces shall also be done. This shall include all the work necessary to remove surplus material from the work site, permanently repair or replace fences, shrubs, buildings, or other obstructions disturbed by the pipe laying process.

2.2.11.7 INSTALLATION FEATURES

Safety: Piping will carry flammable gas and hence it is much safer to lay underground, away from sources of ignition. This will also give protection from physical damage and ultra-violet radiation to MDPE pipe. However, limited piping within the gate station for custody transfer and flow measuring instruments will be above ground. Piping with in CNG service stations will be either above ground or in trenches.

Standards: As per Explosive Rule 1976 (clause no. 92.2) pipe lines shall be laid below the ground level except when laying them above the ground level as desirable for topographical, economic or other special reasons. '

Current Practice: Current practice is to provide underground pipelines. Minimum depth of cover shall be as per OISD-141 clause 13.4 varying from 1.0 M to 1.5 M depending upon location of the pipeline.

Design Basis: The proposed distribution system shall consist of primarily of underground piping.

Installation may be completed by the following methods.

- Trenching
- Trench less
- Auguring

- Plowing
- Boring
- Directional Drilling

2.2.11.8 SERVICE LINES

To facilitate access for meter reading and operating functions meter sets will be located at the property boundary. If there is no boundary wall meter sets may be located at the building wall.

PE JOINTING PROCEDURES

Safety: MDPE joints shall be done either by butt fusion, electro-fusion or by socket fusion. The use of long sections of coiled PE pipe will reduce the number of joints.

Cost: Electro-fusion fittings can add significant expense.

Standards: ANSI/ASME B31.8 clause 805.131.

Current Practice: Butt fusion/electro-fusion/socket fusion.

Design Basis: Butt fusion for 60mm and above / socket fusion for 40mm and below. Electro-fusion may be used for tight tie-in situations.

LINE MARKERS

Safety: Line markers shall be put at suitable distances for HP Line only to identify the locations of underground pipes to other agencies before laying their pipes as well as to locate the pipes for future maintenance/repair.

Cost: This is costlier, but for safety purposes it is required.

Standards: ANSI/ASME B31.8 Clause 851.7

Current Practice: Line marker provided in underground services at convenient places.

VALVING

Safety: Valves will be provided to sectionalize the grid in case of emergency, or to repair a particular section.

Cost: Valve cost major capital & operating cost factor. Due consideration will be given at the time of model optimization to sue fewer valves.

Standards: ANSI/ASME B31.8 Clause 846.11

Current Practice: Valves are provided.

Design Basis: Valves will be installed for disaster response situation. Emergency response (i.e. broken gas main) as well as operating and maintenance functions will be completed using other methods of gas flow control including use of stopple equipment and/or squeeze tools.

With the exception of valves installed in stations all valves will be underground. All underground valves will be welded or fused. No mechanical joints will be used. Above ground valves will be weld end, flanged or for smaller sizes screwed.

For reasons of economy and ease of maintenance all valves will be manually operated.

STREAM / RIVER CROSSINGS

Safety: Additional depth of cover and extra thickness will be provided for safety reasons.

Standards: OISD 141 standard clause 13.10

Current Practice: Under stream/river with extra thickness

Design Basis: All stream and river crossings are to be underground. Installation may be via trenched or trench less methods providing environmental protection and safety.

2.2.11.9 ODORIZING FACILITIES

It is good practice to have the natural gas odorized to ensure a safe natural gas distribution system. The natural gas in the GAIL pipeline will be un-odorized and therefore it is necessary to install odorizing plant at the City Gate Station.

Odorant is usually sulphur based chemical compound and project shall use a single odorant called tetra-hydro-thiophane (THT). THT is added to the outlet of the City Gate station, at a concentration of 16 milligrams per cubic meter of natural gas for effective & safe odorization.
It is proposed that the combination of two odourants (30% THT and 70% Tera butyl mercaptan (TBM) provides a better odor impact than a single odorant, especially if there is substantial background odor such as in a mildly polluted environment.

When THT /TBM are used as a combined odorant, a concentration of only 5 milligrams per cubic meter of natural gas is required.

A single odorizing plant at the City Gate Station, upstream of the distribution system, is preferable. Because odorant compounds are dangerous organic chemicals and highly flammable, a reduced number of odorant plants will provide a safer environment and is more cost effective. Odorant sulphur compounds cannot harm a natural gas transmission or steel

distribution system because highly/elevated temperatures are required to convert the compounds into sulphur acid.

2.2.11.10 CATHODIC PROTECTION

Safety: All equipment for cathodic protection coming along the grid will be fenced all around for safety and security reasons.

Cost: Installation and operation cost will be low, at the same time life span of steel pipe will definitely be increased tremendously.

Standards: ANSI/ASME B31.8 Clause 862.4

Current Practice: Cathodic protection is provided all along the steel pipe.

Design Basis: All underground steel piping as well as the tracer wire installed with the PE pipe will be cathodically protected. Cathodic Protection will be provided by an impressed current system to be designed to accommodate effects of inductive currents and ground fault conditions from adjacent High Voltage AC power lines. The impressed current systems will include a rectifier for the DC power source and shallow anode ground beds. The status of protection will be monitored by use of test stations installed at certain intervals to measure the pipe-to-soil potentials along the pipeline. These distance intervals depending on the local climate, soil conditions and the depth of cover for the pipeline system. The stations shall be easily accessible (i.e. adjacent to roads), if possible. Insulating flanges shall be installed at station limits of this Project.

2.2.11.11 PRESSURE REGULATORS

A distribution pressure of 4 bar requires pressure regulation be installed at each meter set to reduce the pressure delivered to the consumer to between 20 and 70mbar. As per ANSI/ASME B31.8, a single

regulator is acceptable for this purpose. If, however, a distribution pressure of exceeds 4 bar, ANSI/ASME B31.8 requires additional overpressure protection such as is provided via two pressure regulators at each meter set. Hence increasing the distribution pressure above 4 bar increases the cost of each meter set. As a distribution pressure of 4 bar has been selected for the feasibility study a single regulator is considered adequate for the Design Basis.

VALVES

With the exception of valves installed in pressure reducing stations all valves will be underground. All underground valves will be either welded or fused; no mechanical joints will be used. Above ground valves will be weld end, flanged or for smaller sizes screwed. Pressure Reducing Station valve will be nonlubricated ball valves. For reasons of economy and ease of maintenance all valves except some identified sectionalizing valves, will be manually operated.

Continuity of Supply

Parallel second runs will be installed to provide 100% redundant capacity in critical stations for emergency or for maintenance purposes.

CHAPTER 3

GAS DISTRIBUTION PLAN FOR DEHRADUN CITY

The objective of the proposed project to provide natural gas to domestic, commercial and industrial customers in the form of PNG and CNG through pipeline networking and compressors. The project aims is to cover the maximum potentially rich area of the city. The distribution network would include

- Tap off point (GAIL transmission pipeline)
- Sub transmission pipeline(Sub-transmission pipeline)
- City gate station
- Downstream pipeline network which include steel, MDPE and PE pipeline.
- District regulating station
- Industrial metering and regulating station(IMRS)

The natural gas would come to CGS through underground GAIL sub transmission pipeline at the pressure of 25 – 49 bar(g).

After entering city gate station, the pressure would be reduced to about 19 bar (g).

The odorants are added to the natural gas before distribution. The gas at 19 bar(g) would go to the primary steel pipeline from there according to the demand profile the gas would be send to the IPRS and DRS. Location of DRS near the group of small industries helps in consolidating the smaller demand of individual units. After pressure reduction upto 4 bar (g), the gas would be fed into secondary pipeline system. In case of high demand of gas in industries IPRS would be installed with metering facility.

A detailed route survey was prepared by taking special consideration of sewage line, railway lines, rivers, canals. Customer survey for different scope of distribution of natural gas was studied in the initial phase of the project.

3.1 CITY GATE STATION

After detailed survey the best place for CGS was selected near ISBT. The CGS would get the gas from GAIL sub transmission pipeline with a pressure reduction system, a filtering unit, pigging and odorant injection facilities.

The specification of the filtering unit would be

- Removal of partial upto 3 micron size
- Have efficiency of 99.9%

The filtering unit would be incorporated with a borosilicate fiber glass cartridge and a manual drainage valve to remove the entrained particle.

3.2 PIPELINE NETWORK:

The pipeline network would be divided in two categories

- Primary network
- Secondary network

The primary steel pipeline network would connects CGS to various MRS and DRS with the operating pressure of 19 -4 bar(g). For supply of natural gas at this high pressure would be by MRS.
The secondary network operates at the pressure range of 4- 1 bar(g). It is of MDPE pipeline network designed to service the Gas to group of industries at low pressure.
By taking the future demand of gas, both the network is designed at 33% more than the estimated amount of gas.

3.3 METERING AND PRESSURE REGULATION STATION

The supply of gas at high pressure would be facilitates by MRS. The MRS would be installed neal the group of industry with auxiliaries like pressure reduction system, a filtering unit, a metering system, valves etc.

3.4 DISTRICT REGULATION STATION

The supply of gas to group of industry would be done by DRS. DRS will serve the industrial area as well as various demand centre for domestic and commercial segment.
The main components of DRS are filtering unit, orifice metering system, drainage system, pressure reduction system. The filtering capacity would be same as MRS.

3.5 CIVIL

Civil structure are to be the constructed at CGS and CNG stations. This will provide shelter to man. machinery, various activities and processes. Control room, office, fire, protection, pump room, generator room, stores, roads etc are to be the constructed at CGS.

In CNG station various civil works include foundation for compressor, cascade, engine, shelter for dispenser, office building etc.

Fencing of CGS and CNG station will have boundary with fencing.

3.6 CATHODIC PROTECTION

For efficient and satisfactory functioning of the main grid line system, both from safety and economic point of view, the pipeline must be protected against corrosion.

External protection shall be provided for prevention of pipeline corrosion. This external protection shall be combination of corrosion coating and cathodic protection technique. Conventional coating of pipelines by 3-layer polyethylene/FBE coating shall be used as "passive" protection.

Complete corrosion protection can't be achieved practically by coating, as it is impossible to avoid fully minor defects such as pores or cracks in the coating. Welded pipelines are particularly subjected to corrosion at coating holidays because of their low longitudinal resistance, i.e, they practically don't resist the flow of current through the pipelines. At these holidays, dangerous pitting corrosion is initiated. Because of the high corrosion current density, this phenomenon often causes rapid corrosion failure.

Cathodic protection is a method for protecting the pipes reliably even at undetected coating holidays. The protective current supplies electron to the structure to be protected.

CHAPTER 4

DESIGN CONSIDERATION OF THE NETWORKING SYSTEM

4.1 DESIGN CONSIDERATION OF METER REGULATING STATION

All the Industrial and large commercial customers is connected either to the steel main grid line or to the nearby DRS through a Meter Regulating Stations (MRS) which shall be installed within the premises of Industrial / Large commercials. The nos. and capacities of these MRS is selected based on the requirement of the industrial and large commercial consumers as per demand survey.

MRS comprises of

- Filtration
- pressure reducing, and
- metering with volume corrector

Filtration unit (with Cartridge Filter) is provided to filter the gas. Pressure Reducing Unit shall be provided to reduce the gas pressure to 2-3 kg/cm^2 (g). Slam Shut-off Valve and Pressure Safety Valves shall also be provided as per guidelines stipulated in OISD 220. Metering shall be in terms of volume as the billing to the consumers is on SCM basis. Thus the type of meters recommended for this purpose is either Turbine Meter (for large flow) or RPD Meter (for small flow).

4.2 DESIGN CONSIDERATION OF COMMERCIAL METER & REGULATOR ASSEMBLY.

The small & medium commercial consumers through MDPE pipes from a designated DRS. In the DRS the Gas outlet pressure shall be regulated to 3- 4 Kg/cm2(g) and then it will be supplied through MDPE pipes to the Meter / regulating assembly. In the Meter / regulating assembly the inlet pressure of the PNG shall be reduced to 300 mille-bars (0.3 bar).

The Meter / regulating assembly shall broadly comprise of:

- Pressure reduction
- Metering

Commercial Meters for these medium and small commercial consumers shall be of diaphragm type (designated as diaphragm meters).

Conventional metering type includes:

Type of customer	Metering system	Capacity
Domestic and Commercial	Diaphragm	0 – 23 SCMH/Customer
Medium to large Commercial	Rotary	0 – 750 SCMH/Customer
Very large industrial customers	Turbine	1100 – 2800 SCMH/Customer

The location selection of metering system will be finalize on the basis of;

- Ease of access for meter reading and maintenance
- Negligible hazardous position
- Clear of all type of crowd
- Aesthetics and noise
- Clear of down pipes for roof space and dripping water

MDPE PIPE FROM DRS UP TO THE CUSTOMER'S PREMISES

For domestic, commercial and small Industrial consumers it is recommended that low pressure [4 kg/cm2 (g)] underground MDPE network shall be provided for safety reasons, as it is safe for inhabited areas, easy to lay and economical. The MDPE pipes shall be tested as per procedure laid down in IS 14885. The pipeline shall have 180mm, 125mm, 63mm, 32mm and 20mm diameter pipes (as detailed in the table below) used to form the complete distribution reticulation system.

Material Grade	Normal Outside Diameter (mm)	SDR	Minimum Wall Thickness (mm)
PE-80	20	11.0	3.0
PE-80	32	11.0	3.0
PE-80	63	11.0	5.8
PE-80	125	11.0	11.4
PE-80	180	11.0	16.4

(SDR – quotient of the nominal outside diameter and the nominal wall thickness).

The system is divided in two broad categories, namely:

- MDPE Distribution Mains
- MDPE / GI Distribution Service

4.3 DESIGN CONSIDERATION FOR MDPE DISTRIBUTION MAINS.

The MDPE Distribution Mains is primarily responsible for carrying the gas to the customers' premises / colonies for further distribution by Distribution Services. Emphasis shall be placed on utilizing

modern construction techniques to install the distribution system. This includes, wherever possible, avoiding disruption/ damage to road and footpaths, by boring and drilling. Large crossings, such as canals, major roads, etc., shall be carried out using Horizontal Directional Drilling (HDD). Valves have been envisaged on the distribution and transmission networks at strategic locations to ensure security of supply (two valves for every 2-km of distribution mains). Plastic protection strips (warning tapes) 300mm above the MDPE pipe are also considered to warn any agency from digging the area well ahead of reaching depth of MDPE pipe.

4.4 Design consideration for MDPE /GI Distribution services.

MDPE / GI / MS Distribution Service pipelines are laid underground to connect customers from the MDPE Distribution Mains up to the customer premises and then laid vertical to rise above the ground level just below the proposed regulator point. The few centimeters 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.

The MDPE pipes required to supply PNG to small industrials, commercials and domestic consumers.

CHAPTER 5
LAYOUT OF CONNECTIONS

5.1 INDUSTRIAL CONNECTIONS

Based on demand survey the industries along with the gas demand have been identified for providing PNG connections.

The gas supply to large number of small and medium size industrial consumers through steel feeder line tapped from the nearest steel grid line.

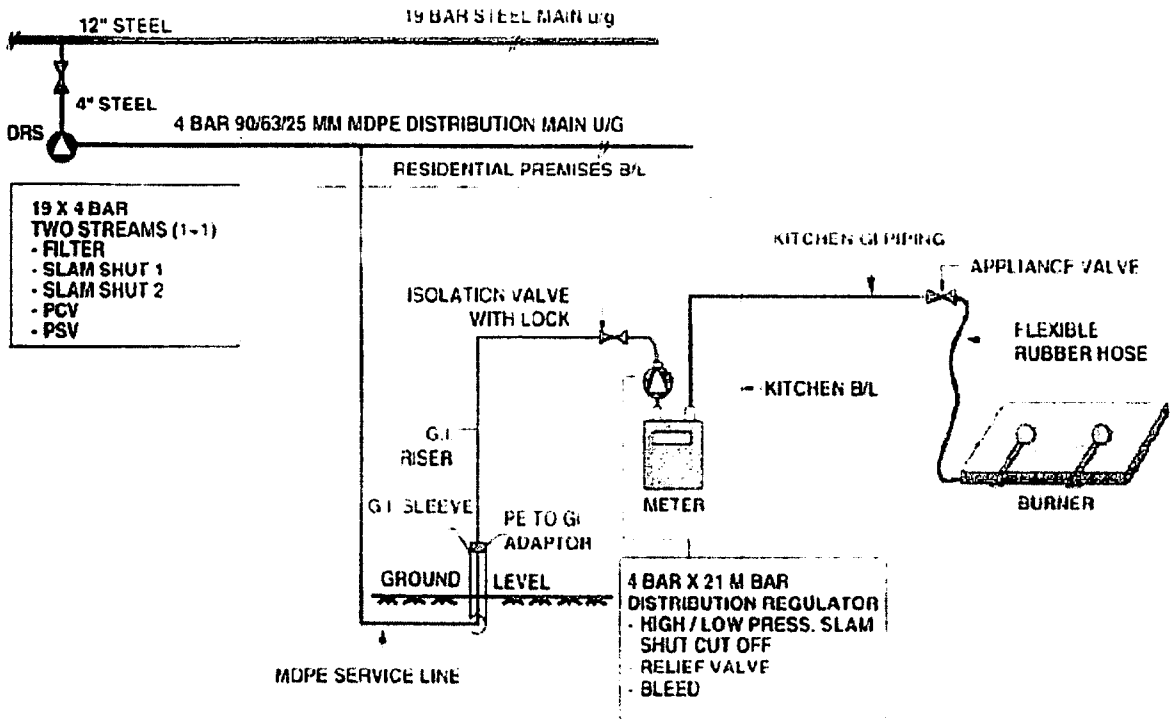
One feeder line may be dedicated to one or more than one industry depending on the geographical location and actual allocation. However, for the purpose of techno-economic analysis, following facilities have been assumed for one industry.

- Steel Feeder line
- Skid mounted Meter Regulating Station (MRS) consisting of
- Cartridge Filter
- Pressure Control Valve (PCV)
- Slam Shut Valve (SSV)
- Pressure Safety Valve (PSV)
- Flow Control Valve (FCV)
- Turbine Meter with Electronic Volume Corrector
- Valves, & Fittings

5.2 DOMESTIC CONNECTION:

In Domestic connections (which comprises the large / medium housing complex) the Gas inlet pressure is regulated from 3- 4 Kg/cm2(g) to 100 milli-bars (0.1 bar) through a service regulator at the entry point to the society / housing complex. It will be further supplied through MDPE and GI pipes to the Kitchen of individual flats with individual meter and regulator assembly. In the Meter / regulator assembly of the individual flats the inlet pressure of the PNG is reduced from 100 mille-bars (0.1 bar)

to 21 mille-bars (0.021 bar). The Domestic Meters shall also be of diaphragm type (designated as diaphragm meters).



The components involved in the DRS / FRS is:

1. Filter
2. Slam shut 1
3. Slam shut 2
4. Pressure Control Valve (PCV)
5. Pressure Shutdown Valve (PSV)

1. **Filter:**

Filter removes the dust particles from the gas which are of 5 to 15 μ in size.

2. **Slam shut 1:**

Slam shut 1 is used to shut the flow if the flow exceeds the designed value. This is active slam shut.

3. **Slam shut 2:**

Slam shut 2 is also used along with the slam shut 1 but this is used to monitor the active one. Even this serves the same purpose as the active one.

4. **Pressure Control Valve:**

Pressure control valve controls the pressure from 19 bar to 4 bar in two stages. The pressure reduction is DRS is done through PCV in two stages.

5. **Pressure Shutdown Valve:**

Pressure Shutdown Valve shutdowns the flow of gas if the pressure exceeds the desired pressure.

The downstream of the regulator contains the following components:

1. Isolation Valve
2. Pressure regulator (4 bar × 21m bar)
3. High / Low pressure, slam shut cut off
4. Relief Valve
5. Bleed and
6. Appliance Valve

5.3 COMMERCIAL CONNECTION

It has already been proposed to connect the small & medium commercial consumers through MDPE pipes from a designated DRS. In the DRS the Gas outlet pressure shall be regulated to 3- 4 Kg/cm2(g) and then it will be supplied through MDPE pipes to the Meter / regulating assembly. In the Meter / regulating assembly the inlet pressure of the PNG shall be reduced to 300 mille-bars (0.3 bar).

The Meter / regulating assembly shall broadly comprise of:

- Pressure reduction
- Metering

Commercial Meters for these medium and small commercial consumers shall be of diaphragm type (designated as diaphragm meters).

CHAPTER 6

COMPRESSED NATURAL GAS

6.1 CNG - THE FUEL OF THE FUTURE

CNG has been widely used in vehicles since the 1930s, in countries that include Argentina, Russia and Italy. It is gaining increasing acceptance, particularly for city transport vehicles such as taxis, buses and delivery trucks due to its relative superiority over other conventional fuels.

6.2 WHAT IS CNG?

CNG is compressed natural gas. It mainly consists of methane (91.9%), with other constituents like ethane, propane and butane. It is an intrinsically pure fuel that emits negligible quantities of pollutants when burnt. Natural gas is compressed to a pressure of 200-250 kg/cm (to be stored in a cylinder) and hence the name Compressed Natural Gas. It is colorless, odorless, non-toxic, non-carcinogenic and lighter than air. CNG is not the same as LPG (Liquefied Petroleum Gas) or LNG (Liquefied Natural Gas). Compressed Natural Gas is a low smoke, low pollution, safe and cheaper (than petrol) fuel. It has been successfully and widely utilized by the transportation sector in developed countries

6.3 WHY NATURAL GAS IN VEHICLES?

- National Benefits of Natural Gas
- Balance of Trade
- Domestic gas cheaper than imported oil
- Imported gas cheaper than imported oil
- Reduced investment in processing plant
- Reduced supply dependency
- Local Benefits of Natural Gas
- Reduced Pollution
- Health costs & loss of productivity
- Crop and building damage

6.4 CNG FUEL CHARACTERISTICS

- Mass of Air Flow required per k.cal of Fuel is practically same for most fuels as well as CNG
- NG provide more energy on mass basis but less on volumetric basis
- NG optimized Engine should be more efficient
- On equivalent Engine Efficiency & Volume of fuel CNG vehicle range will be less (based on volumetric energy)
- Acceleration and Max. Power depends upon fuel vapour density and heating value
- CNG, being lighter density fuel, displace air therefore less air per cycle
- Volume of fuel relative to volume of fuel/air mixture is 9.5 % for methane (CNG) which is high
- Vaporization of fuel increases air density due to cooling (CNG being gas vaporization does not take place)
- CH4 molecule oxidizes with no intermediate HCs results in efficient combustion with low emissions
- Principal pollutant from NG is unburned methane which is less reactive than heavier HCs
- NOx, CO & CO2 emissions are low as methane being low carbon fuel
- SO2 & particulates emissions are low because of vary low sulfur in CNG

TYPICAL FUEL CHARACTERISTIC OF CNG WITH OTHER CONVENTIONAL FUELS

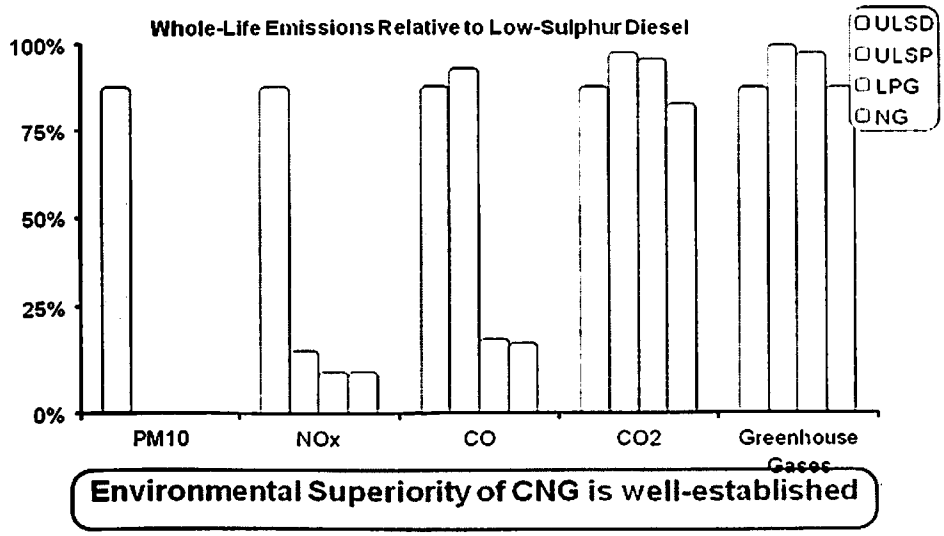
Property	Gasoline	Diesel	CNG	LPG
Storage at STP	Liquid	Liquid	Gas	Liquid at 8 bar
Specific Gravity	0.730	0.84	0.670	0.540
Value (Net) Kcal	10,400	10,200	10,400	10,970
Ignition Temp, C	390	280	640	520
AKI	88	45(CN)	120	104
mability Limits (%	1.4-7.6	0.7-5.0	5.3-14	2.4-9.6
Flame Speed Stoic. A/F	39.6	39.6	33.5	33.5
Composition				
%wt. Carbon	85-88	84-87	75	82
%wt. Hydrogen	12-15	33-16	25	18

CNG as an automotive fuel

- CNG: 80-90 % Methane
- Excellent Knock Resistance
- Clean Burning

- Easy to meter
- Low exhaust emissions
- Low ozone forming potential
- Low Cold-Start Emissions
- Zero Evaporative Emissions
- Reduced Catalyst damage
- Reduced CO2 Emissions
- NG compressed to increase energy
- Density: 200 – 250 bar

NGV: Potential



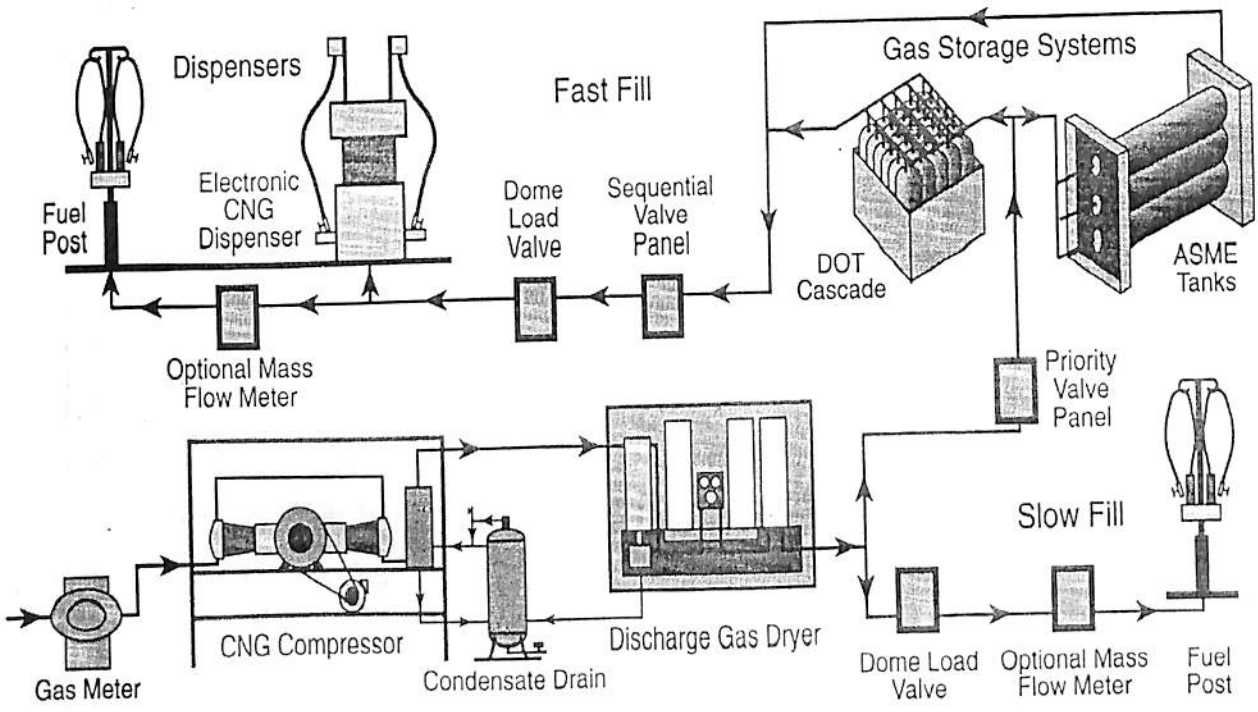
CHAPTER 7

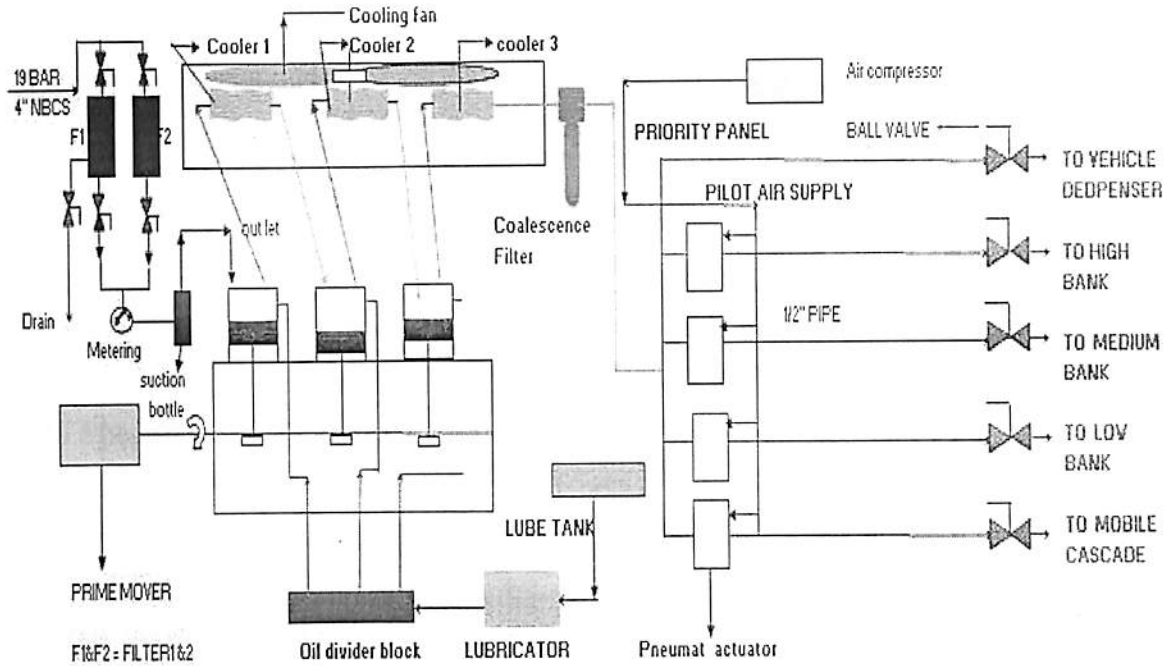
COMPRESSED NATURAL GAS (CNG) STATIONS

7.1 MOTHER STATION

The mother CNG station comprises of several units such as gas conditioning, gas compressor with the priority panel, storage cascade, dispenser and PLC control station. The capacity of Mother Station is high. At the mother station, the no. of compressors is multiples. The no. would be decide according to the demand of the gas.

The following CNG stations are planned in Dehradun city for catering to the demand of automobile sector





P & I DIAGRAM FOR CNG STATION

A. Main Equipment

- Mother Compressor alongwith auxiliaries
- Dispensers for buses
- Dispensers for cars and three-wheelers (autos)
- Loading facility for Mobile Cascades
- Stationary Cascades
- DG Set, UPS & Battery Bank, AVR, Electrical Control Panel
- Instrument Air and Water Facilities
- Metering skid
- Fire Fighting equipment and safety sign

B) Other Facilities

- Office cum Control Room
- RCC forecourt, canopy over dispenser island and signage's
- Stainless steel tube connecting compressor, dispenser & cascades laid in U/G trenches

- U/G drainage and sewerage network
- Approach/exit road, boundary wall etc.

Mother Compressor :

Reciprocating type compressors, each of capacity 1200 SM^3 /hr at suction pressure 19 Kg/cm^2 shall be installed at mother station. Approximate gas consumption of gas engine will be 55 SM^3 /hr. The compressor will start automatically in case cascade pressure falls less than 210 Kg/cm^2 and will unload at pressure 255 Kg/cm^2.

Main Specification/Features

- 3 stage reciprocating type 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, instrument and auxiliaries.
- Gas engine with air and coolant/water based cooling system; gas flow meter with electronic volume corrector, totalize 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 the 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 AS1939. The housing will be flame and fire proof and provided with forced ventilation, flame arrestor, infrared flame detection and alarm system, automatic shutoff, automatic CO2 flooding and other fire retardant features.
- 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 electric supply system.
- The entire compressor system shall be earthed.

Associated Piping

The high pressure pipelines have to be buried in culverts at a deep of at least 0.50 m the welded connections must be located in such a way that it is possible to perform periodic inspections.

Those pipelines that are connected to the dispensing unit must be anchored to the dispenser's base and must have a check valve (to prevent excess flow) near the anchorage point.

All the vent/discharge lines must be realized in special pipeline and delivered in atmosphere in a safe area. The superior extremity of the manifold has to be located at a height not less than 2.50 m from the ground and protected through a flame arrestor device in stainless steel.

From public gas pipeline to the compressor inlet:

- Type: carbon steel API 5LX A 105 – DN 80
- Pressure: maximum 20 bar
- Location: buried in culverts at a deep of at least 0.50 m

From the compressor outlet to the dispensers:

- Type: stainless steel ASTM A 269 TP 316 L – DN 25
- Pressure: maximum 250 bar
- Location: buried in culverts at a deep of at least 0.50 m

Selection criteria of Mother Compressors

Selection criteria for mother station compressor

- uninterrupted power availability in a day,
- a comparative study of the gas engine driven vis-à-vis electric motor driven compressors
- price of electricity unit
- selling price of gas (per kg)

In case of selection of electric motor driven compressors, to cater for running of compressor during power cut a gas engine driven compressor of capacity 1200 SCMH shall be present at mother station.

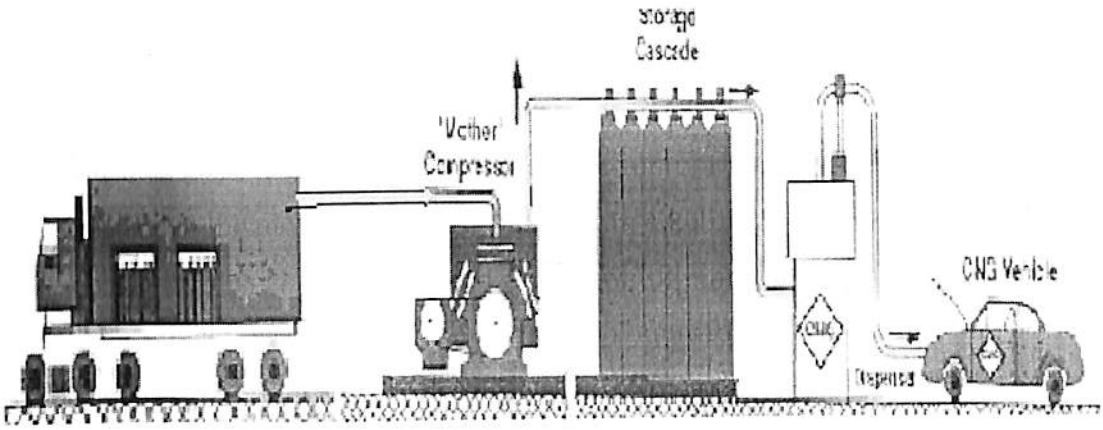
For online stations the DG set shall not be envisaged since these online stations will design for car and auto (3 wheeler) filling only and it will be possible to cater the load (dispensing) from the stationary cascade (of 4500 WL capacity) during the power cut.

7.2 DAUGHTER BOOSTER STATION:

The daughter booster stations are the subsidiary unit of mother station. The supply of natural gas to DBS is through the mother station by mobile cascade filled at the pressure of 200 Kg/Cm^2.

To increase the dispensing speed and reduce waiting time for filling at daughter station and better utilization of cascade capacity, one hydraulic/reciprocating type electric motor driven compressor of capacity 150 SM^3/hr at suction pressure of 30 Kg/cm^2 has been envisaged at daughter station. This booster compressor shall operate at mobile cascade pressure/suction pressure from 30 to 200 Kg/cm^2 with discharge pressure of about 250 Kg/cm^2.

The following units have been envisaged in each Daughter Booster Station:



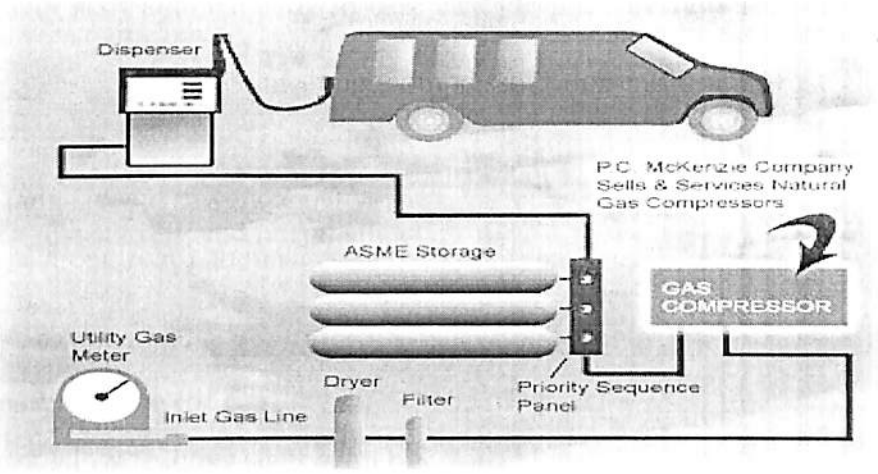
A. Main Equipment

- Booster Compressor alongwith auxiliaries
- Dispensers for cars and three wheelers (autos)
- Stationary Cascades
- DG Set, UPS & Battery Bank, AVR, Electrical Control Panel
- Instrument Air and Water Facilities
- Fire Fighting equipment and safety sign
- Unloading facility from mobile cascades

B. Other Facilities

- Office cum Control Room
- RCC Forecourt, canopy over dispenser island and signages
- Stainless steel tube connecting compressor, dispenser and cascades laid in U/G. trenches
- U/G drainage and sewerage network
- Approach/exit road, boundary wall etc.

7.3 ON LINE STATION



The following units have been envisaged in each On-line station:

A Main Equipment

- On line Compressor alongwith auxiliaries
- Dispensers for cars and three wheelers (autos)
- Stationary Cascades
- Instrument Air and Water Facilities
- Metering skid

- Fire Fighting equipment and safety sign

B Other Facilities

- Office –cum-Control Room
- RCC Forecourt, canopy over dispenser island and signages
- Stainless steel tube connecting compressor, dispenser & cascades laid in U/G. trenches
- U/G drainage and sewerage network
- Approach/exit road, boundary wall etc.

On-line Compressor

Reciprocating type compressors each of capacity 500 SM^3 /hr at suction pressure 19 Kg/cm^2 shall be installed at On-line station. Approximate gas consumption of gas engine will be 30 SM^3/hr. The compressor will start automatically in case cascade pressure falls less than 210 Kg/cm^2 and will unload at pressure 250 Kg/cm^2.

Air receiver and air compressor of suitable capacity shall be provided to meet the compressed air demand for gas engine starting and pneumatic control.

One priority fill system will be provided in the compressor to priorities the dispensing to car dispenser, stationary cascade (of capacity 3000 liters of water).

The packaging and safety features shall be in line with Mother Compressor.

7.4 EQUIPMENT DESCRIPTION

A) Dispensers

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

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 the compressor.

Car Dispenser

To meet the requirement of car and three wheeler filling at mother; on-line and daughter stations, double arm type car/auto dispensers, each with a capacity of 15 Kg/Min have been envisaged. At the Daughter Booster Station, provision shall be kept to install one car dispenser in future.

B) 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 compressor capacity. Compressor will start if pressure in cascade falls below 210 Kg/cm^2 and stop at pressure 255 Kg/cm^2.For a pressure range of 220 Kg/cm^2 to 255 Kg/cm^2, in cascades of 3000 litre and 2200 litre capacity, about 90 kg and 65 kg respectively, of useful CNG can be stored. The maximum storage capacity of these cascades is approx. 600 kg. And 350 kg respectively. The cascade shall supply gas to bus as well as car/auto dispensers.

Main Specification/Features

- Cascade shall be made of group of cylinders fixed with structural steel frame having facility of lifting and placement.
- The cylinder and their neck threading shall be designed as per IS: 7285-1988 & IS: 3224-1979, respectively, and approved by Chief Controller of Explosives (CCOE), government of India.
- The cylinder shutoff valve shall be with fusible disc confirming to requirement of IS: 3224 or CCOE approved.
- All end connections for quick release couplings, PG, valves and fitting of cascade shall be within tamper proof enclosure. These shall be on one side of cascade for ease of operation.

C) Mobile cascade

This cascade of 2200 litre water capacity shall be fitted in, light commercial vehicle (LCV). Three nos. mobile cascades with LCV have been envisaged for each Daughter Booster Station. The mobile cascades will be fitted at Mother Station up to 255 Kg/cm^2 (g) pressure. Mobile cascade at this pressure will be sent to Daughter Booster Station for gas dispensing up to a pressure of 30 kg/cm^2(g). Empty mobile cascade at pressure lower than 30 Kg/cm^2 (g) shall return to Mother Station for refilling. Approximately 335 Kg of gas can be transported from this cascade. The entire assembly shall be CCOE approved.

Suitable loading facility at Mother Station and unloading facility at protection shed.

D) DG Set, UPS & Battery Back-up & AVR

DG Set - To meet the requirement of emergency of emergency power in case of grid power failure, one DG set of capacity 7.5 kW has been envisaged at each station. The DG set shall start automatically in case of grid power failure. Emergency loads shall be connected to DG set.

UPS & Battery Back-up – a one hour UPS and battery back-up system shall be provided at each station.

AVR - A suitable automatic voltage stabilizer based on local supply has been envisaged.

Electrical System - The electrical system shall comprise of conduit work including junction boxes, wiring for lighting and power; fittings and accessories, cables, mains and sub-mains; LT panel, main & sub-distribution panels, capacitor panels; cable trays, GI conduits; earthing system, area lighting, canopy lighting, signage lighting & control room illumination etc.

E) SS Tubing

SS Tubing shall run in underground concrete/masonry trenches for conveying compressed natural gas from compressor to priority panel to dispenser and priority panel to stationary cascade to dispenser. Generally these shall be ¼", ¾" or 1" size tubes of SS 316 grade

F) Water supply & Underground Services

To meet the water requirement at mother stations, water supply network consisting of bore well, vertical pumps, submersible pumps and interconnecting piping has been envisaged.

Two nos. underground RCC water tanks shall be constructed. These tanks shall receive water from municipality and bore well. Water from these tanks shall be pumped to overhead tanks placed at building roof. Two nos. vertical pumps of capacity 2000 to 2500 ltr/hr, head 19 to 26 M, 0.5 HP shall be installed in these RCC tanks.

One bore well of suitable depth and size will be constructed. One submersible pump of capacity 3,000 – 5,000 ltr/hr, head 50-60 meter, approx 2 H.P. shall be installed in the bore well.

Underground drainage, sewerage network comprising of drain pits, drainage pipe, septic tank and soak pit shall be installed apart from municipal connections.

G) Control Room-cum-Office & Other Facilities

This shall be an RCC framed structure of suitable size to house office, control room, electrical room, cash box 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 ceiling has been considered.

- The station shall be enclosed with 2.1 m high boundary wall on three sides.
- The forecourt shall be made of high riding quality RCC pavement with wearing resistant surface.
- The SS tube trenches and drainage shall be covered with heavy duty precast SFRC 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 sum 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 signages using state of art techniques and landscaping.
- The station shall be provided with safety and firefighting equipment, earthling pits and safety instructions.

7.5 SELECTION CRITERIA OF CASCADES

All the stationary cascades in Mother stations shall be of 3000 WL capacity. All Mother stations, daughter booster station and On-line stations shall have as many nos. of stationary cascades as the nos. of compressors. However the stationary cascades in on-line stations shall be of 4500 WL capacity (for large buffer stock) to cater for dispensing during peak load. Further, the priority system in the stationary cascades have been designed and defined for car / auto and bus filling from cascades so as to match the priority system in the Mother / Online compressor.

The capacity of mobile cascade shall be depend on:

- Load at daughter booster station and online station,
- No. of trips.
- Cost effectiveness
- Ease of transportation
- space constraints in the existing ROs proposed for DBS,

CHAPTER 8
ROUTE SELECTION & FACILITY LOCATIONS

8.1 ROUTE SELECTION

Safety: Pipe will be routed on the other side of road and away from the source of ignition and away from other underground services also.

Cost: Shortest route will be selected to minimize the cost.

Standards: OISD 141 standard, clause 13.11 Current Practice as mentioned above

Design Basis: All HP and MP mains are to be installed in the public road right of way except as may be required for specific safety or economic reasons.

Natural gas mains will be installed outside of the actual road structure wherever possible. This will minimize both the costs for restoration (i.e. pavement) and public inconvenience. Crossings and/or conflicts with the location of other utilities will be considered during final route selection.

Construction conditions in typical streets vary from paved wide roads to narrow side streets, depending on age of district.

Accuracy and reliability of foreign utility information (water, sewers, etc.) for older and newer areas of the city, is to be determined.

8.2 ROUTING

8.2.1 Selection of the route:

In consideration of the Environment requirements, construction methodology to be adopted, 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 area.

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 following factors are considered:

- Maximum reach to potential demand centers with minimum length
- Use of existing defined pipeline corridors by respective authorities
- Minimum disturbance to Agricultural land
- Compliance with environmental regulations v Safety of people and property
- Shortest possible route
- Minimum number of Bends
- Favorable ground profile for construction
- Accessibility of the pipeline for the operation and maintenance
- Location of pipeline facility and access thereto
- 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 archeological and sensitive area
- Safe distance from the village

On completion of the above exercise final route is selected for the pipeline network.

8.3 THE PROPOSED ROUTE FOR DEHRADUN

The starting point of the route is the City Gate station. It is proposed to locate the City Gate Station at a location near Clement Town on Dehradun -Delhi Road. GAIL (I) Ltd will deliver gas at the city gate station.

The above optimum route is selected 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

8.4 APPROVALS AND CLEARANCES

For the various major and minor crossings, permissions/clearances shall be obtained from the concerned authority. The broad lists of the approving authorities are as follows:

- PWD / CPWD
- Local Municipal Corporation 3RWA's
- Ministry of Railways
- Ministry of Environment & Forests
- State Pollution Control Board (UPPCB)
- Telephone Department
- National Highway Authority of India
- Jal Board / Water board
- Fire Department
- Chief Controller of Explosives
- Department of Forests / Horticulture

8.5 LOCATION OF STATIONS

City Gate Station:

Convention used:
Location: Near ISBT

Mother Station:

Convention Used:
No. of MS: 3
Location:

1. ISBT
2. Selaqui
3. Vidhansabha

Daughter Booster Station:

Convention Used:
No. of DBS: 6
Location:

1. Ballupur
2. Rajpur Road
3. Telephone Exchange- Patelnagar
4. Raipur Road
5. Prince Chowk
6. Jogiwala

CHAPTER 9

METERING AND METER SETS

8.1 METERING

Metering not only provides a tool for allocation of volumes of gas to various customers. It also provides information required to prepare gas balances and track unaccounted for natural gas. If a natural gas distribution system is installed without metering, billing is done on an estimated allocation method. This approach does not directly encourage equitable energy usage, conservation, or environmental friendly practices. For this reasons for the feasibility study, all custody transfers of natural gas are to be metered.

For the natural gas system One meter per customer will be provided to each Industrial, domestic and commercial user. It is assumed natural gas customers will not be allowed to resell natural gas to others.

Internationally mass meters, sonic meters and compact conventional meters have been introduced. There has also been substantial progress made regarding remote and electronic meter reading. The creation of a new company and installation of an entire new natural gas system is an opportunity to adopt such promising technology. However, the selection of the most appropriate of these technologies for Dehradun would entail a substantial undertaking and may involve some risk for a small and new organization. It is further apparent that such move would be justified only if capital cost or operating saving could be achieved. Hence selecting conventional metering as the basis for the feasibility study allows the study to be completed independent of evaluating other technologies with the knowledge that cost savings may be available if new technology is adopted.

Conventional metering types include:

- Diaphragm - domestic and commercial: 0-23 SCMH/Customers.

- Rotary - medium to large commercial 0-750 SCMH/Customers

- Turbine - very large Industrial customers 1100-2800 SCMH.

Diaphragm meters will be used for residential and small commercial customers. Rotary meters will be used for large commercial customers with a peak hourly load in excess of 23 SCMH. Turbine / Orifice meters will be used for very large Commercial / Industrial customers where there is both a minimum flow rate, and also a high maximum flow rate.

Providing meter set locations and protection shall be the responsibility of the customer. Meter sets will normally be located at the property boundary line inside a meter box. However, even if the meter sets are adjacent to buildings they shall be outside buildings or in a separate room that is sealed against migration of gas. Meter rooms shall have explosion proof electrical fittings.

While locating the gas meter preference will be given to place the meter and its associated equipment in an external location for ease of access, safety, and economy wherever practicable. Access by Gas Company personnel at all times is a requirement. In selecting a mater set location following requirements will be considered:

- Clear access for meter reading and maintenance

- Clear of all hazards

- Clear of walkways, traffic and doorways

- Aesthetics and noise

- Clear of down pipes for eaves and dripping water

In locating the industrial meter sets the nature of customer's process, access restrictions and the maintenance frequency requirements will be considered in addition to the above requirements.

Meters set will be located well clear of any hazards that could cause damage. If there is no suitable location and the meter set is in a potentially hazardous area, the meter set will be protected.

An external meter box providing adequate protection against vandalism and accidental damage will be used whenever it is necessary.

Pressure Factor Measurement (PFM) - to reduce the capital and operating cost of equipment (i.e. electronic or mechanical pressure correctors), pressure factor measurement is to be used. Specifically, regulators that provide very consistent delivery pressures at variable inlet pressure will be installed on these meter sets. When the PFM meters are read for those customers that are provided with natural gas at delivery pressures exceeding 20mbar, the meter reading will be simply corrected for the delivery pressure.

8.2 METERING SYSTEMS

There are several methods, which could be used for metering including orifice plates, turbine meters and ultrasonic meters. Of these methods the orifice plate has been used for many years for fiscal metering of gas and subsequently there is sufficient corrective data available which allows the uncertainty of measurement to be reduced to very small values. For this reason many operating companies prefer them. Project shall also adopt orifice-metering concept. The turbine and ultrasonic meters are relative newcomers for the use in fiscal metering of gas with ultrasonic meter only adopted recently. Both of these meters are costlier and have added disadvantage of needing to be taken out of line for calibration.

The primary function of the metering system is to meter gas entering and exiting the operators' pipeline system for fiscal and operational purposes. The metering information is transferred to SCADA through local RTU and displayed bath locally and in the MCR.

The inlet metering and metering at the MRS feeding single consumer is for fiscal purpose and the overall uncertainty of the metered standard volume flow rate should not exceed +/- 1.0% over the full operating range. All fiscal metering shall have multiple meter runs with a spare to enable

calibrations to be carried out. Each meter run has a dual chamber orifice fitting to allow routine orifice plate inspections.

It should be noted that flow rates may increase with time and that the metering facilities must be capable of meeting the ultimate design rate.

8.2.1 Check Metering

Metering at PRS feeding multiple consumers is for pipeline control and check purpose only and the overall uncertainty of the metered standard volume shouldn't exceed +/- 5% over the full operating range.

8.2.2 Fiscal Metering

The fiscal metering includes all systems for the following activities:

- Sales and allocation measurement gas
- Measurement of fuel and vented gas
- Sampling
- Gas Chromatograph
- The measurement system consists of the following main elements:
- Mechanical elements including flow meter
- Instrumentation

CALCULATIONS

In Distribution of Natural Gas, the project covers two sectors

- Domestic
- Commercial

1. Domestic

Population of Dehradun city = 4,00000

Assume each family has four person (Average)

So, no. of family to whom PNG will be supply = 400000/4

= 100000 family

Assume each family consuming 14.2 Kg of LPG per month

So, LPG consumption = 14.2* 100000

= 1420000 Kg of LPG per month

Corresponding amount of Natural Gas = 1420000 * 1.28

(1 Kg=1.28scm of NG)

= 1817600 scm of Natural Gas per month

=1.817600 MMSCM/Month

= .075 MMSCMD

Economics Analysis of PNG

Assume one family consumes 1LPG cylinder per month = 310/month

Price of PNG = 17/ scm

Consumption of LPG per month = 0.5 * 30

=15 scm/month

So, rate of PNG/month = 15*17

= 255 Rs/month

Saving = 310 – 255

= 55 Rs.

% Save = 55/310

= 17.75% of saving per month

ii) Commercial calculation:-

No. of automobile (3 wheeler) = 800

No. of city bus + cars = 400

The average of 3-wheeler = 20 Km/Litre

Distance cover in a day = 130 Km

So, fuel requirement per day = 130/20

= 6.5 Litre

Total fuel requirement for 3-wheeler

= 6.5 * 800

= 5200 Litre

Energy requirement per day by three wheeler

= 5200 * 8398

= 43.6696 * 10^6 kcal/day

Calculation for 4 wheeler

Assume average of 4 wheeler

= 7 Km/Litre

Average distance covered

= 130 Km

So, fuel requirement

= 130/7

= 18.57 Litre/vehicle

Total, fuel requirement for 4 wheeler

= 18.57*400*8398

= 62.3803*10^6 Kcal/day

So, Total energy requirement

= 43.6696*10^6 + 62.3803*10^6

= 106.0499*10^6 Kcal/day

The energy content of LNG = 5031 Kcal/litre

Therefore, volume of natural gas required

= 106.0499*10^6*600/5031

= 12.6475*10^6

= 12647.57 scm

= .001264757 MMSCM

Combining the commercial and industrial sector requirement, the total natural gas requirement

= 0.023 + 0.012647

= 0.035647 MMSCM

NETWORK ANALYSIS

Gas supply to domestic consumers of SHASTRI NAGAR Colony, Dehradun.

Required quantity of gas:

According to the Municipality report of 2006 total population of the Municipal area of shastrinagar colony is 100653. Now if we consider there are 4 member in a family, so on calculating equivalent domestic consumers that come 25200, and gas required for shastrinagar colony domestic gas grid per day (cubic meter) is 50,400 cubic meter.

Here we have made up a network as per the water pipeline network of shastrinagar colony and solve it for pressure at different nodes with the help of waymouth formula.

Gas consumed by one EDC per day (cubic meter)	**Total number of EDC**	**Total gas required for shastrinagar colony (cubic feet per hour)**
2	**50,000**	**1,00,000**

Here we have reduced the network of water pipeline in shastrinagar colony. On the basis of water pipeline network we can lay the gas pipelines. In this project we have reduced the network of water pipeline in the form of gas pipeline shows by **figure (A)**, which is made only for the main nodes of the pipeline network.

As water pipeline lay in region, same on that we made up the network of gas pipeline. And flow rate in each stream decided by the density of population in between different nodes, as per data given by water office in the form of **table (A)**.

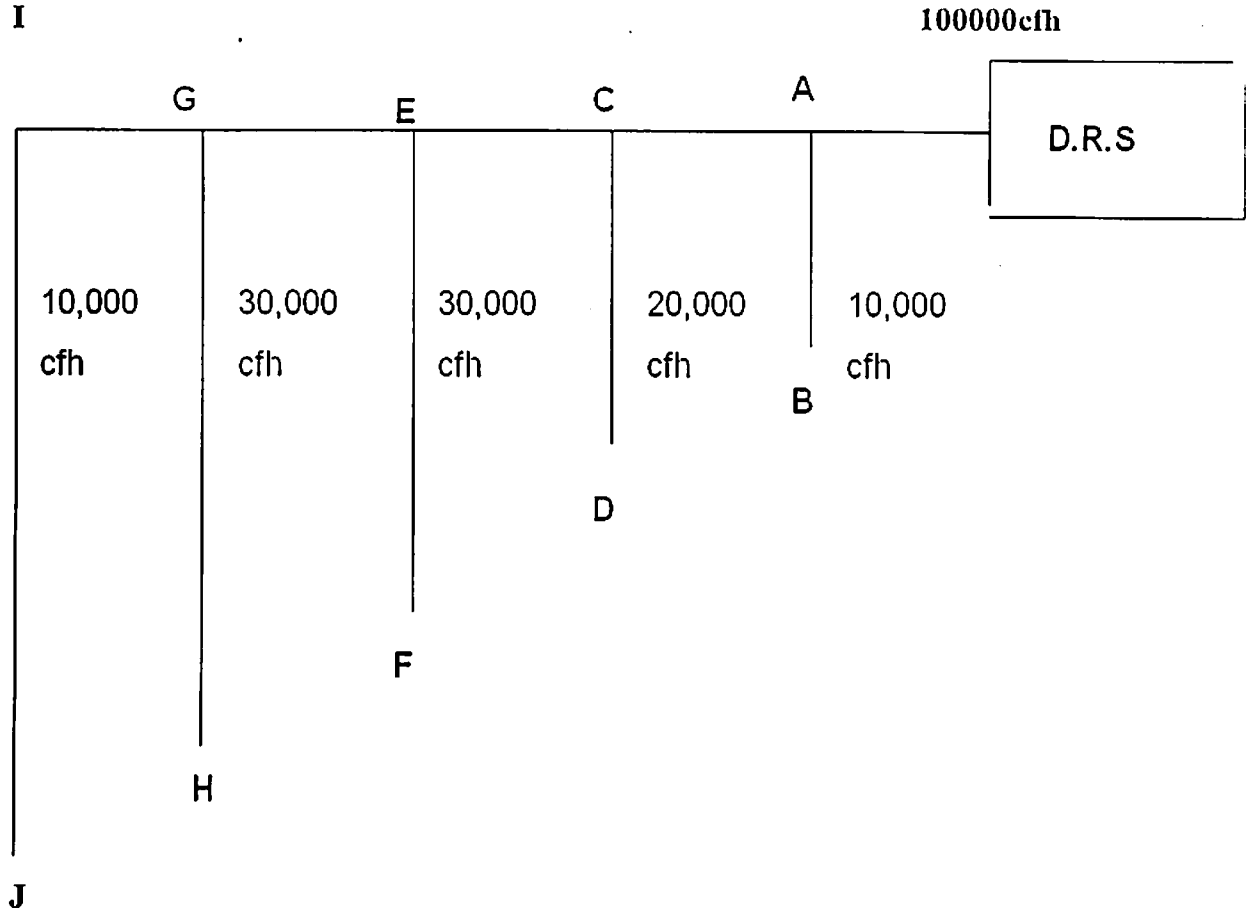


Figure A

TECHNICAL CALCULATIONS

Using waymouth equation

$$q_h = \frac{18.062\ Tb\ [(P_1^2-P_2^2)D^{16/3}]^{1/2}}{Pb[\gamma_g TLz]^{1/2}}$$

q_h = gas flow rate, cfh at P_b and T_b

T_b = base temperature, ^0R

P_b = base pressure, psia

P_1 = inlet pressure, psia

P_2 = outlet pressure, psia

D = inside diameter, inch

γ_g = gas specific gravity

T = average flowing temperature, ^0R

L = length of pipes, miles

Z = gas deviation factor at average flowing temperature and average pressure

Assume data

$T_b = 520^0R$

$P_b = 14.73$ psia

$\gamma_g = 0.64$

$T = 528^0R$

$Z = 0.979$

PRESSURE CALCULATION

Used formula

$$P_1^2 - P_2^2 = \frac{(q_h * Pb)^2 [\gamma_g TLz]}{(18.062 * Tb)^2 D^{16/3}}$$

Pressure points

In between D.R.S. and point A

Initial pressure $P_1 = 4$ kg/cm^2 or 56.92 psia

$q_h = 1{,}00{,}000$ cfh

L = 0.798 miles

$P_1 = 56.92$ psia

$$P_2^2 = 56.92^2 - \frac{(100000 * 14.73)^2 [0.64 * 528 * 0.798 * 0.979]}{(18.062 * 520)^2 (8)^{16/3}}$$

P_2 = 56.04psia

At point C

$q_h = 90{,}000$ cfh

L = 0.944 miles

$P_2 = 56.04$ psia

$$P_3^2 = 56.04^2 - \frac{(90000 * 14.73)^2 [0.64 * 528 * 0.944 * 0.979]}{(18.062 * 520)^2 (8)^{16/3}}$$

P_3 = 55.18psia

At point E

q_h = 70,000 cfh

L = 1.485 miles

P_3 = 55.18 psia

$$P_4^2 = 55.18^2 - \frac{(70000*14.73)^2[0.64*528*1.485*0.979]}{(18.062*520)^2\,(8)^{16/3}}$$

P_4 = 54.35psia

At point G

q_h = 40,000 cfh

L = 1.562 miles

P_4 = 54.35 psia

$$P_5^2 = 54.35^2 - \frac{(40000*14.73)^2[0.64*528*1.562*0.979]}{(18.062*520)^2\,(8)^{16/3}}$$

P_5 = 54.06psia

At point I

q_h = 10,000 cfh

L = 1.60 miles

P_5 = 54.06 psia

$$P_6^2 = 54.06^2 - \frac{(10000*14.73)^2[0.64*528*1.60*0.979]}{(18.062*520)^2\,(8)^{16/3}}$$

P_6 = 54.04psia

At point J

q_h = 10,000 cfh

L = 0.699mile

P_6 = 54.04psia

$$P_7^2 = 54.04^2 - \frac{(10000*14.73)^2[0.64*528*0.699*0.979]}{(18.062*520)^2\,(8)^{16/3}}$$

P_7 = 54.03psia

At point H

q_h = 30,000 cfh

L = 0.205 miles

P_5 = 54.06 psia

$$P_8^2 = 54.06^2 - \frac{(30000*14.73)^2[0.64*528*0.205*0.979]}{(18.062*520)^2\,(8)^{16/3}}$$

P_8 = 54.03psia

At point F

q_h = 30,000 cfh

L = 0.22 miles

P_4 = 54.35 psia

$$P_9^2 = 54.35^2 - \frac{(30000*14.73)^2[0.64*528*0.22*0.979]}{}$$

$$(18.062*520)^2\,(8)^{16/3}$$

P_9 = 54.32psia

At point D

q_h = 20,000 cfh

L = 0.433 miles

P_3 = 55.18 psia

$$P_{10}^2 = 55.18^2 - \frac{(20000*14.73)^2[0.64*528*0.433*0.979]}{(18.062*520)^2\,(8)^{16/3}}$$

P_{10} = 55.16psia

At point B

q_h = 10,000 cfh

L = 0.1118 miles

P_2 = 56.04 psia

$$P_{11}^2 = 56.04^2 - \frac{(10000*14.73)^2[0.64*528*0.1118*0.979]}{(18.062*520)^2\,(8)^{16/3}}$$

P_{11} = 56.03psia

CONCLUSION AND FINDINGS

The sample calculations for the network are conducted, selecting a small section within the network. The pipe diameters and gas quantity requirements according to Dehraduns population are also calculated.

ECONOMICS

The economic study is as follows:

Saving amount = Rs. 55

Percentage save = 17.75 %

(W.R.T. to LPG)

CNG PROJECT COST

The tables below show the cost requirements for construction of various CNG Stations. From these tables we can select the optimum type of CNG Station as per the gas demand.

Mother Station Cost

S.No.	Component	Cost (Rs.in Mn.)
1	Compressor	32.00
2	Cascade (2 Nos. 200 Liter)	7.00
3	1 Dispenser	6.00
4	2 Power Dispenser	7.00
5	Civil & Other misc. works	7.50
6	Piping & Instrumentation	0.25
7	Fire detection	0.15
8	DG Set	1.00
9	Contingency	0.70
	Total	**61.60**

COST OF 3 MOTHER STATION = 61.60*3 = 184.8 Mn

Daughter Station Cost

S.No.	Component	Cost (Rs.in Mn.)
1	1 Dispenser	1.50
2	2 Mobile Cascade	3.00
3	1 Stationary Cascade	4.00
4	Civil & Other misc. works	7.50
	Contingency	0.70
	Total	**16.70**

COST OF 6 DAUGHTER BOOSTER STATION = 16.70*6 = 100.2 Mn

It is also seen that constructing a CNG Station on an existing petrol pump station is profitable and feasible as the cost of land etc. reduces and the various statutory requirements for such stations are lower.

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