INDUSTRIAL TRAINING

Project:

- **Automation Technology in CGD System**
- **GIS-Based Asset Management in CGD**
- **Integrity Management System in CGD**

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We perceive this opportunity as a big milestone in our career development. We will strive to use gained skills and knowledge in the best possible way, and continue to work on their improvement, to attain desired career objectives. Hope to continue cooperation with all of you in the future.

GENERAL INFORMATION ABOUT IRM

- A group Company of Cadila Pharmaceuticals Ltd, IRM Energy Pvt Ltd is an integrated value-driven energy enterprise developing Natural Gas distribution projects across districts in the country for customers in the industrial, commercial, domestic, and transport sectors.
- The company is committed to contributing to the energy needs of its consumers.
- IRMEPL has recently been awarded authorization for implementing the City Gas Network CGD network in the Geographical Areas (GAs) of Banaskantha and Diu & Gir Somnath in the state of Gujarat and Fatehgarh Sahib in the state of Punjab.

PRODUCTS AND SERVICES

IRM Energy Pvt Ltd is engaged in the supply and distribution of natural gas as a product in two forms, namely;

1. Piped Natural Gas (PNG)
2. Compressed Natural Gas (CNG)

PNG (PIPED NATURAL GAS)

PNG (Piped Natural Gas) is the natural gas supplied through steel and polyethylene (PE) pipelines to cater to the natural gas demand of customers in various segments, i.e. Domestic / Commercial & Non - Commercial / Industrial segments.

DOMESTIC CUSTOMERS

- As a safer alternative to LPG cylinders, Piped Natural Gas is becoming more common amongst residential customers who use natural gas primarily as cooking fuel and for water heating through Gas Geyser.
- At present, the company is supplying Piped Natural Gas for Domestic Usage to more than 17,000 customers in Banaskantha, North Gujarat.

INDUSTRIAL CUSTOMERS:

- Industrial customers comprise those natural gas consumers who need natural gas for their industrial applications.
- They use piped natural gas mainly as a source of energy for many industry-specific processes. Natural gas is mainly used in industrial applications like heating, cooling, power, processes, and manufacturing.
- The company is supplying PNG to industrial customers in Palanpur and Deesa cities of Banaskantha.

COMMERCIAL CUSTOMERS

- Commercial setups/entities like Tea / Snacks shops, restaurants, food courts, hotels, hospitals, resorts, canteen, hostels, etc. are categorized as Commercial Customers.
- At present, the company is supplying PNG to more than 100 Commercial and Non Commercial premises across Banaskantha, North Gujarat.

CNG (COMPRESSED NATURAL GAS)

- Compressed Natural Gas, also well known as CNG, is an auto fuel in a Gaseous state. Mainly comprising of Methane (80% to 90%) CNG is low density and is compressed up to 200 bar pressure so that it can be stored in a larger capacity in the fuel tank. Hence, it is named Compressed Natural Gas. Some salient benefits of CNG are as below:
- CNG is economical and one of the preferred alternative fuel sources for vehicles today.
- CNG is pollution-free and is a clean-burning fuel.
- CNG is colorless, non-toxic, and non-carcinogenic.
- CNG is lighter than air; hence in case of leakage CNG disperses quickly into the air instead of on the ground, reducing the risk of fire and ground contamination. This natural gas is mixed with an odorant to add a distinct odor similar to the odor of LPG from a domestic cylinder to facilitate the detection of its leakage.

CGD Industry in India

- ## History

➢ The CGD business in India dates back to 1857 when Calcutta Gas Company and Bombay Gas Company commenced operations in Calcutta (now Kolkata) and Bombay (now Mumbai) respectively, with coal gas as the primary input. Subsequently however, the industry remained by and large dormant, until Oil and Natural Gas Corporation Limited (ONGC) and Assam Gas Company Limited entered the business in the mid- to late-1980s.

➢ The commercial success of these companies in the ensuing period along with improving gas supplies has drawn a number of new entrants to the CGD business in the recent past. Even while the industry has been gathering momentum, GoI has set up a regulator, the Petroleum and Natural Gas Regulatory Board (PNGRB), which has, among other mandates in the hydrocarbon sector, the mandate of regulating the CGD business. PNGRB has recently finalized a set of guidelines for the CGD sector.

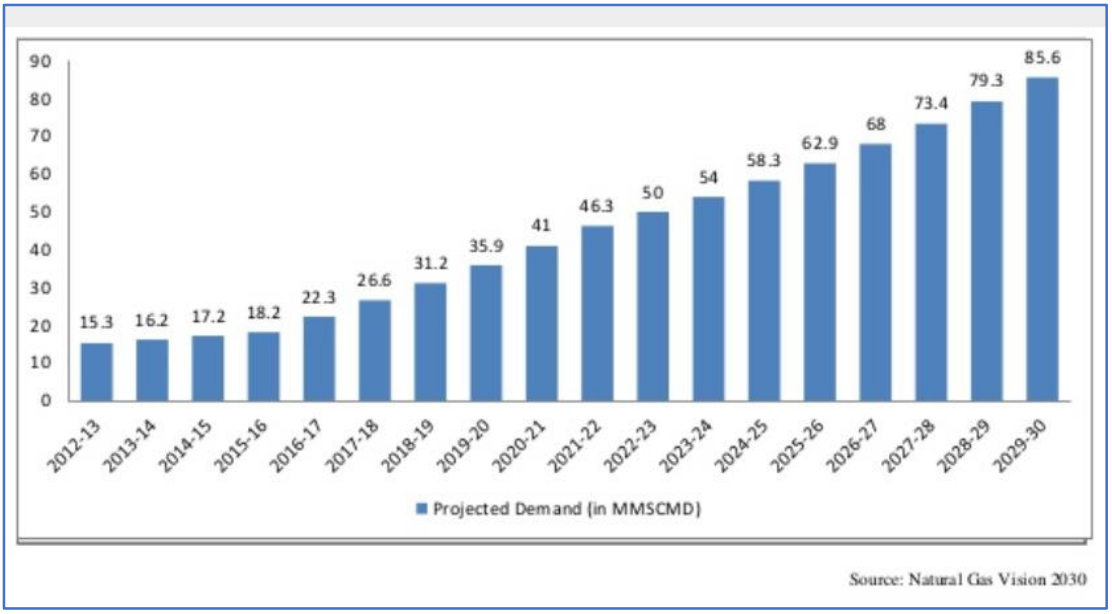


Figure:1 Project demand in CGD

State	Company Name
Gujarat	Adani Energy, Gujarat Gas, Sabarmati Gas, HPCL, Vadodara Gas, Charotar Gas, Torrent gas, IRM Energy
Delhi / NCR	Indraprastha Gas, Delhi
Maharashtra	Mahanagar Gas and Maharashtra Natural Gas
Andhra Pradesh/Telangana	Bhagyanagar Gas Ltd. and Hyderabad Godavari Gas Pvt. Ltd.
Rajasthan	Rajasthan State Gas Limited, Torrent Gas
U.P.	Green Gas, Central UP Gas, Siti Energy, GAIL Gas, Sanwaria Gas, Indraprastha Gas, Adani Gas, Indian oil-adani gas
Tripura	Tripura Natural Gas Co. Ltd (TNGCL) Agartala
Haryana	Haryana City Gas Ltd., GAIL Gas Ltd. and Adani Gas Ltd
West Bengal	GEECL
Karnataka	GAIL Gas Ltd.
Chandigarh	IOC-Adani
Daman	IOC-Adani

Table : 1 State wise company name

Departments in CGD Company in General

CGD company has a function to provide piped natural gas & compressed natural gas to the end consumers (Domestic, Industrial, Commercial & vehicles) In a particular geographical area (GA) by pipeline network laid, maintained and operated by the company.

CGD company comprises various departments with different functional area, but should work in synergy for smooth function of the Company.

- **General Departments**

I) Finance Department

The function of this department include:

- Preparing Budget and forecasting
- Planning & organizing company finance
- Management of Company cash flow
- Financial Reporting and analysis.
- Management of Investment of company
- Tax management
- Financial management of Company Resources

II) Human Resources Department

The Function of this Department includes: -

- Recruitment and selection of new employees
- Ensure compliance of company operation with laws
- Manage relations with other companies
- Maintaining good working conditions
- Management of employ relations
- Training & development of employees

III) Marketing & Sales Department: -

This department divided in to several sub-divisions.

A. CNG Marketing
B. PNG Marketing
   - Domestic PNG Marketing
   - Industrial PNG Marketing
   - Commercial PNG Marketing

Their functions are: -

- Direct and Indirect potential customer interaction
- Develop promotional program to attract new customers
- Promote the company through different media platforms.
- Development of feasibility plan for potential industry customer
- Design and organize promotional event & campaign to reach the consumers
- Design company brochure and promotional material
- Market survey of Geographical area
- Represent company in seminar, conference or meeting.

IV) Health & Safety Department

This departments plays major role in maintaining health & safety of the personals & equipment of the company & its associates.

Their functions are: -

- Develop and execute zero accident policy
- Ensure company follow best practice to improve HSE performance rather than just compliance of the company to legal, statutory rules and regulations of the government
- Develop Comprehensive and compulsory action plan to execute the policy.
- Provide and channelize resource for implementation of HSE policy.
- Development, operation & monitoring of Emergency response system(ERS), Disaster management system(DMS) and other safety
- Plan safety and awareness program for personals working for the company & contractor at site.
- Promote HSE in work culture of company by recognition and reward to the contributors for improving HSE performance of company.
- Timely review of HSE Policy

Technical Departments:

❖ Operation & Maintenance Department

- This department in the CGD Company is responsible for smooth & safe operations of the company equipment's, this department has divisions like

❖ PNG Operation & Maintenance Department:-

The main function of this departments are:-

- Ensure continuous supply of gas at required pressure to the end PNG customers
- Scheduled checking of high pressure gas pipeline to find and remove leakage or defect if any
- Timely checking & maintenance of safety device and metering skid at customer facility for their smooth & accurate operations.
- Regular maintenance of service regulator, district regulation system for smooth operations of the equipment.
- Ensure damage to pipelines or leakage is attended as soon as possible while following best safety procedures.
- Replace or repair damaged equipment or part of gas pipeline

❖ CNG Operation & Maintenance Department:-

The main function of this departments are

- Ensure safe operational practice at CNG Station
- Reduce the breakdown time of station
- Scheduled maintenance of compressor (Both Hour based and time based) for its smooth operation
- Maintain the good working condition at station
- Scheduled checking of cascade for leakage or other fault
- Ensure proper working of all Gauges in the equipment
- Ensure timely cleaning of filtering device to remove dust
- Replace or repair damaged part of the equipment like dispenser at the station
- Check availability of safety equipment's at station within their service life

❖ Project & Planning Department: -

The function of this department includes: -

I) **Design Prefeasibility report of potential work area or Project**

II) **Decide project capacity on basis of consumer base & expected demand**

III) **Selection of a proper site**

IV) **Designing, Execution and commissioning of Project**

V) **Cost Calculation**

VI) **Equipment Requirement and clearance from respective authority**

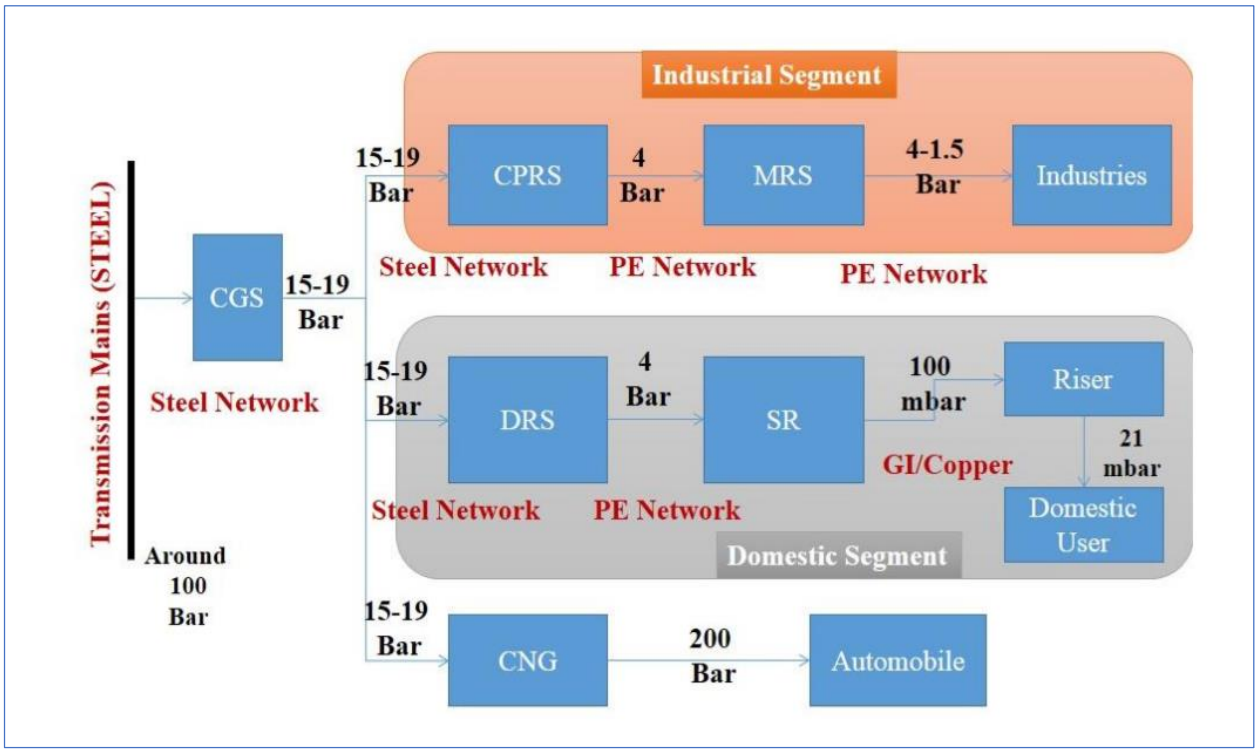
VII) **Staff Requirement**

CGD Network

- The selection of design for CGD Network is based on the gas properties, required flow rates, operating pressures and the environment.
- A typical CGD Network shall comprise of one or more or all of the following:

❖ CGD network comprises of

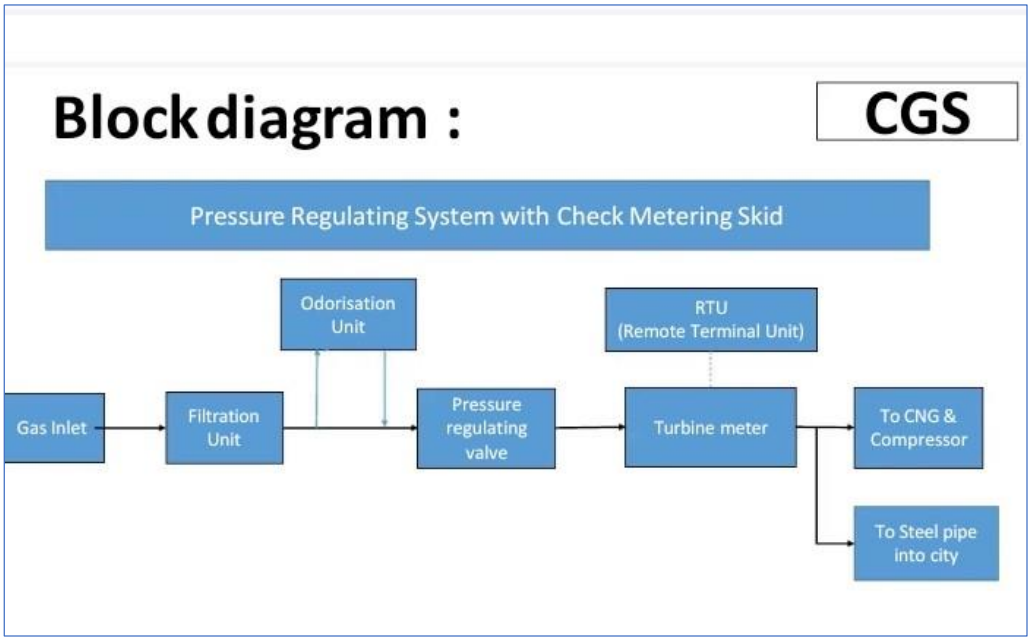
- City Gate Station(CGS)
- Pipeline Network - Steel Pipeline, Polyethylene Pipelines, GI/Cu Pipes
- Regulating Stations - District Regulating Skid (DRS), Service Regulators, Domestic/Commercial/Industrial Regulators
- Metering Stations/Metering & Regulating Skid (MRS)
- CNG Stations



(Figure:2 CGD value chain**)**

CGS (City Gate Station):

- City Gate Station for the pipeline network is usually located at the main tap off point of transmission line.
- The CGS has a transmission pipeline inlet supply, a pressure reduction system, a filtering unit, gas chromatograph, metering system, odorant injection system, related piping along with specific monitoring and control systems.
- The gas transported at the CGS in the city is of high pressure. The pressure reduction facility consists of a pressure regulator running with standby units, each with an active/ monitor controller, each with slam- shut protection facilities.
- Furthermore, as per the design requirements, provision can be made for preheaters of natural gas. A CGS should be placed in a protected fenced off area.
- DRS is required to supply the rest of the distribution system from the maximum transmission pressure system of 26 bar. The DRS will be similar with different capacity in design to the City Gate, except that normally no allowance is required for gas heating.
- The main components of City Gas Station and their functions are as follow:



(Figure: 3 Block Diagram of CGS)

Filtration skid:

- Gas enters in the knock out drum (KOD) in which dust & liquid particle in gas stream are separated by high efficiency filters.
- Demister pad or mist extractor causes coalescence of droplets and thus mist can be removed.
- Larger solid particles are removed by gravity, since the velocity of incoming gas decreases.
- 1st stage - Smaller size solid particles are removed by means of filter elements.
- 2nd stage - Gas enters the 2nd stage where liquid particles are removed.
- Contaminants generally are collected in a separate storage which remains connected to the filter separator.
- Gas is maintained at the same pressure from the inlet to the filtration skid and the filtration gets bifurcated into two streams namely active stream and passive stream from the main line. The line which is in function is known as active line.

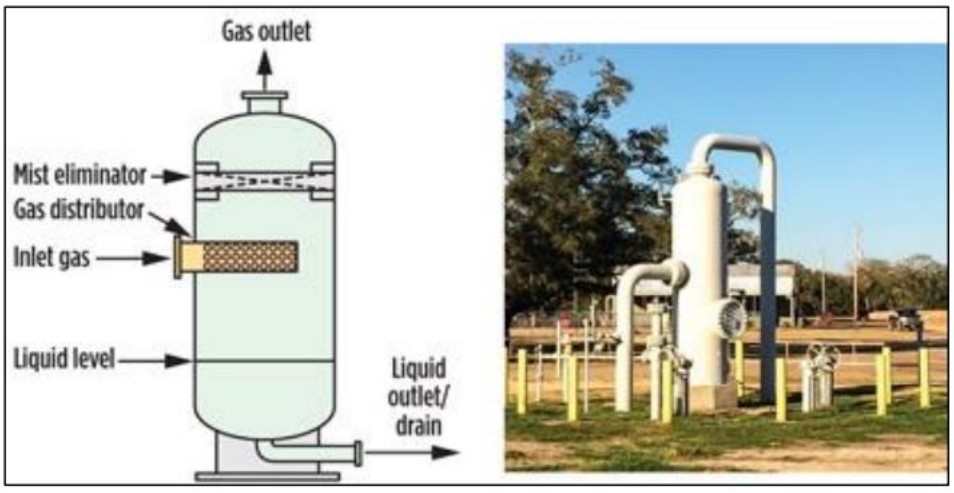


Figure 4: Filtration Skid

Pressure Reduction Skid:

- A pressure reduction skid is used to reduce the pressure of the gas stream from 40-45 bars to 25-30 bars.
- Safety relief valve (SRV), Slam Shut off valve (SSV), pressure regulating valves (active and monitor PRVs) and creep relief valve (CRV) is being installed in this skid for safety purposes.

Metering Skid:

- Metering skid is installed for the gas flow measurement.
- Temperature, Pressure, Flow are monitored through SCADA system.
- Types of meters used for measuring volume of incoming gas are orifice meter, coriolis meter, rotary meter, diaphragm meter, turbine meter and ultrasonic meter.

Odorization Unit

There are basic three things in an odorization system

1. A pump
2. A verometer
3. A controller (N-300G)

- During normal operation the pump injects an exact quantity of odorant at a rate determined by the controller.
- The quantity of odorant injected per stroke is set using a spacer in pump actuation assembly, the rate at which pump is actuated is determined by controller.
- The verometer verifies the amount of odorant that has been injected by the pump, once the odorant level falls to a predetermined low-level point, the

controller actuates the solenoid valve which open the fill valve, allowing the verometer to be refilled.

- The controller allows us to operate in two modes either time-based mode or proportional-to-flow mode.
- The dosing unit of the odorant should be of 9 mg/m3. This unit consists of mainly two cylinders of the capacity of 160 kg, pneumatic panel, level indicator and a filter.
- This unit is directly connected to the main line after the metering skid.

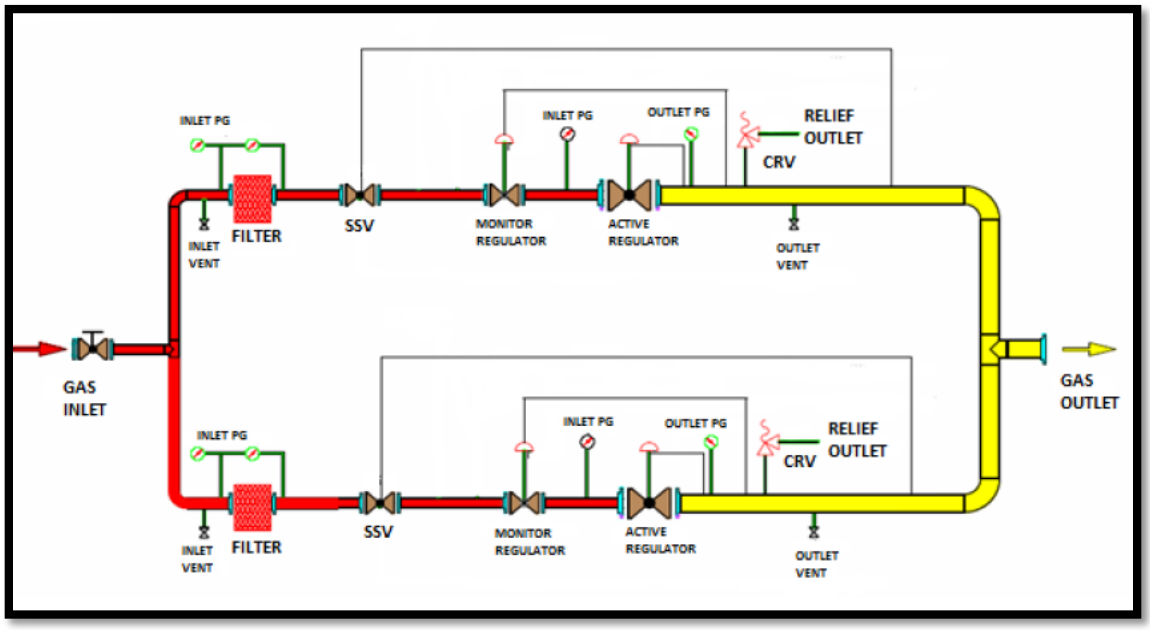
Types of Odorants:

- Ethyl Mercaptan (EM)
- Tetrahydrotiphene (TMT)
- Dimethyl Sulphide (DMS)
- Diethyl sulphide (DES)
- Methylethyl sulphide (MES)
- Sec butyl Mercaptan (SBM)
- Tert Butyl Mercaptan (TBM)
- N-Propyl Mercaptan (NPM)
- Isopropyl Mercaptan (IPM)
- Methyl Acrylate (MA)
- Ethyl Acrylate (MA)

(Figure: 5 Odorization Unit)

District Regulating System:

- DRS is a station used to reduce the pressure from 19 bars to 4 bars. It is the interface between the steel grid network and the medium pressure PE network. It is located at various demand centers for domestic /commercial users.
- Gas at high pressure enters into the filter, where borosilicate cartage is provided to remove the impurities and solid particles.
- There is a pressure gauge attached to it which measures the differential pressure. If differential pressure reaches 0.5, immediate cleaning of the filter is required. And if differential pressure reaches 1 barg then filter stop working. The above filter safety relief valve is provided to vent off inlet gas if pressure increase more than 42 kg/cm2 as the maximum pressure handling capacity of steel pipe is 49 kg/cm2.
- DRS outlet pipeline can resist pressure up to 7 kg/cm2.
- Chances of a trip in DRS are mainly due to back pressure-induced when the flow is stopped in the downstream line.
- District Regulating Station (DRS) is an arrangement for reduction, regulation & monitoring of Natural gas used in city gas distribution projects.



(Figure:6 DRS (Twin Stream Model))

There are several sections used in DRS as written below:

1. Filter

Filters are systems or elements used to remove substances such as dust or dirt.

2. Pressure Reduction Skid

- Pressure reduction skid is installed at CGS for the reduction of the gas pressure from 38-40 bar to 15-19 bar. A pressure reduction skid is installed with Monitor and Active Regulating streams with 50 % redundancy.
- Two regulating devices in series with stepped pressure settings to allow one (Active) to control the outlet pressure and the other (Monitor) to assume control in the event of failure of the active device.
- An active regulator normally assures pressure reduction to the setting value. The monitor is installed to assure continuous gas supply (in case of failure of the active regulator).
- The Monitor regulator is normally wide open, and in case of pressure fluctuation, the monitor regulator will take over as a control valve. Usually, one line is working while the other line is on stand-by.
- Over/Under pressure slam shut valves and creep relief valves are also installed to protect the system's fluctuating pressure. Pressure relief valves are installed in the line to release gas in small quantities.

3. Creep relief Valve (CRV)

Pressure relief valves are a dependable means of protecting a regulator or downstream systems, storage vessels, and other systems against overpressure conditions by relieving the excess gas pressure. Designed to protect against excessive pressure in systems and vessels, suitable for use as creep relief and as part of stream discrimination in systems and vessels.

The controlled pressure is generally set to a predetermined designed value using the adjusting screw.

- Any accumulation of the gas results in an increase in controlled pressure
- This increases the compensation force, which balances the controlling force, hence the valve opens.

4. Slam Shut off Valve (SSV)

Slam Shut-off valve is installed immediately after the filter & before the Regulator or inbuilt with PRV. It normally remains open, in case the outlet pressure of the regulator exceeds the permissible limit, the slam shut-off valve senses it through the impulse line & immediately shut off the flow downstream.

5. Pressure Gauges

Pressure gauge, instrument for measuring the condition of a fluid (liquid or gas) that is specified by the force that the fluid would exert, when at rest, on a unit area, such as pounds per square inch or newtons per square centimeter.

6. Non-return Valve (NRV)

A non-return valve allows a medium to flow in only one direction. A non-return valve can be fitted to ensure that a medium flows through a pipe in the right direction, where pressure conditions may otherwise cause reversed flow.

7. Temperature Gauges

A temperature gauge is a device used to indicate the temperature of an item being monitored. Common methods of measuring temperature include bimetallic strip (the bending of which increases with temperature) and the thermocouple which produces an electronic voltage that depends on the temperature.

8. Differential Pressure Gauges

- A differential pressure gauge is a visual indicator, designed to measure and illustrate the difference between two pressure points within a process system.
- The gauge usually has two inlet ports that are each connected to the pressure points being monitored.

Service Regulator

- It is used to reduce the pressure from 4 bars to 110 millibars and to maintain the flow. Flow can be of 200 SCMH (Standard Cubic Meter per Hour), 150 SCMH, 100 SCMH, or 50 SCMH based on the requirements.

- 50 SCMH capable to fulfill the demand of approx. 150 domestic connections theoretically.

- Maintains the required maximum and minimum pressure with shut off the device.
- Located at customer premises for maintaining safe conditions in the event of a rupture in the regulating downstream section.

(Figure:7 Service Regulator)

Design criteria	
Inlet Pressure	1.5 to 5.0 bar-g
Outlet Pressure	110 mbar-g
UPSO	40 – 60 mbar
OPSO	145-175 mbar

Table: 2 Design Criteria

Cathodic Protection:

- cathodic protection is used to protect pipelines from corrosion.
- The main objectives and requirements of cathodic protection (CP) systems are to prevent external corrosion throughout the design life of the pipeline by providing sufficient current to the pipeline to be protected.
- Subsurface test station
- Above ground test station

Operation & Maintenance (Metering)

Metering

- Metering is one of the important parts of the O&M department at SGL.
- Meters are installed as per different premises.
    1. Domestic Premise
    2. Commercial Premise
    3. Industry Premise

Types of meters used in CGD

- Diaphragm Meter (use in Domestic/commercial)
- Rotary Positive Displacement Meter (RPD) (use in Industry)
- Turbine Meter (use in CGS/MRS/DRS)
- EVC Meter (use in DRS/MRS)
- Ultrasonic
- Thermal

Meters used in CGD:

Type	Qmax
G6	10
G10	16
G16	25
G25	40
G40	65
G65	160
G160	250
G250	400
G400	650
G650	1000
G1000	1600

Table: 3 Meters with their flowrate capacity

Sizing & Selections – Recommendation for CGD Sector

Parameters	Diaphragm	RPD	Turbine meter	Coriolis MFM	USM
Application	Domestic/ Commercial Customers	MRS/DRS	MRS/DRS/CGS	CNG/DRS/MRS/CGS	CGS/ Cross – Country Pipeline
Flow Range	G1.6 - G25	G10 – G400	G65 – G6500	G65 – G6500	G650 – G40000
Pipeline Size (NB)	½" to 2"	2" to 6"	2" to 6"	1/2" to 6"	4" to 36"
Operating Pressure	10mbar – 500 mbar	500 mbar – 19 bar	19 bar – 99 bar	4 bar – 345 bar	4 bar – 100 bar
Typical Rangeability	160:1	20:1 (G10 – G65) 160:1 (G65 –G400)	20:1	40:1	100:1
Accuracy on Gas	+/- 1.5 % to 3%	+/- 1 % to 2%	+/- 0.5 % to 1%	+/- 0.25 % to 0.5%	+/- 0.1 % to 0.3%
Estimated Capital Cost (INR)	2K to 0.25L	1L to 5L	1L to 10L	1.5L to 10L	20L to 2Cr

EMERSON. Process Management

Figure:8 Comparison of Flow meters

Compressed Natural Gas(CNG) Overview

- CNG (compressed natural gas) is natural gas mainly containing methane which is compressed up to 250 bars and used as vehicular fuel in vehicles running on CNG kits.
- It has a Research Octane Number above 120.
- The excellent knock resisting property of CNG allows for use of a higher compression ratio resulting in increased power output and greater fuel economy when compared to petrol.
- CNG can be used in engines with a compression ratio as high as 12:1 compared to normal gasoline (7.5:1 to 10:1). At this high compression ratio, natural gas-fueled engines have higher thermal efficiencies than those fueled by gasoline.
- The fuel efficiency of CNG driven engines is about 1020% better than diesel engines.

The following are the benefits of using CNG:

Green Fuel:

- Commonly referred to as the green fuel because of its lead and sulfur-free character, CNG reduces harmful emissions.
- Being non- corrosive, it enhances the longevity of spark plugs. Due to the absence of any lead or benzene content in CNG, the lead fouling of spark plugs and lead or benzene pollution are eliminated.

Increased life of Oil:

- CNG does not contaminate and dilute the crankcase oil.
- Mixes evenly in Air.
- Being a gaseous fuel CNG mixes in the air easily and evenly.

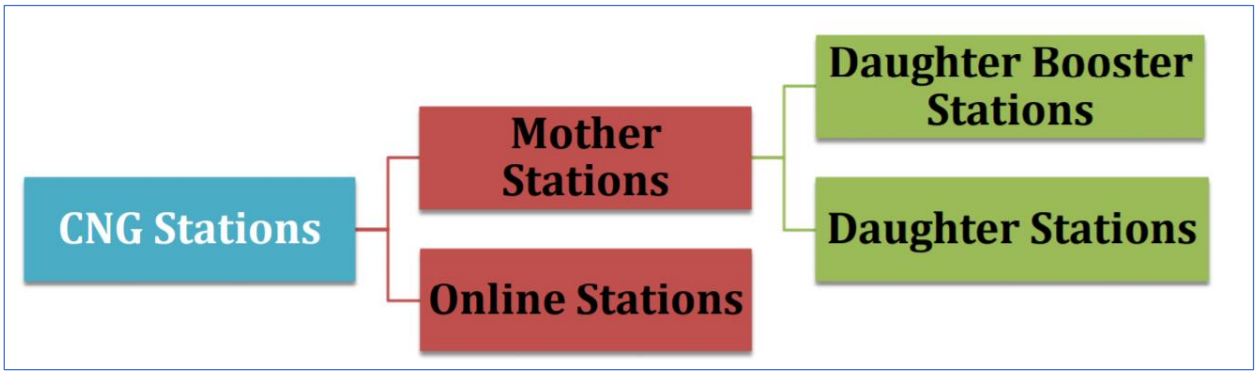
Safety:

- CNG is less likely to auto-ignite on hot surfaces since it has a high autoignition temperature (540°C) and a narrow range (5%-15%) of inflammability.
- It means that if CNG concentration in the air is below 5% or above 15%, it will not burn.

Low Operational Cost:

- At the prevailing price of fuel, the operational cost of CNG vehicles is 68% lower than petrol and 36% lower than diesel.

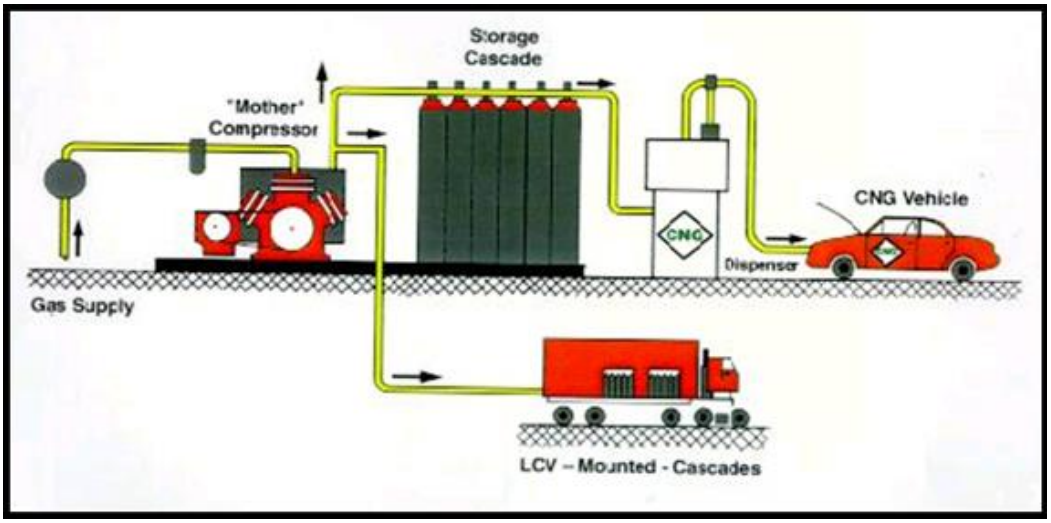
CNG Distribution:



(Figure:9 Types of CNG Station)

Mother Stations:

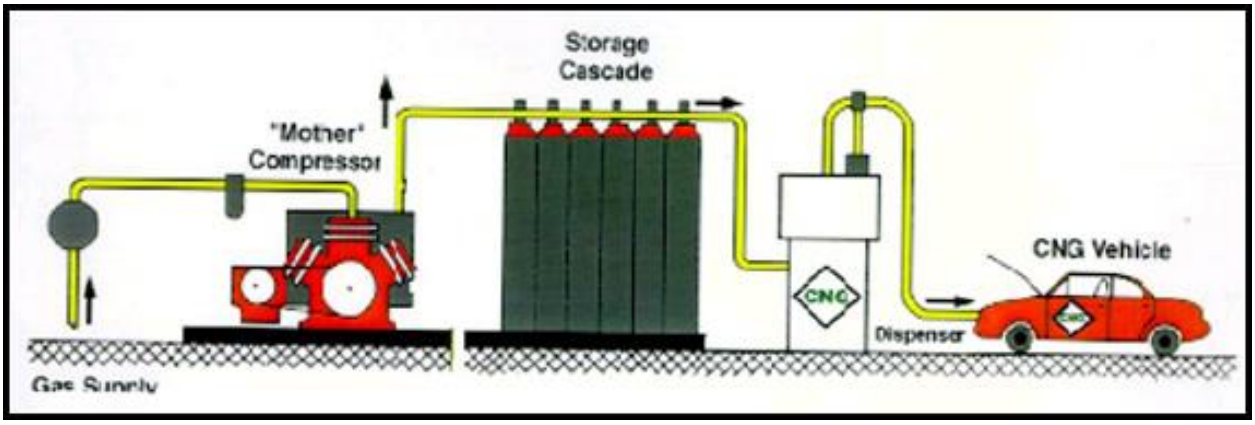
- Mother stations are connected to a natural gas pipeline and having a compressor meant primarily (have high compression capacity) to fill mobile cascades for the daughter station (through mobile cascades).
- Also fills stationary cascades for CNG dispensing into vehicles.
- Typically they have the facility of filling all types of vehicles – buses/autos/cars.
- In addition to its sales, it can feed 2 to 3 daughter stations.
- It is preferred to install more than one compressor at each Mother Station for better reliability.



(Figure:10 Mother station)

Online CNG Station:

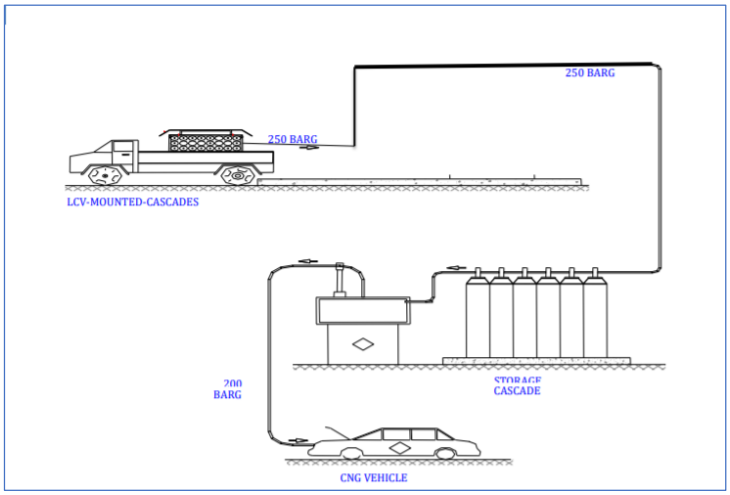
- Online stations are connected to the natural gas pipeline.
- CNG vehicle storage cylinders need to be filled at a pressure of 200 bars. Online Stations are equipped with a compressor of relatively small capacity, which compresses low-pressure pipeline gas to the pressure of 250 bar for dispensing CNG to the vehicle onboard cylinder
- On line, the station may have the facility to feed small vehicles alone or small vehicles and Buses.



(Figure:11 Online Station)

Daughter CNG Station:

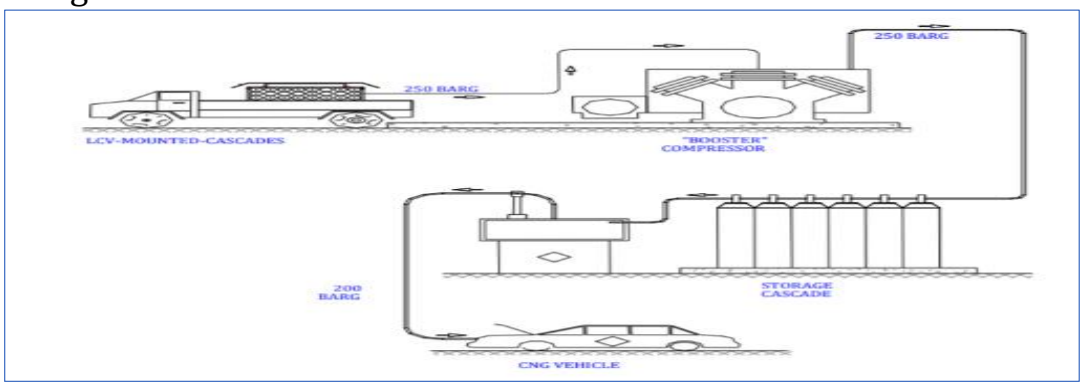
- The "Daughter Stations" dispense CNG using mobile cascades.
- These mobile cascades at daughter stations are replaced when pressure falls and pressure depleted mobile cascade is refilled at the "Mother Station".
- There is a reduction in storage pressure at daughter stations with each successive filling. Once the storage pressure drops, the refueling time increases, while the quantity of CNG dispensed to the vehicle also decreases
- Sizing of mobile cascade and truck to be decided based on distance and capacity to be transported from Mother stations.
- Nos. of LCV/HCV, To & Fro frequency & cut off pressure may be decided based on load.



(Figure: 12 Daughter Station)

Daughter booster Station:

- Daughter-Booster stations are not connected to natural gas pipeline
- They dispense CNG using mobile cascades.
- These mobile cascades at daughter stations are replaced when pressure falls and pressure depleted mobile cascade is refilled at the Mother Station
- Booster station improves the utilization of residual CNG in mobile cascade up to 70-80%.
- Daughter station may have the facility to feed small vehicles alone
- Installing a booster compressor can eliminate drawbacks of daughter stations. The mobile cascade can be connected to the dispensing system through a booster.
- The daughter booster (compressor) is designed to take variable suction pressure and discharge at a constant pressure of 200 bars to the vehicle being filled with CNG.



(Figure 13: Daughter Booster Station)

AMR (AUTOMATIC METER READING)

- Automatic meter reading or AMR is the technology of automatically collecting consumption, and status data from Gas & Energy metering devices and transferring that data to a central database for billing troubleshooting and analyzing.
- This advance mainly saves utility providers the expense of periodic trips to each physical location to read ammeter. Another advantage is billing can be based on near real-time consumption rather than on estimates based on previous or predicted consumption.
- This timely information coupled with analysis can help both utility providers and customers better control the use and production of consumption.

AMI (Advanced Meter Infrastructure)

- AMI (Advanced Meter Infrastructure) incorporates a network communications system with radio-based transmitters or transceivers that report a variety of data, including but not limited to meter readings, to the utility daily and/or enable the utility to interact with the meter or other devices at the point of service with no human intervention.
- Depending on the radio architecture employed, the radios can be a lower or higher power. The difference between these types of systems lies within the functionality.

Benefits and limitations of AMR vs. AMI

- AMR systems greatly enhanced meter reading efficiency, and it can also virtually eliminate inaccuracies related to human error from recording the reading to inputting the data at the office.
- As radio technology improved, drive-by systems were developed, which use a vehicle-mounted recording device to gather readings even faster. With the advent of the computer modem and lowering cost of technology, some telephony-based systems “called” the utility at a set point each month and delivered the reading directly to the utility billing system.

Benefits

- ❖ Low Cost
- ❖ Efficiency/Accuracy
- ❖ One Reading Incrementally lower reading cost
- ❖ Hourly usage information
- ❖ Remote communication
- ❖ Reduce labor cost
- ❖ Reduced vehicle upkeep and liability costs
- ❖ High efficiency/accuracy
- ❖ Upgradable
- ❖ Detailed information/improved system analytics
- ❖ Accommodates a growing list of applications

Limitations

- Low functionality
- Requires staff interface
- No history detail
- Higher infrastructure cost
- May require nontraditional partnerships with other utilities

Range & Infrastructure:

AMR and AMI networks are comprised of three basic components:

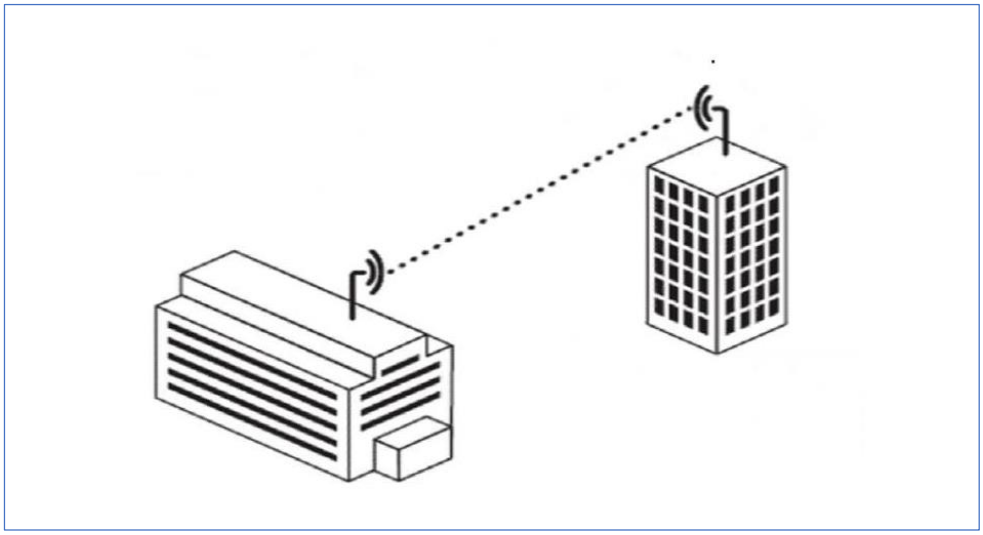
- An endpoint, which is a radio mounted on the gas meter or other field-based device.
- A collector, which is either handheld or vehicle-based in the case of AMR, or a field-based gateway that wirelessly relays information between the utility and a series of endpoints.
- A centralized interface, at the utility, that is used to collect and disseminate information throughout the utility's information systems.

Wireless Network Topologies

- There are several types of wireless networks available on the market today.
- They include point-to-point networks, point-to-multipoint networks, and newly emerging mesh networks.

Point-to-Point Networks

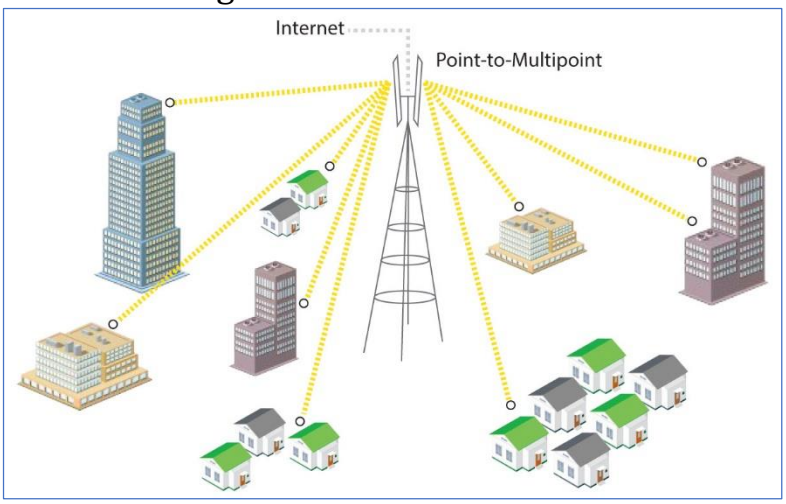
- In a point-to-point network, each network node directly communicates to only one other node.
- Figure 13 shows a typical topology of a point-to-point network.
- Wireless point-to-point systems are often used in wireless "backbone" systems such as microwave relay communications, or as a replacement for a single communication cable.



(Figure 14: Point-to-point network topology)

- The biggest disadvantage of a point-to-point wireless system is it is strictly a one-to-one connection.
- This means that there is no redundancy in such a network at all.
- If the RF link between two point-to-point radios is not robust, the communicated data can be lost.

- Point-to-multipoint networks have a star topology that can provide either one-way or two-way communications.
- Figure 14 shows a typical topology of a point-to-multipoint network. Examples of such a topology include cellular systems, WLAN, and satellite systems in which one satellite station communicates to multiple ground stations.
- Signals in point-to-multipoint networks converge at the central node, for example, a base station of a cellular system, an access point of a WLAN, or a satellite space station in a satellite system.
- The reliability of the networks with such a topology depends on the quality of the RF link between the central node and each end node.
- In many industrial environments, it can be impossible to find a location for the central node from which it can provide robust communication links with all of the end nodes in the network.
- Usually, moving the central node to improve communication with one end node will often degrade communication with other end nodes.

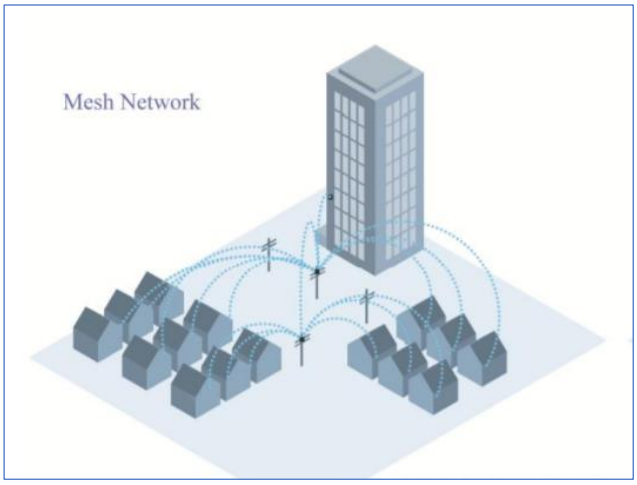


(Figure 15: Point-to-multipoint network topology)

- While it may be possible to wire together multiple central nodes to improve reliability, the issue of cost will rise again.

Mesh Networks

- As in a point-to-multipoint network, most of the WSN with a mesh topology also has a single central node to collect information from all the end nodes (wireless sensor nodes in a WSN).
- However, the mesh topology is different from the point-to-multipoint topology in that every end node also can communicate with one or more nearby end nodes within the network.
- Figure 15 shows a typical topology of a mesh network.
- In a mesh WSN, not only can each end node transmit its information (i.e. information collected from its sensor), but also it can relay information generated from other nodes.
- Thus, it is possible for the messages generated from an end node to reach the central node via multiple hops (going through multiple other end nodes to finally reach the central node).
- The path that a message takes to reach the central node is called a "route". And there may be multiple routes in a mesh network that can relay a message to the central node.
- This is a basic difference from how both point-to-point and point-to-multipoint topologies work; in both of those topologies, all of the transmissions are strictly limited to one hop.
- Besides, a mesh network is often designed in such a way that it allows a message to automatically use another route when the quality of the current route is degraded.



(Figure 16: Mesh network topology)

Mesh Network Flexibility

- The flexibility of the mesh network arises from its self-configuration, self-healing, and scaling capabilities.
- These capabilities are implemented in most mesh networks as part of their required network functions.

Self-Configuration

- One of the popular functions that can be programmed into a mesh network is the ability to build and configure itself.
- When each end node is powered on, it listens to its neighbor nodes.
- If it finds one or more, it issues a request to join the network and gets admitted, provided that it meets admission criteria such as set by security requirements.
- After the end node joins the network, it will not need human intervention to get a message to its destination.
- Paths (or routes) will be automatically formed by the end node as the information that it transmits gets relayed by neighboring nodes until it reaches the central node.

Self-Healing

- Self-healing is another popular mesh network function.
- It refers to the ability of a mesh network to reorganize itself and keep functioning even if one or more end nodes are moved from one location to another, or are simply removed from the network.
- This function of the mesh network is made possible largely because of the redundancy existing in the mesh topology. If a node in a mesh network fails, messages are sent around it via other nodes.
- Loss of one or more nodes does not necessarily affect its operation.
- Thus, a mesh network is self-healing because of its self-configuration capability by which human intervention is not necessary for the re-routing of messages.

Scalability

- The self-configuration and self-healing capabilities of the mesh network render it eminently scalable.
- In many cases, expanding a mesh network is simply requires the addition of more end nodes to cover additional areas.
- A mesh network is reliable because of its redundancy.
- A mesh network is flexible because it is capable of self-configuration and self-healing, and is easily scaled to include more end nodes.

Benefits to Gas Utilities

- Natural gas utilities have a significant opportunity to utilize wireless meter communications to successfully transition into the utility of the future.
- When a utility's business plan is based on improving operational efficiency throughout the organization – not just faster meter readings – they will see the benefit of investing in a robust and secure communications network that connects, monitors, and controls devices to the network analysis data gathered to provide actionable intelligence and proactively communicates with their customer base.
- Wireless communications networks, the ability to connect monitor and control devices to that network, and the software that turns the data into business intelligence will deliver the benefits that drive the bottom-line results.

Business Case

- Advancements in wireless meter communications, positive deployment case studies, and advancements in standards are helping to reduce the reluctance of some natural gas utilities to invest in the technology.

- Stable, sophisticated platforms requiring minimal infrastructure allow for system upgrades without disrupting service and higher efficiencies in operational costs and human capital are creating a compelling business case to justify the investment.

- It should be noted that gas utilities do not have the same needs as an

electric utility, and the business case for gas AMI must be developed using different criteria. Electric utilities have the fundamental need to generate the electrons at the time of use.

- ❖ Therefore, they have an incentive to build a "smart grid" to assist in matching the supply to the demand at various hours of the day and conditions.

- ❖ Electric utilities also have the inherent issues of power outages due to the complex electricity infrastructure that is generally above ground and subject to damage.

- ❖ A "smart grid" is a tool to assist in the management of common and frequent outages in portions of their systems. What factors should gas utilities consider when planning their wireless meter communications networks? Which should they weigh most heavily?

- ❖ Now that we've established the radio qualities and architectural considerations that differentiate each approach, we will note which of these and other top considerations most impact the performance of a wireless network.

Top Gas Utility Business Case Components:

1. Field Labor

- Labor cost reduction for collecting readings
- Reduction of repeat field visits to meters to correct readings
- Reduce field visits to meters to collect off-cycle meter readings
- Elimination of high meter reader turnover (hiring & training)

2. Back Office Labor

- Accuracy of meter readings
- Consistency of meter readings
- Reduction of calls due to billing errors
- Lower back-office cost for meter reading exceptions

3. Customer Use

- Confidence in readings
- Ability to view usage information more frequently than monthly
- Establish correlation between their behaviors to their natural gas usage

Improved Operations

- ❖ Each year, gas utilities dispatch thousands of orders to shut off residential service for safety, move-outs, or lack of payment. If service personnel can't access the meter, an additional trip is required, further increasing operational costs.
- ❖ Soon, the expansion of wireless meter communication and applications will make it possible to perform these functions remotely.
- ❖ These devices are available today as add-on options - such as remote gas shutoff devices.
- ❖ Future meters will be available with integrated radios that offer a wide range of options such as disconnect and reconnect; distribution pressure monitoring; gas leak detection; internal meter intelligence, and alarm capabilities will all play a significant role in improving efficiency and safety for the utility and its customers. The adoption of these features will vary by gas utility.

Examples:

Disconnection

- ❖ The ability to shut off natural gas service during a structural fire is invaluable to the safety and security of rescue personnel.
- ❖ In some cases where the gas meter or street valve is inaccessible, it significantly increases the risk for safety personnel attempting to save the structure. The ability to remotely disconnect offers immeasurable savings in this situation.

Cathodic Protection

- Looking ahead, utilities may be able to integrate an AMI network with cathodic protection (CP) monitoring systems.
- Since the AMI system is built to receive input data from a source, a system application could be used to collect voltage information from CP monitoring systems for centralized data collection, lowering the cost of CP maintenance to allow more time for personnel to perform maintenance leading to increased system integrity.
- How much can this contribute to the bottom line? Consider that overall corrosion costs are estimated at $276 billion in the United States and $2.2 trillion worldwide.

Improved Customer Service

- Detailed information on-hand results in immediate satisfaction for the customer and greatly minimizes the need to send service personnel to investigate concerns.
- For the customer service representative, the ability to answer an inquiry on the first call gains the customer's respect and establishes a feeling of trust.
- The representative can then help the consumer determine ownership of the situation through a civil discussion of the circumstances surrounding the inquiry.
- Without this trust, the customer may make several additional calls or enlist the help of a consumer advocate in the media – which in itself may create a larger public relations situation.

Benefits to Customer

- Natural gas utilities are beginning to offer customers more detailed information about their bills – and more opportunities are on the horizon. While online portals are most common, some electric utilities are going a step further by sharing consumption information through home energy monitoring devices, similar to a thermostat.
- This information empowers customers to learn as much as they choose about their usage and the impact it has on their bill.
- Over time, customers learn how behavioral changes can lower their bills, conserve energy, and reduce their overall carbon footprint.

What else can be done with the network and volume of information?

- The heart of AMI is data. And we're only scratching the surface with how we can use this information to provide better service to our customers and returns to our shareholders, overall.
- The data from AMI systems is staggering, and management of this information is more than a full-time task for IT analysts throughout the industry.
- Information gathered by the system gives operations staff greater insight into resource allocation thanks to a better understanding of system performance.
- Engineering staff can use actual hourly flows at points on the system (rather than historical estimates) to model system operation for capacity planning. Service and billing departments can now resolve questions over the phone on the first call from a customer.
- One utility has used its wireless communications system to eliminate a three-day lag between the date of a meter reading and when the bill is sent to the customer, thus improving meter-to-cash process time.
- Meter reads required to open or close an account can be executed remotely, reducing the burden on-field personnel and inconvenience to the consumer.
- And personnel, once required for non-revenue generating tasks can now be redeployed to other areas of the company, where their knowledge and experience can be utilized for improving operations.
- A gas utility should seek a system that offers flexibility over the life of the product. Most natural gas utilities, if automated at all, currently have legacy walk-by or drive-by systems with limited functionality that may be nearing the end of their lifecycle.
- A wireless communications system that can support their walk-by/drive-by meter reading needs today with the ability to transition to a fixed-base meter reading system in the future will ensure their operations will be able to keep pace with changes in their business. As natural gas utilities learn more about the benefits of an AMI system for their specific needs, the technology will continue to be adopted at a growing pace.
- Fixed-base communications networks, the ability to connect monitoring and control devices to that network, and the software that turns the data into business intelligence will deliver the benefits that drive the bottom line result.

Automation in Metering:

Cello 6 V3 - GSM Meter Reader (Gas)

(Figure 17: Cello 6 V3)

- The Cello 6 V3 GSM Meter Reader is Technology's most advanced and cost-effective solution for gas AMR.
- The Cello 6 V3 is compatible with the pulse output of gas meters. The meter reading is calculated by totalizing pulses corresponding to a known volume of gas.
- The meter readings and profile data are transmitted to a host computer or data center at predetermined intervals including daily, weekly, or monthly.

- Pulse input and tamper detect
- Replicated pulse output
- SMS or GPRS operation
- User-replaceable standard SIM card (optional large internal memory eSIM 'Chip' SIM)
- Certified for the use in Zone 0 hazardous locations (**Zone 0** is an **area** in which an explosive atmosphere is present continuously for long periods or will frequently occur.)
- Profile data stored at predetermined intervals
- Programmable index read time

- High and low flow rate and daily consumption alarms
- Internal antenna (optional external antenna)
- User-replaceable battery

MacR6 Data Logger

(Figure 18: Mac R6)

- ❖ MacR6 data logger is a volume recorder dedicated to working with diaphragm gas meters.
- ❖ Registered parameters are transmitted to SCADA systems or PLUM eWebtel cloud-platform.
- ❖ MacR6 reacts to alarms situations as following: magnetic interruption, counterchange, battery change, low GSM range, cover opening.
- ❖ The basic version is designed to work in Ex Zone 2. Versions for Zone 0 are also available. MacR6 has a capacity for up to 2 volume monitoring channels and the data is transmitted directly to a SCADA system thanks to the built-in GSM/GPRS 2G/3G modem.
- ❖ The estimated battery life of the device is 5 years with 1 data transmission per day. A fast configuration of the device is made through an Android app.

MacBAT 5

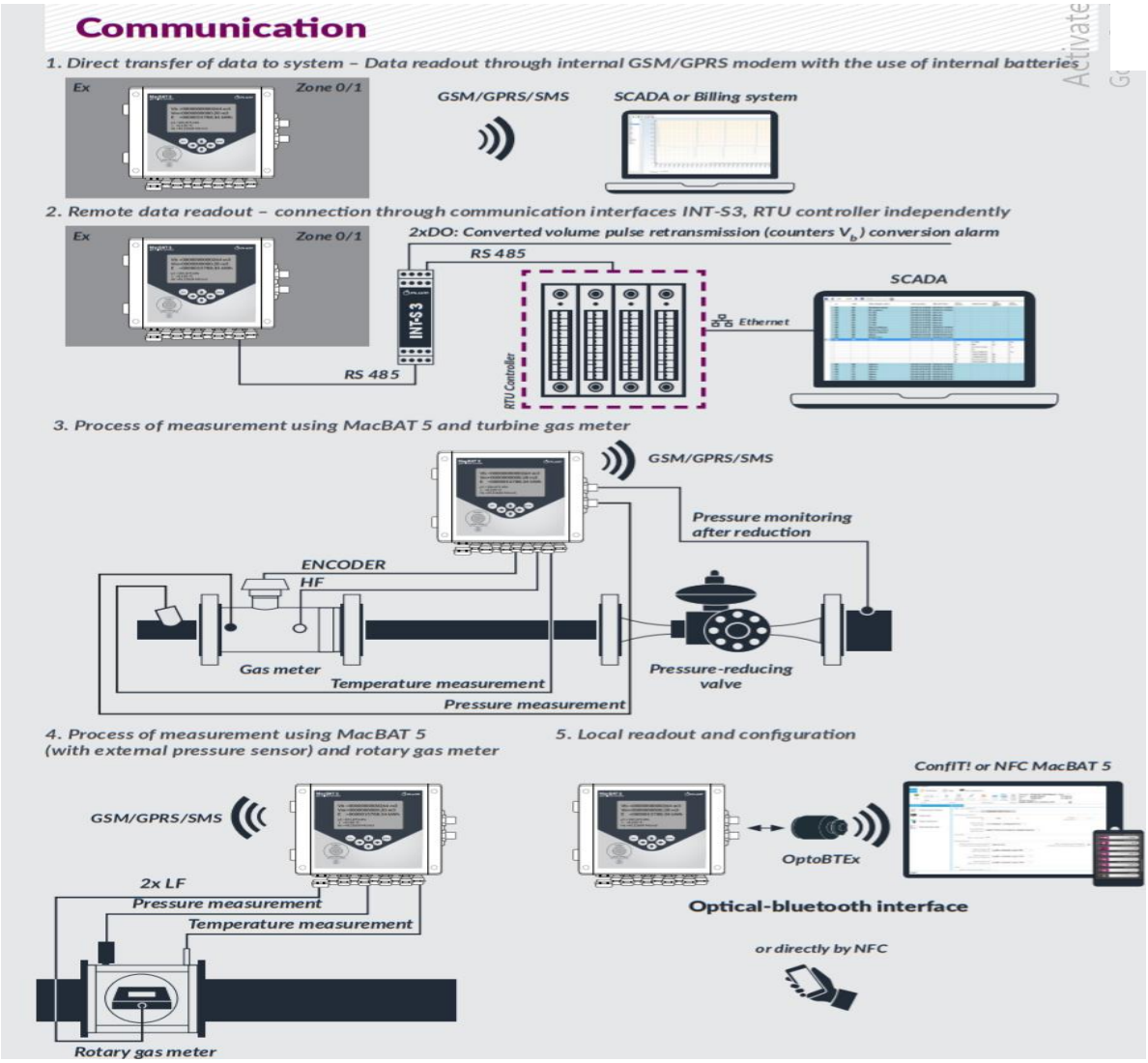
(Figure 19: MacBAT 5)

- ❖ MacBAT 5 is a gas volume corrector that enables PTZ, PT, or T conversion. The device is designed to measure volume, energy, and flow of gas.
- ❖ Primarily battery powered with the possibility to connect the external power supply.
- ❖ The device converts the volume of gas counted by the gas meter (turbine, rotary, ultrasonic) into the base conditions. Gas compressibility factor is calculated with the use of algorithms SGERG-88, MGERG-88, AGA8-92DC, AGA8-G1, AGA8-G2, AGA NX-19 mod or a constant value of relative compression factor.
- ❖ MacBAT 5 is an intrinsically safe device ready to be installed in explosive hazardous zone 0.

Main features of the MacBAT 5:

- Industrial housing cooperates with various types of gas meter like turbine, rotary, ultrasonic directly by LF, HF, Namur, Encoder, and Wiegand.
- 4 independent serial transmission ports
- Built-in GSM/GPRS modem (option)
- Backlight graphic display
- 5 configurable binary Ex inputs
- 2 configurable binary NAMUR Ex inputs (operating on battery mode)
- Binary and frequency outputs

- Internal or external pressure transducers available
- More than 10 years of archive registered data storage (with monthly sampling interval)



(Fig 20: Communication Plan of MacBat5)

❖ IRM energy is also implementing this type of technology by taking a step towards automation and installing Cello 6 V3 - GSM Meter Reader (Gas) and MacR6 Data Logger, taking the feedback of the customer and education the customer about the availability of the technology and its usage.

City Gas Automation:

- For city gas distribution (CGD) companies, efficiency in business operations is essential to remain profitable.
- However, the expanding gas pipeline network and customer base have placed a tremendous burden on the existing infrastructure.
- There have been increased instances of wrong meter readings (either by meter readers or due to faulty meters) and house lock cases being reported, leading to losses in revenue.
- Pipeline leakages and incorrect billing (due to a mismatch between gas supplied and consumed) are some of the other concerns that plague CGD operators.
- In this backdrop, gas utilities have started recognizing the need for business process automation and the use of advanced technologies to bring down costs and increase efficiency.

CNG automation:

1.Goals Of CNG Automation:

- Compilation of Data
- Transmission of Data
- Analysis of Data
- Maintain History
- Elimination of manual error
- Management of Data
- Generation of report
- Decision facilitation

2.Scope Of CNG Automation:

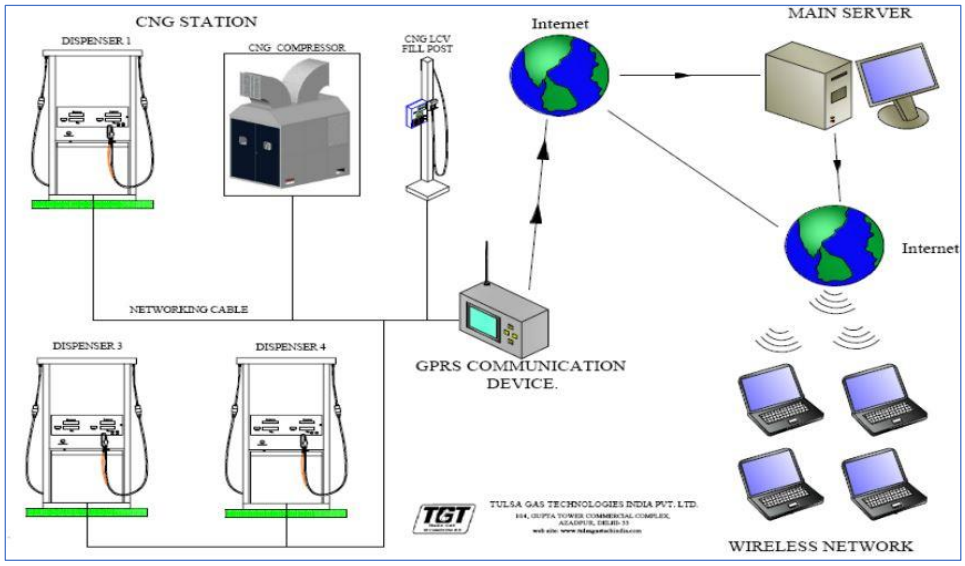
- Measurement of total gas purchase and sale.
- Re-conciliation of gas transmission and sale.
- Safety functionality over the entire gas transmission.
- Data collection and Logging.
- Forecourt Management.
- Logistics Management.
- Cost Analysis.
- Sale Reconciliation and Analysis.

- ❖ Equipment operation data.
- ❖ Rate change control.
- ❖ Remote Alarm and Shutdown.
- ❖ Forecourt cashless transaction.
- ❖ Customer smart relation.
- ❖ Export of Data and Report to financial and other ERP.

3.Process Involved In CNG Automation:

- ❖ The entire stated scope to be automated.
- ❖ The process by a combination of wired and wireless devices.
- ❖ Involves GSM/GPRS/RF Ethernet and other processes.
- ❖ Use of Compatible Software(Scada System)
- ❖ Piecemeal addition for expansion.

CNG Automation Scheme layout :



(Figure 21: Automation scheme Layout)

Requirements:

1. Hardware:

- **WI-ONE :**

  Wi-ONE is the starting point for building wirelessly connected projects- in the same way, that Nanode is a dev-kit for internet-connected devices.

- **RTU:**

  A remote terminal unit (RTU) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA (supervisory control and data acquisition) system by transmitting telemetry data to a master system, and by using messages from the master supervisory system to control connected objects.[1] Other terms that may be used for RTU are remote telemetry units and remote telecontrol unit.

- **Router and SIM**

- **Server**

2. Software:

- **Station Automation**

- **AMR :**

  Automatic meter reading or AMR is the technology of automatically collecting consumption, and status data from Gas & Energy metering devices and transferring that data to a central database for billing troubleshooting and analyzing.

  This advance mainly saves utility providers the expense of periodic trips to each physical location to read ammeter. Another advantage is billing can be based on near real-time consumption rather than on estimates based on previous or predicted consumption. This

timely information coupled with analysis can help both utility providers and customers better control the use and production of consumption.

- SQL: Server Licensing
- CAL: Client Access License

- **Crystal report:**

  - Crystal Reports is a business intelligence application used to create custom reports from a variety of data sources.
  - The package includes the major features needed for a business to create a database reporting environment, such as data access, report design/formatting, report viewing, and application integration.
  - This allows the application to be enterprise-wide, available to users, and to support data reporting from report creation to upload and execution.

Example: Automated control systems in Russia:

❖ Automated control systems ensure the operation of a CNG-station in three modes: automatic, manual, and debugging mode.

❖ The main operational mode of a CNG-station is automatic. The automated control system ensures the following operating modes of a CNG-station:

- Pre-start conditions check
- Waiting for mode
- Start
- Operation
- Normal stop
- Emergency stop without guessing
- Emergency stop without guessing

Automated control systems: structural features

- Automated control system produced in Russia includes: control board for receiving, processing, and distribution of signals (analog, discrete, digital) and performing the following functions:
- Pre-start conditions check;
- Automated and manual start of the equipment;
- Technical parameters control;
- Gas and fire detectors control;
- Power line monitoring;
- Emergency stop with or without outgassing;
- Circuit continuity monitoring.
- Traditionally there is also a server cabinet. This equipment is designed for data receiving, processing, and storing (Ex. Operational reports). Inside the cabinet there are:
- Uninterrupted power supply enabling the operation of the server in case of voltage spikes or blackouts;
- Memory capacity enough to keep a six-month operating archive;
- RAID backup system;
- Server;
- Automated working station;
- KVM switches;
- Software with a user-friendly interface.
- Moreover, a switch cabinet serving for cross-plugging and signal distribution, as well as for cable lead-in from the processing area, and an emergency control and alarm board intended for security features backup are included in the supply package. Another important component of the system is an input and output station intended for control of automation objects located in the outer area as well as for receiving their signals. The station is equipped with:
- Medium level container (Ethernet);

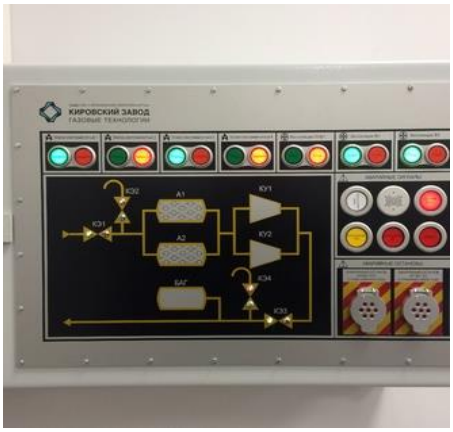
- Intermediate relays;
- Light signaling hardware;
- Automatic switches;
- IS barriers.

Last but not least is the gas fiscal metering cabinet made as a space-saving distribution cabinet. Cabinet configuration:

- Gas volume corrector;
- Power unit;
- IS barriers;
- GSM/GPRS modems;
- Interface converter;
- Set of cables.

Automated control systems: Advantages

- High reliability of CNG-filling stations automated control systems due to application of high quality certified components, supplied by the manufacturers directly or by their recognized agents.
- Possibility of equipment backs up control in the event of failure of the operator's automated working station.
- Close quality control of installation works.
- Convenient and functional equipment design.



(Fig 22: Control System)

SCADA SYSTEM

Supervisory Control and Data Acquisition.

- SCADA is the process by which real-time information is gathered from a remote location for processing and analysis and the process by which equipment is controlled.
- SCADA generally refers to an industrial computer system that monitors and controls a process.
- The industrial process includes those of Manufacturing, Production, power generation, fabrication, and refining and may run in continuous, batch, repetitive, or discrete modes.
- SCADA is a control system architecture comprising computers, networked data communications, and graphical user interface for high-level process supervisory management.
- It is also comprising other peripheral devices like programmable logic controllers and discrete proportional integral derivative controllers to interface with process plants or machinery.

Components of the SCADA System:

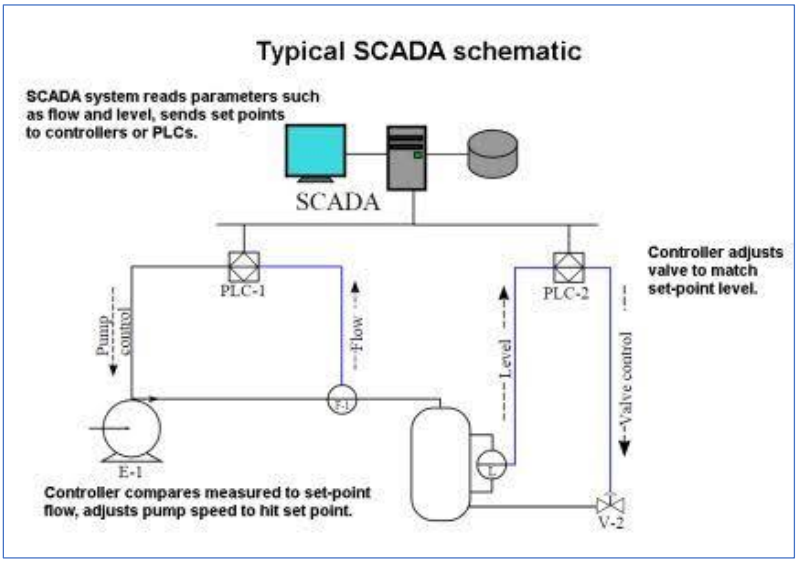
- A human-machine interface is an apparatus that presents process data to a human operator and through this the human operator monitors and controls the process.
- A supervisory system, gathering data on the process, and sending commands to the process.
- Remote terminal units connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory purpose system.
- The programmable logic controller is used as field devices because they are more economical, versatile, flexible, and configurable than special-purpose RTUs.
- Communication infrastructure connecting the supervisory system to the remote terminal units.
- Various process and analytical instrumentation.

SCADA refers to the combination of Telemetry and Data Acquisition.

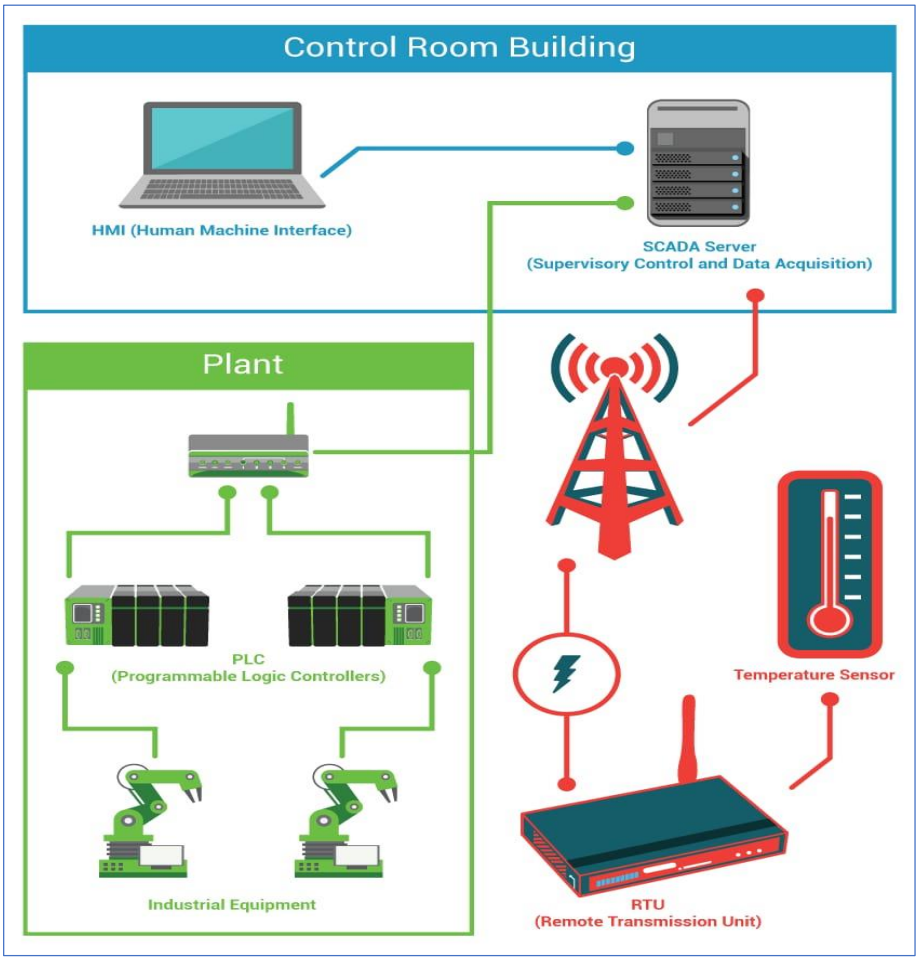
Function:

1. Collecting information
2. Transferring it back to the control site
3. Carrying out necessary analysis and control
4. Displaying this data on several operator screens

- The term SCADA usually refers to centralized systems which monitor and control entire sites of systems spread out over large areas.
- Most control actions are performed automatically by RTUs or by PLCs. Host control function are usually restricted to basic supervisory level intervention,
- Ex: a PLC may control the flow of Gas through part of an industrial process, but the SCADA system may allow operators to change the setpoints for the flow, and enables alarm conditions, such as loss of flow and high pressure, to be displayed and recorded.
- The feedback control loop passes through the RTU and PLC, while the SCADA system monitors the overall performance of the loop.
- Data acquisition begins at the RTUs or PLCs level and includes meter readings and equipment status reports that are communicated to SCADA as required. Data is then compiled and formatted in such a way that a control room operator using the HMI can make supervisory decisions to adjust RTU's control.



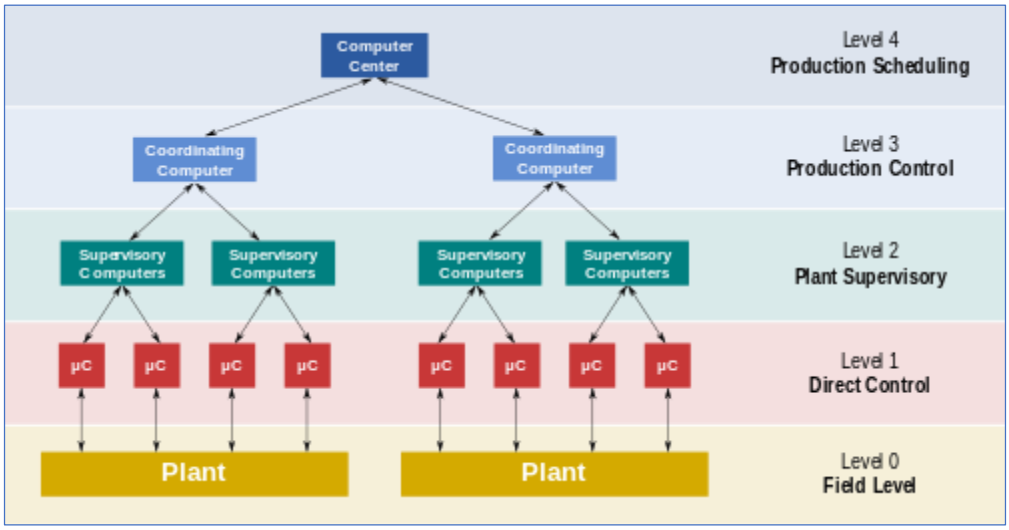
(Figure 23: Schematic diagram of SCADA)



(Figure 24: Basic SCADA System)

Control operations

- The key attribute of a SCADA system is its ability to perform a supervisory operation over a variety of other proprietary devices.
- The accompanying diagram is a general model that shows functional manufacturing levels using computerized control.
- Level 0 contains the field devices such as flow and temperature sensors, and final control elements, such as control valves.
- Level 1 contains the industrialized input/output (I/O) modules, and they are associated with distributed electronic processors.



(Figure 25: Different Control Level Of SCADA)

- Level 2 contains the supervisory computers, which collate information from processor nodes on the system and provide the operator control screens.
- Level 3 is the production control level, which does not directly control the process but is concerned with monitoring production and targets.
- Level 4 is the production scheduling level.

- Level 1 contains the programmable logic controllers (PLCs) or remote terminal units (RTUs).
- Level 2 contains the SCADA to readings and equipment status reports that are communicated to level 2 SCADA as required.
- Data is then compiled and formatted in such a way that a control room operator using the HMI (Human Machine Interface) can make supervisory decisions to adjust or override normal RTU (PLC) controls.
- Data may also be fed to a historian, often built on a commodity database management system, to allow trending and another analytical auditing.
- SCADA systems typically use a *tag database*, which contains data elements called *tags* or *points*, which relate to specific instrumentation or actuators within the processing system.
- Data is accumulated against these unique process control equipment tag references.

Benefits and Drawbacks of SCADA System.

Benefits	Drawbacks
Reduce Pipeline maintenance	Challenges in integrating, managing, and debugging wireless instrumentation networks with communication infrastructure
Improves efficiency of pipeline management	Security concern about virus attack through the internet
Ensures more environmental protection	Possibility of data interpretation, alteration, re-transmission
Reduces manpower requirements	Increased traffic on networks
Maximize equipment lifetime	

Use of SCADA by key CGD players

- Many CGD companies have installed SCADA technology and are using it extensively for their gas operations.
- Reliance Gas Transportation Infrastructure Limited (RGTIL), GAIL (India) Limited, Adani Gas Limited, Gujarat State Petronet Limited (GSPL), Haryana City Gas Distribution Limited, Indraprastha Gas Limited (IGL), Mahanagar Gas Limited (MGL), and Assam Gas Company Limited are the major players in the CGD segment.
- Meanwhile, GSPL's gas grid is equipped with the latest bidirectional gas transmission technology to enable a two-way gas flow.
- RGTIL uses a state-of-the-art SCADA system on the East-West Gas Pipeline, which transports gas from Kakinada (Andhra Pradesh) to Bharuch (Gujarat). The company has deployed an optical fiber cable-based telecommunication system for effective long-distance communication.
- The network is continuously monitored through SCADA systems integrated with geographic information system technology.
- GAIL has also implemented a centralized SCADA system using the FAST/TOOLS data communication package for all its natural gas pipeline networks.
- It relies on dual redundant front-end processor servers for uninterrupted monitoring and control.

- SCADA is even being used globally by major gas companies. For instance, the supervision of more than 200,000 km of Russia's pipeline network is done through a SCADA system.
- The lessons gained by Turkey's largest gas distribution firm, IGDAS, from implementing a SCADA system have helped detect gas failures in real-time and enabled their immediate rectification.

REMOTE TERMINAL UNIT (RTU)

- The Remote Terminal Unit (RTU), shall be installed at Substations to acquire analog data required for city gas applications such as pressure reduction stations, storage stations, gate stations, and metering stations at each Sub-Station under this scope of work and transfer that information to the data server.

- RTU shall also be used for control of station devices from the Master station. Necessary database creation at the main station for the integration of RTU with control Centre i.e. main station is also included under this scope of work.

- Also that each substation under the scope of this project shall have a PC based Local Data Monitoring System (LDMS).

- These PCs shall be used for acquisition, monitoring of various gas flow parameters, and generation of reports and log sheets in line with the requirements of the specification.

- The supplied RTUs shall be interfaced with the Control & Relay (C&R) panels, communication equipment, gas supply distribution boards.

RTU Function :

- Near real-time Device to Server communication.
- Capability to communicate up to 9 dispensers simultaneously.
- Front panel Alphanumerical LCD and mode configuration.
- Error Detection and reporting.
- Inbuilt EEPROM, 72000 cycle data storage.
- Communication protocol – o RS232 o RS485
- Transceiver data to Server using a 4G/3G/2G compatible module.
- Variable Supply Voltage Range 7-40v.
- Battery supported
- Multiple standalone channels for RS485.
- 20 analog input / Digital IO.
- Server Publish, request, and Rate change feature.
- Dual sim Support for GSM.

Architecture:

- An RTU may consist of one complex circuit card consisting of various sections needed to do a custom-fitted function, or may consist of many circuit cards including a CPU or processing with a communications interface(s), and one or more of the following:
- (AI) analog input,
- (DI) digital (status) input, (DO/CO) digital (or control relay) output,
- or (AO) analog output card(s).

- An RTU might even be a small process control unit with a small database for PID, Alarming, Filtering, Trending and other functions complemented with some (programming language) tasks.
- Modern RTUs typically support the IEC 61131-3 programming standard for programmable logic controllers. Since RTUs may be routinely deployed in pipeline and grid guarding systems, or in other hard-to-reach or extreme environments, they are required to operate under harsh conditions and implement energy-saving measures (such as switching off IO modules when not in use).

1. Power Supply:

- A form of power supply will be included for operation from the AC mains for various CPU, status wetting voltages, and other interface cards.
- This may consist of AC to DC converters where operated from a station battery system. RTUs may include a battery and charger circuitry to continue operation in event of AC power failure for critical applications where a station battery is not available.
- It does not have moving parts and uses extremely low power and is often solar-powered.

2. Digital status input:

- Most RTUs incorporates an input section or input status cards to acquire two state real-world information.

- This is usually accomplished by using an isolated voltage or current source to sense the position of a remote contact (open or closed) at the RTU site.
- This contact position may represent many different devices, including electrical breakers, liquid valve positions, alarm conditions, and mechanical positions of devices. Counter inputs are optional.

3. Analog inputs :

- An RTU can monitor analog inputs of different types including 0-1 mA, 4–20 mA current loop, 0–10 V., ±2.5 V, ±5.0 V, etc.
- Many RTU inputs buffer larger quantities via transducers to convert and isolate real-world quantities from sensitive RTU input levels.
- An RTU can also receive analog data via a communication system from a master or IED (intelligent electronic device) sending data values to it.
- The RTU or host system translates and scales this raw data into the appropriate units such as the quantity of water left, temperature degrees, or Megawatts, before presenting the data to the user via the human-machine interface.

4. Digital output:

- While not as commonly used, analog outputs may be included to control devices that require varying quantities, such as graphic recording instruments (strip charts). Summed or processed data quantities may be generated in a master SCADA system and output for display locally or remotely, wherever needed.

5. Software and logic control:

- Modern RTUs are usually capable of executing simple programs autonomously without involving the host computers of the DCS or SCADA system to simplify deployment and to provide redundancy for safety reasons.

- An RTU in a modern water management system will typically have code to modify its behavior when physical override switches on the RTU are toggled during maintenance by maintenance personnel.
- This is done for safety reasons; a miscommunication between the system operators and the maintenance personnel could cause system operators to mistakenly enable power to a water pump when it is being replaced, for example.
- Maintenance personnel should have any equipment they are working on disconnected from power and locked to prevent damage and/or injury.

6. Communication:

- An RTU may be interfaced with multiple master stations and IEDs (Intelligent Electronic Devices) with different communication protocols (usually serial (RS232, RS485, RS422) or Ethernet).
- An RTU may support standard protocols (Modbus, IEC 60870-5-101/103/104, DNP3, IEC 60870-6-ICCP, IEC 61850, etc.) to interface any third-party software.
- Data transfer may be initiated from either end using various techniques to ensure synchronization with minimal data traffic.
- The master may poll its subordinate unit (Master to RTU or RTU to IED) for changes of data periodically. Analog value changes will usually be reported only on changes outside a set limit from the last transmitted value.
- Digital (status) values observe a similar technique and only transmit groups (bytes) when one included point (bit) changes.
- Another method used is where a subordinate unit initiates an update of data upon a predetermined change in analog or digital data.
- Complete data transmission must be performed periodically, with either method, to ensure full synchronization and eliminate stale data.
- Most communication protocols support both methods, programmable by the installer.
- Multiple RTUs or IEDs may share a communications line, in a multi-drop scheme, as units are addressed uniquely and only respond to their polls and commands.

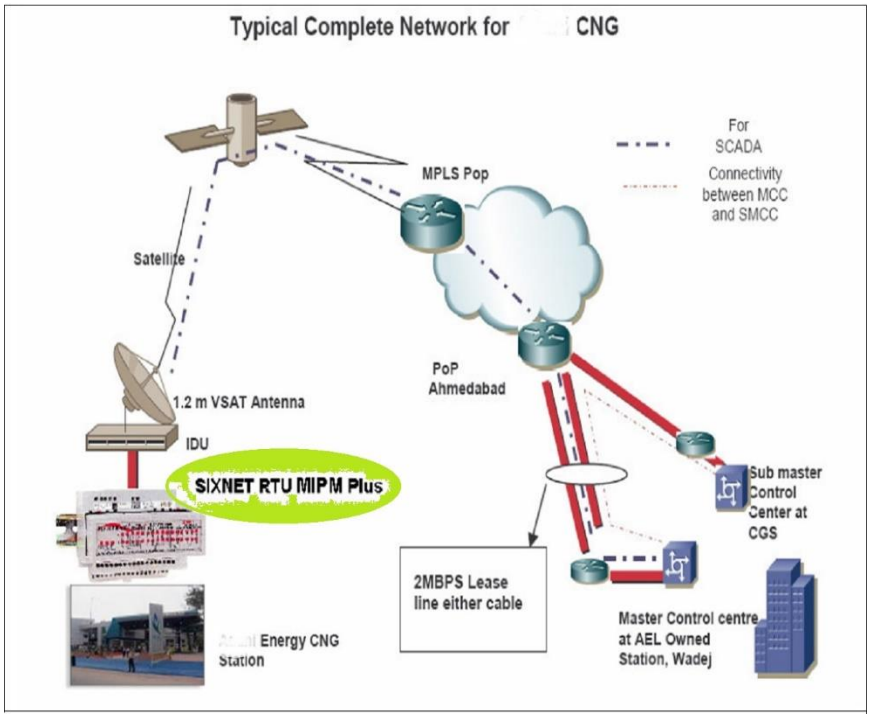
IED(intelligent Electronic Device) communications

- IED communications transfer data between the RTU and an IED.
- This can eliminate the need for many hardware status inputs, analog inputs, and relay outputs in the RTU.
- Communications are accomplished by copper or fiber optics lines.

Master Communication:

- Master communications usually occur between an RTU and a larger control system or a data collection system (incorporated into a larger system).
- Data may be moved using a copper, fiber optic, or radio frequency communication system.

➢ **Typical Complete Network For CNG:**



(Figure 26: Typical Complete network for CNG)

The flow of information from Dispensers to Master Control Centre

CNG Station comprises of Compressor and Dispensers which communicate on Modbus RTU protocol and interconnected with RS-485Profibus 2- wire cable.

Generally, dispensers communicate with their proprietary protocol and needs to be converted to Modbus RTU protocol by installing Protocol Converters in each dispenser.

The dispenser data is processed at compressor PLC (programmable logic controller) and send to the modem along with compressor data on Modbus RTU encapsulated in Ethernet protocol. The compressor PLC and Modem is interconnected with CAT 6 cable.

The total compressor and dispenser real time data is then send to centralized Master Control Room server through Modem via VSAT/ Radio Frequency/ GPRS/ Wired Broadband communication network.

it is also opting for SCADA system redundancy at CNG Station by installing additional Local RTU with GPRS Modem, so even if compressor PLC or Primary Modem fails the local RTU or GPRS Modem will take over accordingly.

GIS – Geographical Information System

A framework to organize, communicate and understand the science of our world.

GIS can show many different kinds of data on one map, such as streets, buildings, and vegetation. This enables people to more easily see, analyze, and understand patterns and relationships.

- A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.
- GIS is used as a tool in both problem solving and decision-making processes, as well as for the visualization of data in a spatial environment (Map).
- GIS has 5 key factors i.e Hardware, Software, Data, People, and analysis to prepare different reports.
- GIS Maps are also facilitated to other statuary auditors/ Companies on request.
- GIS and Synergee (network planning software) integration for planning/extending the current Gas Pipeline network and determining capacity utilization of different sections of pipeline to achieve maximum utilization of existing Pipeline.
- Identification of isolation valve in upstream and downstream in case of planned or unplanned outages/leakages to isolate the section of pipeline to reduce gas loss.

Map and Mapmaking:

A map is a representation or a drawing of the earth's surface, or a part of it, on a flat surface, according to a scale. It could be hand-drawn or printed. Cartography is the art and science of making maps and charts.

- Until the first high-altitude photographs were taken, the principal methods of cartography have been the same throughout the entire history.
- If you can measure distances and angles, you have everything you need to map the world - this is the main focus of geodesy. Cartography then is just a trivial visual representation of geodetic data.

There is 3 method used for mapmaking.

Triangulation:

- Triangulation is the process of determining the location of a point by measuring only angles to it from known points at either end of a fixed baseline, rather than measuring distances

Modern total station:

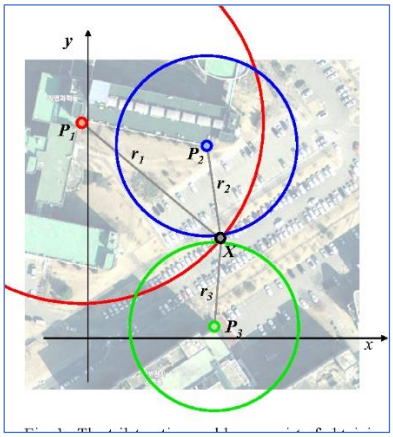
- A typical total station uses an infrared laser to measure distances and uses an onboard electronic theodolite to calculate angles to reference points.
- It is used for a variety of survey purposes, including the mapping of archaeological sites and features, as well as the laying out of datum points and excavation grids.

(Figure 27: Modern Total Station)

Trilateration:

Trilateration is defined as the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres, or triangles.

The angle is not required for this method.
In surveying, trilateration is a specific technique. The term true range of multi alterations is accurate, general, and unambiguous.



(**Fig 28: Trilateration of small GA)**

Types of Map Projection

The process of creating map projections is best illustrated by positioning a light source inside a transparent globe on which opaque earth features are placed. Then project the feature outlines onto a two-dimensional flat piece of paper.

There are mainly three types of map projection:

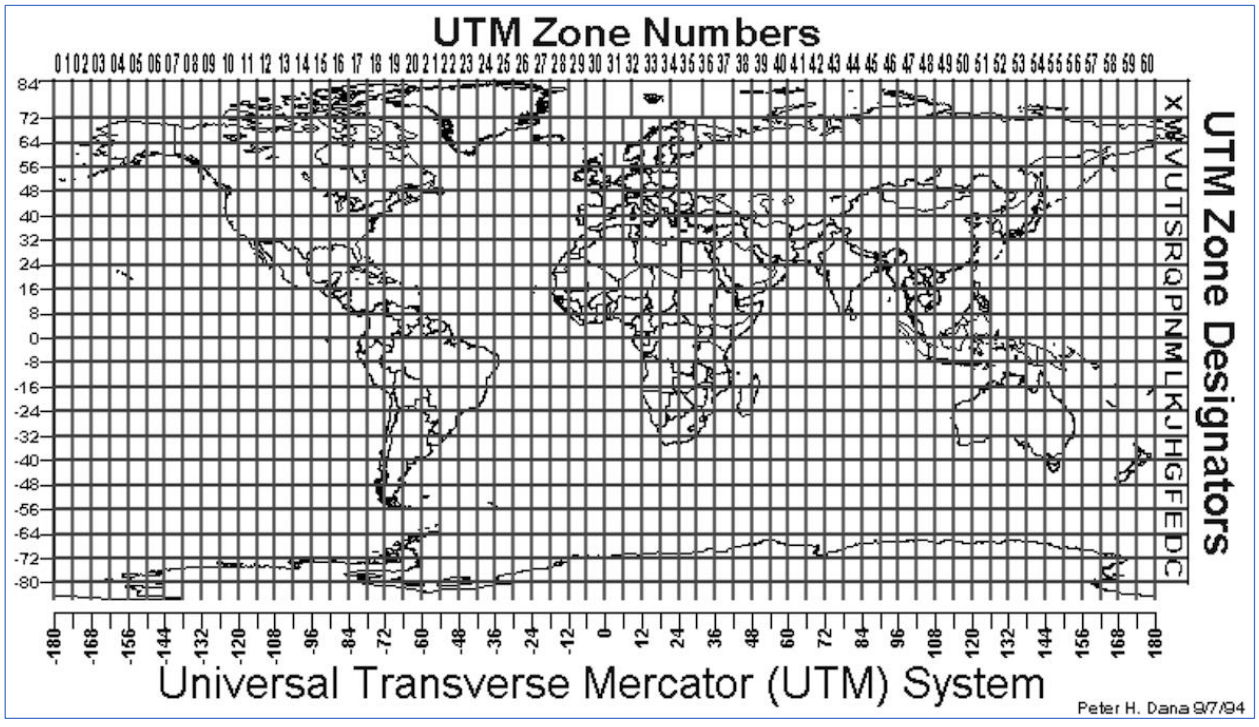
Cylindrical

Azimuthal

Conic

UTM(Universal Transverse Mercator) projection system:

- The Universal Transverse Mercator (UTM) is a system for assigning coordinates to locations on the surface of the Earth.
- As the traditional method of latitude and longitude, it is a horizontal position representation, which means it ignores altitude and treats the earth as a perfect ellipsoid.
- However, it differs from global latitude/longitude in that it divides the earth into 60 zones and projects each to the plane as a basis for its coordinates. Specifying a location means specifying the zone and the *x*, *y* coordinate in that plane. The projection from spheroid to a UTM zone is some parameterization of the transverse Mercator projection.
- The parameters vary by nation or region or mapping system.

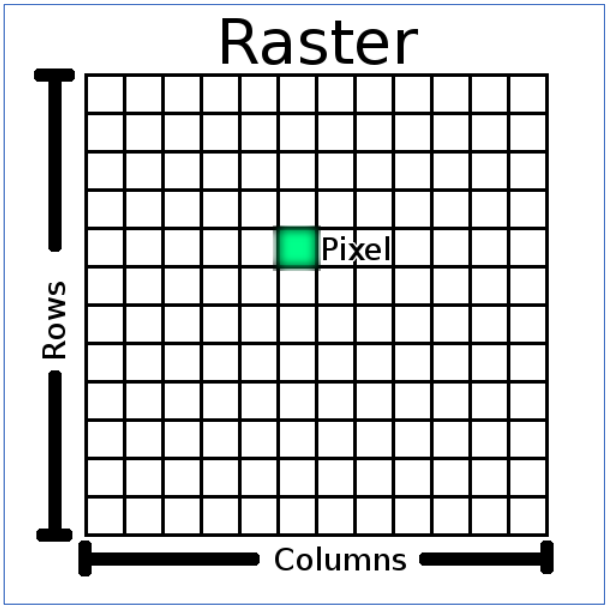


(Figure 29: UTM System)

SPATIAL DATA TYPES IN MAP

Raster data:

- Raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as temperature.
- Raster is digital aerial photographs, imagery from satellites, digital pictures, or even scanned maps.
- Raster data, use a matrix of square areas to define where features are located
- Equal sized square (pixel) is used
- Typically are of uniform size
- Describe interiors rather than boundaries
- Raster data are well suited for capturing, storing, and analyzing data such as elevation, temperature, soil pH, etc
- Raster data formats also are used to store aerial and satellite imagery



(Figure 30: Raster Data)

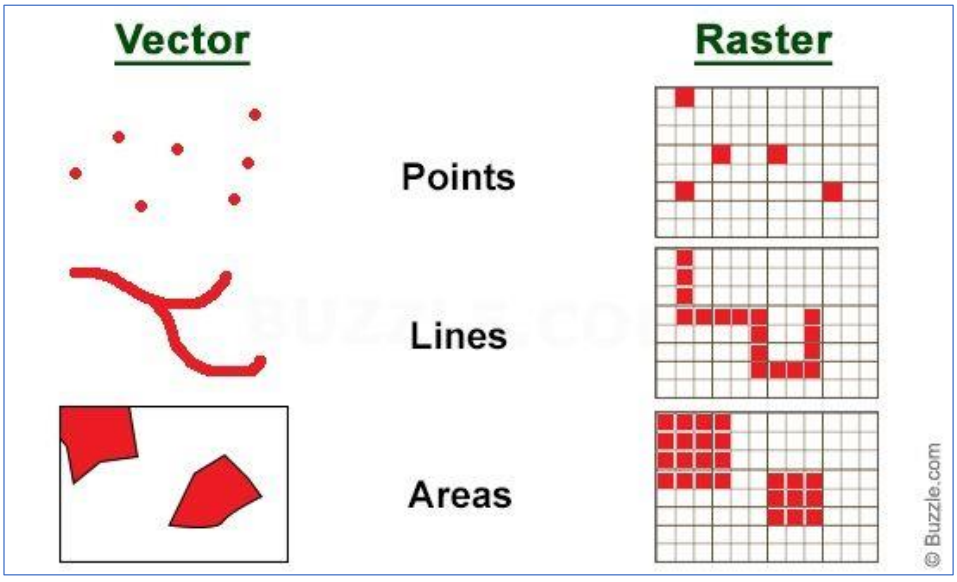
Vector data:

A representation of the world using points, lines, and polygons. These data are created by digitizing the base data.

They store information in x, y coordinates. Vectors models are used to store data, which have discrete boundaries like country borders, land parcels, and roads.

Vector data use X and Y coordinates to define the locations of point

- Points, lines, and areas (polygons) correspond to map features
- Generally not of uniform size
- Vector data tend to define centers and edges of features
- Vector data are excellent for capturing and storing spatial details
- Optimal Utilization of Resources and Assets



(Figure 31: Vector and Raster Data)

TYPES OF DRAWING USED IN CGD (VECTOR DATA)

AS-BUILT/ALIGNMENT SHEET:

- Alignment sheets or drawings graphically show the exact route and location of the pipeline and associated facilities and all the knowledge that exists for a pipeline when it is being designed.
- Hence they are a vital set of documents for maintenance, recovery, etc.
- Blueprint showing the exact route of the pipeline and virtually all the knowledge that existed for that pipeline when built located.
- Topographical features such as type of soil, hilly, rolling hills, wetlands, etc.
- Important reference points are used to locate pipelines.
- Provide data for underground pipeline and above ground equipment
- Can be customized to represent relevant data
- Drawn to a scale

Isometric Drawing:

Isometric drawing is a type of 3D drawing that is set out using 30-degree angles. It's a type of axonometric drawing in which the same scale is used for every axis, resulting in a non-distorted image

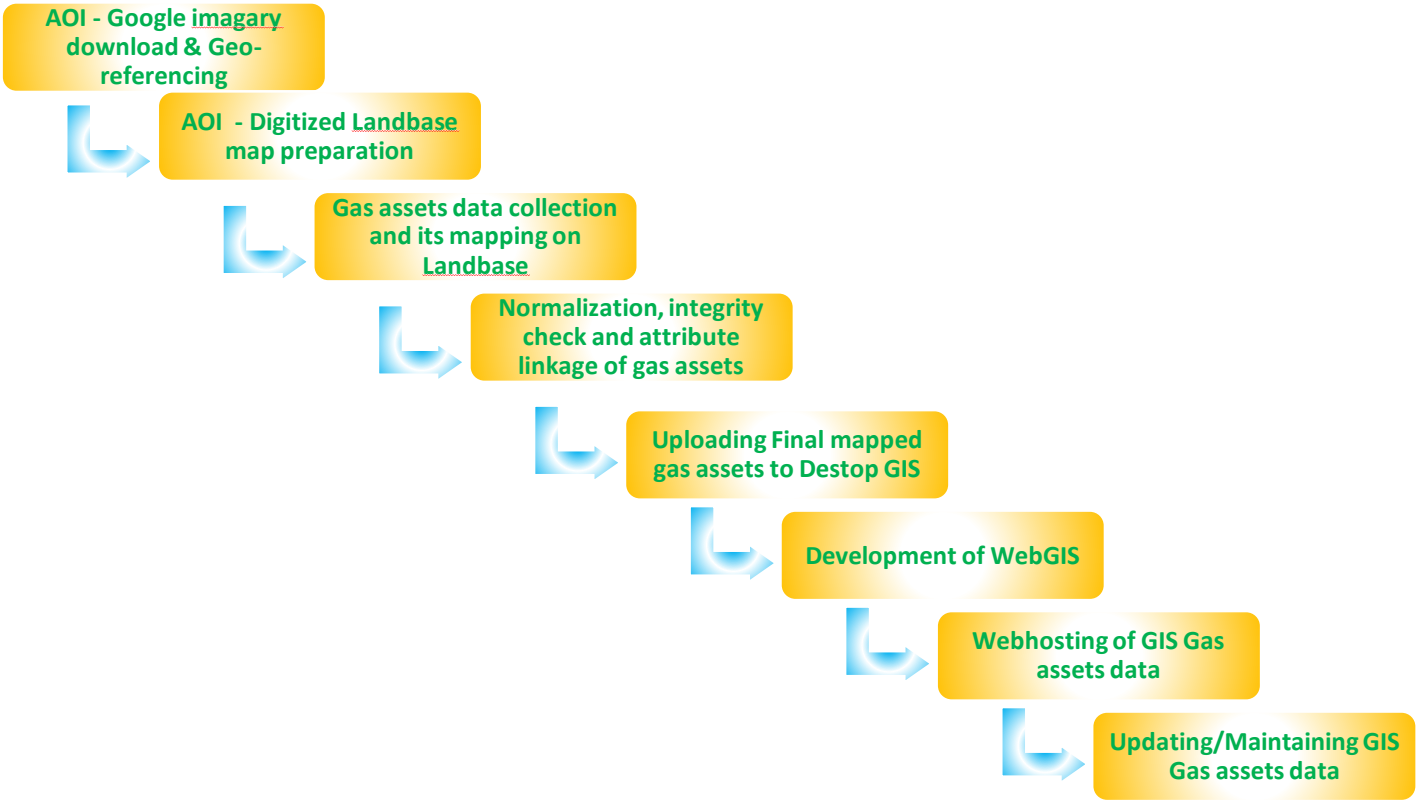
Isometric drawing in itself is a 2-D drawing but represents a 3-D piping system. Angle b/w any two-axis is 120°.

- Provide detailed & accurate dimension of a piping system
- Generally not of uniform size
- Combining height-width-depth/length into a single view at 30◦ forms a horizontal plane
- Not a scale drawing, however, it is proportional with exact dimensions given

GIS implementation:

Pipeline	Gas asset	Customer
GIS Mapping & MDPE line	Critical Gas assets on GIS like CGS, CNG, Pipe, DRS, MRS, SR, etc.	Geotagged customer & related non-spatial information

Creating Customized GIS Gas Asset Data Model



Gas Assets On GIS

- Metallic Steel Pipeline
- PE Pipeline
- MS Valve & PE Valve
- Service Regulator (SR)
- Meter Regulator Skid (MRS)
- District Regulator Skid (DRS)
- City Gate Station (CGS)
- CNG Stations
- Compressor
- Dispensers
- Customer – Domestic, Commercial, Industrial
- Decompression Skid
- Elbow
- End Cap
- Tee, Reduce Tee
- Saddle
- Reducer
- Coupler
- Transition Fittings
- Test Lead Point (TLP)
- Warning Markers & Route Markers
- Cascades

GIS Value Addition

- User Management
- Gas Asset & Land Base Module
- Gas Editor Module
- Map Sharing Module – Local Administration & DDMA
- Planning Module
- Outage Analysis Module
- Emergency Response Module – Android & web Synced

Land Base on GIS

- All land base features shall be mapped on GIS in different layer forms using satellite image and secondary data available.
- This will mostly include roads and its associated features, landforms, building footprints, water bodies, etc. (around 30 + layers)
- Prior mapping helps in route planning and feasibility check.

Gas Asset on GIS

- All Gas assets considered to be mapped in the Data Model shall be reflected in the Gas Asset Map View Module.
- Users can view associated attributes attached to the gas asset for information and planning purposes.

Editor Module

- This Module shall be used to check the gas network integrity for its correctness, as per Gas and GIS topology.
- Specialized Plugins shall be developed to check and correct the data using machine-based algorithms.
- Editing functions are used to add, delete, or manipulate the geographic position of features.
- Sliver or splinter polygons are thin polygons that occur along the borders of polygons following digitizing and the topological overlay of two or more coverages.

- Address Matching is a mechanism used to integrate two files using their features' respective addresses as the common item.
- Geographic coordinates and attributes can be transferred from one address to the other.
- Plugin Developed for Gas Assets only
- Checks gas network and gas flow using Plugin
- Identified errors based on Gas Topology using an algorithm developed
- Manual Correction of Data based on Gas Topology Rules
- GIS-based editing (add, delete, modify) and adding attributes as per Data Model
- Create New Layer

Outage Analysis

- This Feature Helps Engineers to find SR/Customer getting affected due to a pipeline breach reported, with few mouse clicks.
- The Tool can fetch records of SR/Customers and can flash Notifications to end-users about the Outage & its duration. The Tool is capable of tracing Downstream Customers and Upstream DRS.
- The outage analysis system (OAS) serves as the graphical focal point for information on the distribution networks.
- OAS is the tool for the creation and maintenance of the feeder connectivity model which traces the electric connection from the substation to the customer.

Valve Analysis

- Valve Analysis helps in defining endpoints getting affected after the closure of the Valve
- The Valve Isolation module is the ideal tool to simulate the isolation of user-defined areas of a distribution network for maintenance, emergency planning, or other operational needs.

To determine the isolation, information is pushed to a geoprocessing tool to run the analysis and process the results.

Commissioning Year/DRS

- This tool is based upon Data Model definitions set in the Blueprint Document where Gas Pipelines can be segregated based upon the year of commissioning, Material, or DRS for Planning purposes.

Segregation of MRS by Business Type

- This Tool is highly effective in differentiating Industries based upon their type of business, like hazardous, non-hazardous, for planning and during an emergency.
- This segregation can be further done for the region or user-defined area.

Buffer Analysis

- Tracking Gas Assets/ Consumers based upon Buffer Distance and proposing plans accordingly.
- The Buffer tool creates a new coverage of buffer polygons around specified input coverage features.
- Features can be polygons, lines, points, or nodes. You can use the Buffer tool to identify or define an area within a specified distance around a feature.

Vulnerable Area Marking

- All vulnerable areas (bridges, crossings, railway crossings) can be pre-identified and marked on GIS for better maintenance and preventive measure planning.

Spatial Search-Based Area

- This tool can be best utilized to identify on a map, critical utilities like the police station, fire station, hospitals, and their list during an emergency.
- This tool can also be utilized to locate CNG Stations, DRS, Customers, SR, MRS for a defined geographic boundary or user-generated boundary on the fly.

WebGIS Dashboard

- WebGIS is developed with basic functionalities such as Map navigation (zoom-in, zoom out, pan), customized visualization of gas assets on a GIS map, Simple query tools, Search tools, Geo-coordinate locator tools, Measurement tools, etc.
- The dashboard tool provide the details of GIS data.

Android Based Event Reporting System

- This Module has been designed for ground technicians who can use mobiles or tablets to mark and close leak/incidents of gas escape, received in the control room, the control room operator just needs to create an Event ID, and it is automatically pushed as notification to the Ground Technician of the said area. Events of Dig can also be reported via Android device, synced to Web GIS System.

Area Wise Analytics

- This tool shall help Engineers and Senior Management to View area wise charged and uncharged customers thereby giving them potential customer data. This tool can further be utilized for viewing distribution of contracting agencies for various gas assets.

Map Sharing Module

This tool can be used in three ways;

1. Share/Sell restricted gas asset data to Third Party Utility Companies.
2. Share restricted gas asset data to Local Administration or DDMA via WMS Services or by creating a Temporary Guest User.
3. Share restricted data with geo-position in KML file format.

Advantages of GIS In CGD:

- GIS helps in asset management by locating pipeline assets such as main and service lines by tracking their coordinates and calculating their relative distances.
- Leak management and analysis is swifter as GIS provides faster response time in case of a leak or an accident, by sharing the information of the incident to the response team.
- GIS stores consumer data and various thematic maps can be prepared to identify future potential consumers and plan the pipeline network accordingly.
- Study of demand and supply of consumers through survey and mapping can help in the expansion planning of the pipeline network and prediction of the future growth can be accessed.
- To produce calculations such as pressure, inlet quantity of the gas etc., as well as to generate maps and BoM showing various design parameters at all nodes and lines.
- Network size critically designed to ensure supply pressure at consumer & intermediate points without over/ under sizing any element.
- Flexibility to change the design to suit the site conditions.
- Ability to manually adjust the automatically calculated locations.
- For operations and maintenance, it is important to identify weak sections of the pipeline and to replace the segment to prevent a leak or an accident. Pipes made of steel or iron are subject to rust due to environmental factors which needs to undergo cathodic protection.
- Optimal DPRS location, service area & routing for substantial cost saving.
- Plan route to ensure maximum reach with minimum length.
- Reduce the network design time.
- Maintenance affordable
- Data sharing to local administration made easy.

Five component of GIS

A working GIS integrates five key components: hardware, software, data, people, and methods**.**

- Hardware. Hardware is the computer on which a GIS operates. Computers, Networks, Peripheral devices like Printers, plotters, digitizers.

- Software. GIS software, Database software, OS software, Network software. GIS software provides the functions and tools needed to store, analyze, and display geographic information.

- Data. Vector data, Raster data, image data, Attribute data.

- People. GIS technology is clearly of limited value without people to manage the system and to develop plans for applying it. People like, Administrators, managers, GIS technician, End users, Consumers.

- Methods. Methods like, Guidelines, Specifications, Standards, Procedures.

Software of GIS :

- ArcGIS (Esri) ArcGIS 9.x. ...
- 2 Geo media (Hexagon Geospatial) Geo media has been the main rival to ArcGIS for years, even decades. ...
- 3 MapInfo Professional (Pitney Bowes) ...
- 4 Global Mapper (Blue Marble) ...
- 5 Manifold GIS (Manifold) ...
- 6 Small world (General Electric) ...
- 7 Bentley Map. ...
- 8 Map Viewer and Surfer (Golden Software)

Some objectives of GIS solution

- **Information management**:

  - GIS enables the gas industry in managing pipe network information, device information, user information, economic information and environment information.

- **Integrity management:**

  Gas distribution companies constantly face several risks in the form of leakages, corrosion, excavation damages and unplanned outages. Against this backdrop, it is essential for CGD companies to tackle integrity requirement. For this, GIS technology helps utilities understand the existing network elements such as mains, service valves, regulators, and cathodic sections and meters. It proves information about the material used for piping, diameter, operating pressure and leaks in pipes and maintains history.

- **Leak management:**

  ❖ GIS technology provides leak survey tools that allows a gas utility to administer leakage in the distribution system. Leaks are plotted on digital GIS maps, and leak repair schedules can be automatically generated and sent to repair crews located nearest to a leak.

- **Risk management:**

  ❖ GIS identifies exposed pipes in a particular location. If CGD companies expect the demand for gas to increase in this location, they can make prior plans to replace the vulnerable pipes and reduce the risk damage.

- **Corrosion management:**

  ❖ Underground gas distribution pipes are prone to corrosion due to their proximity to the earth.
  ❖ This requires steel pipelines to be cathodically protected. In this case, GIS technology proves companies are visual display of those pipe segments that are covered by cathodic protection and those that are not.

Digital Technology Initiatives in CGD For Improving Effectiveness of Control Room

Why need control room:

- Control room ensure the monitoring check calls, responding to telephone and email queries and a variety of administration duties. This will include compliance, statutory, contractual and company regulations and processes.

For emergency:

- Control rooms are one of the aspects of an extensive emergency management system which operators use to ensure that they are quickly notified when something unusual is detected.

For monitoring:

- Control room is known as Eyes and Ears of CGD industry.
- It is ensuring the activity of station by maintaining general information by Control room.

Real Time Complaint Logging:

- Control room operators receives complaints 24x7 and logs them in PNGNet software.
- Main motto of control room to solve that complaint immediately so that it wouldn't affect the other area of supply.

Types of complaints and request received at Control room

Normal complaint

1. Gas stop
2. Gas smell
3. Low/High pressure

Emergency complaint

1. Fire
2. Explosion
3. Line damage

After sales services

1. Alteration & Modification
2. Extra points.
3. TDC
4. Reconnection
5. PDC

Role of Third Parties at a excavation activities to be carried out near gas pipelines

As per the guidliance of PNGRB every company have their own bidding round for the third party contract.
If we talk about in general then the main points are as under:

- Third parties contractor have all the information regarding excavation for landing gas pipeline.
- Company will select the third parties after bidding round because every company will see their benefit so that better prospective can be gained.
- Company told third parties for their requirement from them and also company instruct two men from their company for the daily report work of third parties.
- Company provides money and then third parties manage all the activity of laying pipelines.
- Foe the excavation third parties contractor manage JCB and workers and trenching equipment reqire for excavation and there should be some technician we take care about environmental aspects and prevent hazards to mens and environment.
- And they have to manage data, because if there is any government pipeline of water or any obstacles like river, road, house etc.
- So, third parties need to be manage all this things for excavation activity near gas pipelines.

Control room activities:

- Receiving Complaints
- Control room receives complaints and forwards them to respective person

Real Time Complaint Logging And Documentation

- Received complaints are logged in PNGNet software and are updated in complaint register. Hard copy as well as Soft copy.

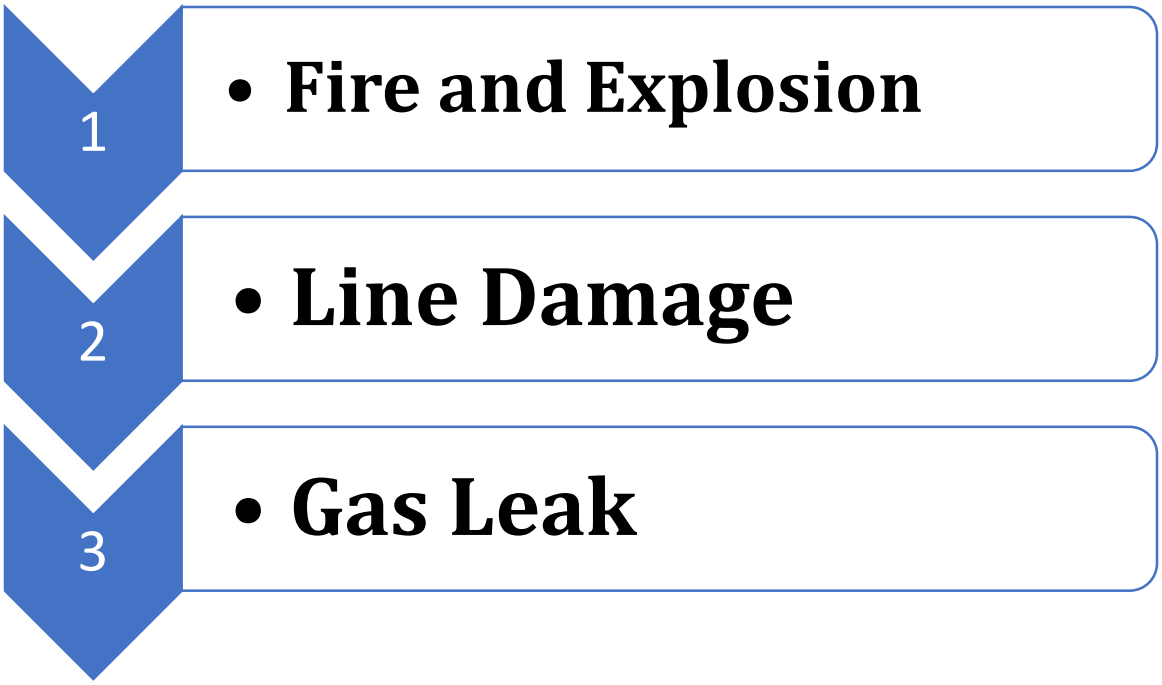
Customer Queries

- Control room operator solves customers queries up to customer satisfaction.

Emergency Handling

- Receives emergency complaints and forward it to respective person on immediate basis.

Types of Emergency:

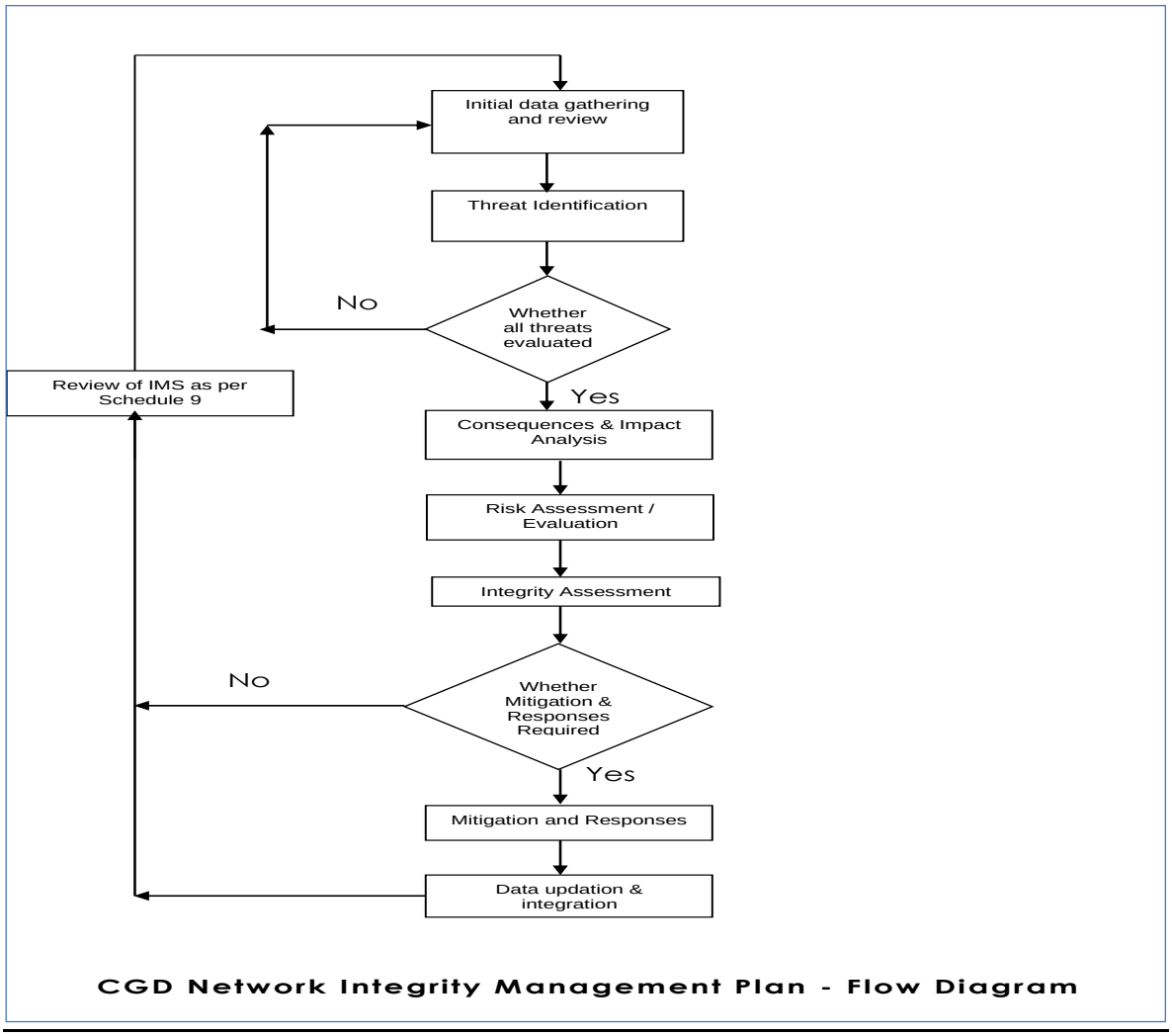


In case of line damage or fire:

- In case of emergency control room operator immediately transfer the complaint to respective site location.
- Emergency team reach the location in that time control room operator analyse the valve and affected customers in Web GIS.
- Control room operator guide the team to which valve should be closed using the Web GIS.
- After closing the valve emergency team close the emergency using suitable resources in mean time control room operator message all the affected customer regarding emergency.
- After closing the complaint team inform to control room operator. Once gas supply start the operator send the effected customers message regarding resumes the gas supply.

INTEGRITY MANAGEMENT SYSTEM

- Every natural gas/city gas distribution pipeline primary focus shall be on operation and maintenance of natural gas pipeline in such a way that it would continuously provide un-interrupted services to customers with utmost reliability and safety without any untoward incident which can adversely impact the environment.
- A pipeline Integrity Management System shall provide a comprehensive and structured framework for assessment of pipeline condition, likely threats, risk assessment and mitigation actions to ensure safe and incident free operation of the pipeline system.



(Figure 32: Flow Diagram Of IMS)

Objective of Integrity Management System

i) evaluating the risk associated with city gas distribution networks and effectively allocating resources for prevention, detection and mitigation activities;
ii) improving the safety of city gas distribution networks so as to protect the personnel, property, public and environment;
iii) bringing more streamlined and effective operations to minimize the probability of CGD network failure.
iv) The objective of Integrity Management System (IMS) is to ensure the integrity of CGD networks at all times to ensure public protection of environment, maximum availability of CGD networks and also minimizing business risks associated with operations of gas network.

Why Integrity Management System ?

- CGD network comprises of important assets transporting flammable gas under pressure within the densely inhabited areas. As such, they expose people, communities and the environment to risks in case of failure.
- On the other hand, CGD network are themselves exposed to external damages caused by third parties and in many cases such external damages are the main cause for network failure.
- a system is introduced which ensures maximum availability of the network with minimum disruption and damages.
- An Integrity Management System for CGD networks provides a comprehensive and structured framework for assessment of CGD networks condition, likely threats, risks assessment and mitigation actions to ensure safe and incident free operation of CGD networks.

5 Elements of Integrity Management System

Integrity Management Plan (IMP):

- This encompasses collection and validation of data, assessment of spectrum of risks, risk ranking, assessment of integrity with reference to risks, risks mitigation, updating of data and reassessment of risk;

Performance evaluation of Integrity Management Plan:

- This is a mechanism to monitor the effectiveness of integrity management plan adopted and for further improvement;
- Every CGD entity shall define suitable performance indicators which can be monitored to give a picture of the integrity levels of various aspects of the company's assets. The regular monitoring of these indicators (on a periodic basis) against pre-defined targets helps to assess the effectiveness of asset performance.

- A performance indicator may be either leading or lagging indicator. Lagging measures are reactive in that they provide an indication of past integrity management programme performance. Leading measures are proactive in that they provide an indication of how the plan may be expected to perform.

- The company shall conduct periodic internal audits to validate the effectiveness of its integrity management programs and ensure that they have been conducted in accordance with the plan.

- A list of items is provided below in developing a company integrity management and performance evaluation program.

Communication Plan:

- This covers a structured plan to regulate information and data exchange within and amongst the internal and external environment;
- The CGD entity shall develop and implement a communication plan in order to keep appropriate company personnel, jurisdictional authorities,

and the public informed about their integrity management efforts and the results of their integrity management activities.

- The information may be communicated as part of other required communication.

Management of Change:

- This is the process to incorporate the system changes (technical physical, procedural and organization changes) in to integrity management plan to update the integrity management plan;
- Formal management of change procedures shall be developed in order to identify and consider the impact of changes to CGD network systems and their integrity.
  - A management of change process includes the following:
  - Reason for change
  - Authority for approving changes
  - Analysis of implications
  - Acquisition of required work permits
  - Documentation
  - Communication of change to affected parties
  - Time limitations
  - Staff involved
  - Planning for each situation
  - Unique circumstances if any

Quality Control:

- This is the process to establish the requirements of quality in execution of the processes defined in the integrity management plan.
- Requirement of a quality control plan include documentation, implementation, and maintenance.

The following activities are usually required-

- Identify the processes
- Determine the sequence operation of these processes

- Prepare standard operation procedures and guidelines for critical processes
- Provide the resources and information necessary to support the operation and monitoring of these processes.
- Monitor, measure, and analyze these processes.
- Implement actions necessary to achieve planned results and continued improvement of these processes.

Integrity assessment and evaluation:

Some of the tools for integrity assessments are provide below:

- The operator should use as many support system necessary to achieve the integrity management plan for CGD network.
- It may be noted that the baseline data for specific measurement should be available with the operator as a ready-reckoner;

Direct assessment and evaluation

- External corrosion direct assessment can be used for determining integrity for the external corrosion threat on CGD network segments.
- The external corrosion direct assessment process has the following four components:
    1. Pre-assessment
    2. Inspections
    3. Examinations and evaluations
    4. Post-assessment

- While implementing external corrosion direct assessment and when the pipe is exposed, the company is advised to conduct examinations for threats other than that for external corrosion .
  Like,
- Thickness assessment and periodic review against baseline values
- Cathodic protection system survey
- Pressure testing

Identification of Threats:

- Gas pipeline incident data analyzed and classified by Pipeline Research Council International (PRCI) represents 22 root causes for threat to pipeline integrity. One of the causes reported by the operator is "unknown".
- The remaining 21 threats have been grouped into three groups based on time dependency and further in to nine categories of related failure types according to their nature and growth characteristic as below:

(I) Time Dependent Threats:

1) External Corrosion
2) Internal Corrosion
3) Stress Corrosion Cracking

(II) Stable Threats:

4) ***Manufacturing related defects***
   i. Defective pipe seam
   ii. Defective pipe

5) Welding/fabrication related

- Defective pipe girth weld
- Defective fabrication weld
- Wrinkle bend or buckle
- Stripped threads/broken pipe/coupling failure

6) Equipment

- Gasket O-ring failure
- Control/relief equipment malfunction
- Seal pump packing failure
- Miscellaneous

(III) Time independent threats:

7) Third party/mechanical damage:

- ❖ Damage inflicted by first, second or third party
- ❖ Previously damaged pipe
- ❖ Vandalism
- ❖ Rat bites
- ❖ Electric arching

8) Incorrect operational procedure

Health and safety environment(HSE)

SAFETY AND RESPONSIBILITY

- In general execution/implementation of HSE system/ processes at locations/ sites.
- Review of PTW work request & safety critical site compliance monitoring.
- Mock drill exercise.
- Local level HSE committee meeting.
- Field compliance monitoring-Work Place Inception/ HSE tour & Life Saver monitoring.
- Contractor Engagement for HSE aspect.
- New Project HSE facilitation & compliances monitoring.
- Participation & facilitation HSE audits – internal.
- Environmental Monitoring.
- Facilitating Incident fact finding & field investigation.
- Driving HSE Campaigns & Celebrations at locations.
- Location HSE performance reporting to corporate and facilitation in mandatory compliance.

Following processes is prepared as part of HSE Management System –

- Emergency Management System to safely handle emergencies with minimal risk.
- Disaster Management Plan encompassing offsite and onsite emergency response plans and mutual aid system.
- Hazard Identification Processes such as HAZOP.
- Risk Analysis and Risk Assessment Process such as QRA.
- Safety and Technical Competency System.

Safety Systems present to avoid accidents at CGS

- Isolation Valves
- Gas Detectors
- Emergency Shutdown Device (ESD)
- CO2 Flooding systems
- Fire Extinguishers
- Wind Sock

- MCBs (Miniature Circuit Breaker)
- Safety Shower

Safety systems to present to avoid Accidents at CNG Station

- Spark-proof appliances
- Gas detectors and Fire detectors
- CO2 Flooding system
- Fire Extinguishers
- Crash Guard
- Break Away Coupling
- Earthed appliances

Case study:

Control of Solenoid Valve System Using GSM Technology

- This study proposes a valve control system using Arduino, GSM module to control the Solenoid valve which helps in providing an effective and reliable valve control system.
- The Arduino gets the input from the GSM module to operate solenoid valves that indeed can help to close the main valves.
- The input to the GSM module is given as messages from the person-in-charge of the system working.
- The presence of solenoid valves reduces the number of people required to control the valves present in the system's areas.
- Here the person can remotely operate the valve in the case of an emergency or the routine usage of the valve to control the gas flow.

System Design

The proposed system has the following components.

A. GSM Module

- GSM module is a distinguished type of module which accepts a SIM card and operates similarly to a mobile phone.
- Whenever a GSM module is connected to a computer, it allows the computer to use the GSM module to communicate over the mobile network.
- GSM modules are most frequently used to provide the mobile internet connection; many of them are often used for sending and receiving SMS messages.
- Several GSM modules are available in the market out of which GSM SIM900 is the GSM module that has been used in this project.
- This GSM module receives the message from the User GSM Mobile and decodes it to the corresponding string value.
- The GSM Module thus communicates with the Arduino.

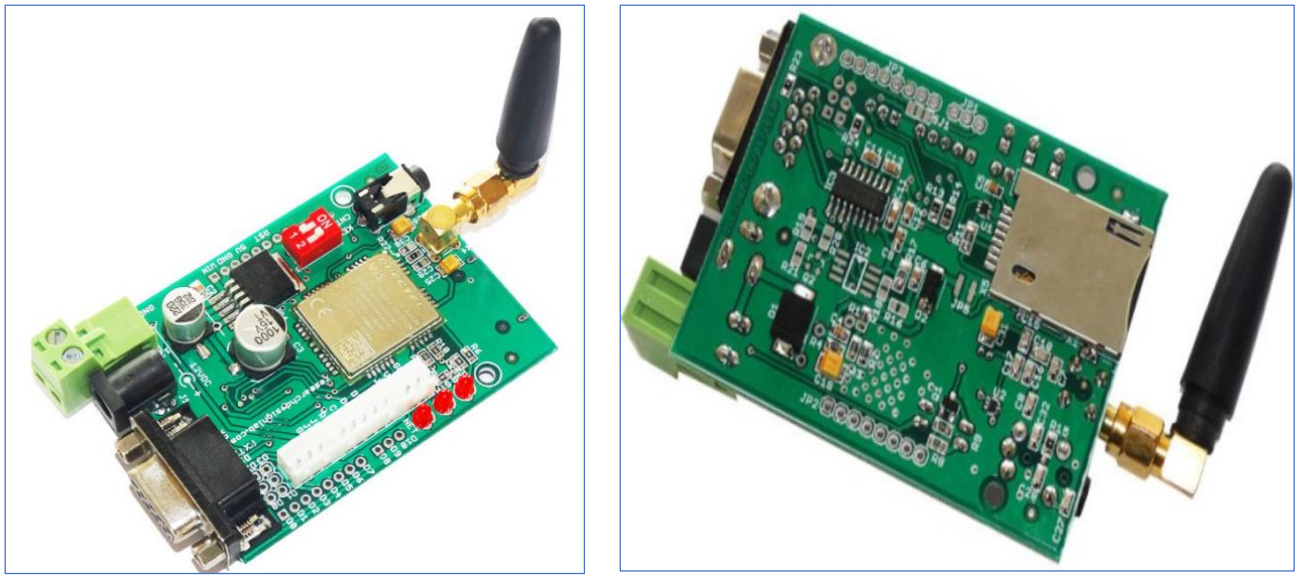
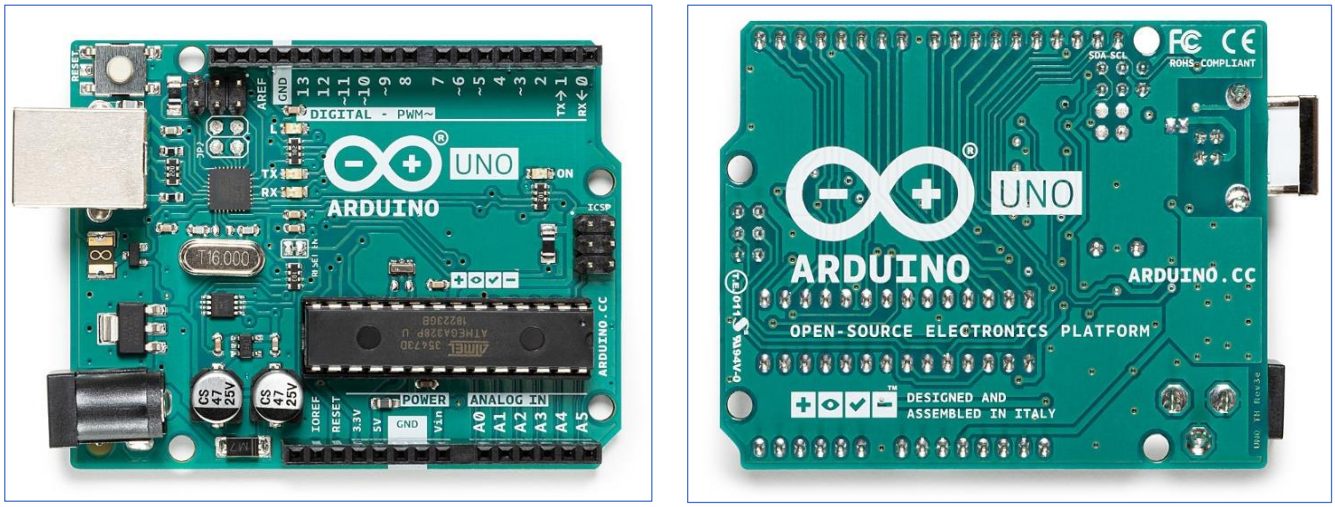


Figure: 33 GSM SIM900

B. Arduino UNO

- A microcontroller is a computer on-chip that is, a single integrated circuit containing a core processor, memory unit, and programmable input/output ports.
- Microcontrollers are versatile and hence used in places where automatic control of products and devices, such as controlling automobile engine systems, implantable medical devices, remote controls, toys, and other embedded systems.
- The size and cost of employing a microcontroller are very less than that compared to a design that uses a microprocessor whose units are separate such as memory, timer, counter, and separate input/output devices, hence to achieve required performance at a decent cost.
- ARDUINO UNO microcontroller is used in this project; it is a development kit that helps in easy programming and real-time implementation.



(Figure: 34 Arduino Uno board)

Parts Required:

- Arduino UNO
- DC connector cable & 12v adapter
- 8- Bit Microcontroller that comes as a 28 pin package with 14 digital I/O pins and 6 analog pins.
- Relay board (12v board with active HIGH, i.e. if you send HIGH from Arduino then Relay will be ON)
- Solenoid Valve

❖ The board features serial communication interfaces, including USB, which helps loading programs from personal computers.

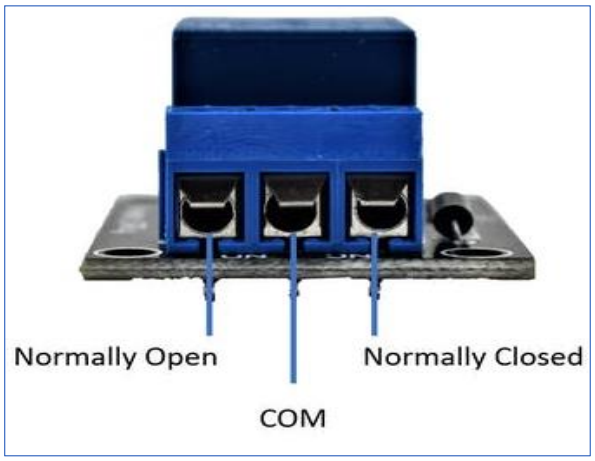
❖ In the programming of microcontrollers, the Arduino platform provides an integrated development environment (IDE) based on the Processing project, which includes support for the C, C++, and Java programming languages. Thus these features make the microcontroller the right choice for our application.

C. Relay Module

- The relay module used here is 1-channel. There are other options such as a 2-channel relay which consists of two 1-channel relays on a single PCB.
- There are two sides on the relay: one that contains a 3-pin terminal block and one that contains a 3-pin male header as shown below.
- The terminal block is used to connect the high-power load and the 3-pin male header is used to connect to the Uno.

(Figure: 35 Relay Connections)

- First, the 3-pin terminal block from left to right are normally closed (NC), common (COM), and normally open (NO).
- The pin assignments may vary from the relay to relay, but you can quickly determine which pins are NO or NC.
- To do so, set your voltmeter to do a continuity check. Place one probe on the middle-pin block and the other probe on the left-pin block. If there is continuity, the left pin is NC.
- If not, the left pin is NO. The pin assignments for the terminal block that are shown below.



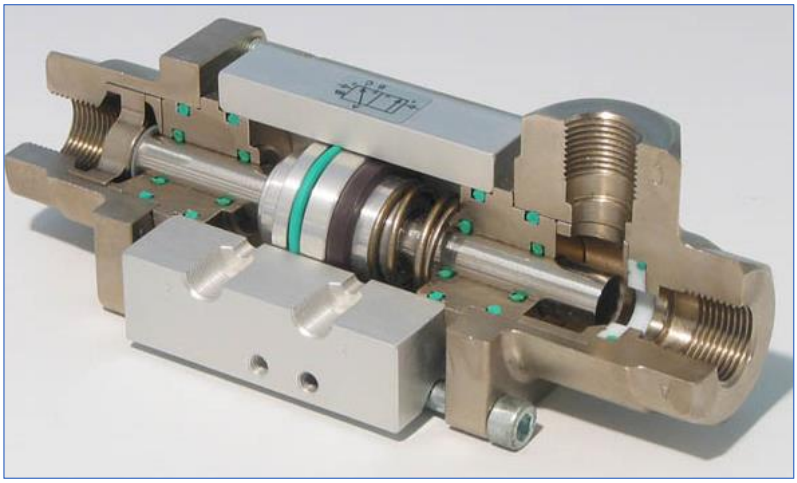
Terminal Block Pin Assignments

Male Header Pin Assignment

(Figure: 36)

Next, the 3-pin right-angle male header which is used to connect to the Uno. The pins are labeled as "+", "-", and "S" which are shown below. Connect "-" pin to GND, the "+" pin to +5Vdc, and "S" to any of Uno's digital I/O pins.

D. Solenoid Valve



(Figure: 37 Solenoid Valve)

- A solenoid valve is an electromechanically actuated valve.
- The control of this valve is done by an electric current through a solenoid, in our case we use a two-port valve where the flow is either switch on or off that is the microcontroller either gives a high or low signal which makes the value either open or close, flow control cannot be done.
- The most frequently used control elements in fluidics are the solenoid valves. Solenoids provide fast and safe switching, higher reliability, low control power, and compact design.
- A 2-way valve, for example, when 2 ports; if the valve is open, it means that the two ports are connected and fluid may flow between them and if the valve is closed, the ports are isolated.
- If the valve is open when the solenoid is energized, then the valve is termed normally open (N.O.).

- Similarly, when the solenoid is not energized the valve is closed, then the valve is termed normally closed (N.C).
- A 12V solenoid valve is used to control the flow. Since the microcontroller cannot drive a 12V solenoid directly, it is triggered by a relay that gets signals from the microcontroller.

E. Control Unit

- The control unit is the control relay circuit that operates according to the signal received from the microcontroller and makes the motor to operate and thereby opens the solenoid valves.
- The relay used in this project is a 12V relay. The relay consists of a coil with multi turns, wound on an iron core, forming an electromagnet.
- Whenever current passes through it, the coil gets energized, the core gets magnetized temporarily.
- This magnetized core attracts the armature made of iron. The pivoted armature causes it to operate with one or more sets of contacts. When the coil is de-energized it releases the armature and contacts.
- The coil can be energized from a low power source such as a transistor while the contacts can switch high powers such as the main supply. The relay can also be situated in a remote area from the control source.
- Relays generate a very high voltage across the coil when switched off which will damage other components in the circuit.
- To prevent this, a diode is connected across the coil. The diode cathode is

connected to the most positive end of the coil.

F. Battery

- The battery circuit is essential to operate the GSM Module, Microcontroller, and Solenoid valves.
- 12V, Adapters are used to supply the above-mentioned components in the circuit.

Figure: 38 DC connector cable & 12v adapter

Working of the System

- The system works with a GSM SIM900 module and an Arduino Uno microcontroller.
- The system works based on the following algorithm depicted in the flow chart (Figure 32).
- The command signals from the user are obtained as messages from the user by the GSM module.
- This GSM module converts the message into hexadecimal code so that the microcontroller could process it. The microcontroller gets the information from the GSM module frequently.

Block Diagram

- The main parts are the microcontroller, GSM module, moisture sensors, solenoid valve, control unit, and motor drive system.
- From the battery, appropriate power to the GSM module, microcontroller, solenoid valves, and moisture sensors are delivered.
- The microcontroller receives the signal from GSM and moisture sensor, this

received command is further used by it to operate appropriate solenoid valves.

❖ Whenever the moisture level exceeds the critical value the microcontroller shuts the motor off.

Connections

- Digital pin 8 of Arduino is connected to Relay board INPUT
- Rx of Arduino to Tx of GSM, Tx of Arduino to Rx of GSM
- GND of Arduino to GND of GSM
- 12V Adapter is used as a power source. The power socket is provided on GSM & Arduino boards. DC connectors are used to power up GSM & Arduino. As Arduino has a 5v regulator on board you can safely use 12v at the power socket.
- The +ve pin of Relay board is looped with +12v of adapter & -veto GND of Relay board.
- Ensure that all GND pins are made common, that of GSM, Arduino & Relay boards.

Aim

- By sending SMS **$v1** Relay(solenoid valve) is made OPEN
- BY sending SMS **$v0** the Relay(solenoid valve) is switched CLOSED
- GSM SIM900 board is used in this demo, but you can use SIM800 also. A valid SIM to be inserted into the slot on the GSM board. Do not use 4G SIM like JIO, as the SIM 800 / 900 is 2G /3G enabled.

Code

```
char inchar; // variable to store the incoming character
int Relay = 8;
void setup()
{
 pinMode(Relay, OUTPUT);
 digitalWrite(Relay, LOW);
 // wake up the GSM shield
 Serial.begin(9600);
 delay(2000);
 Serial.println("AT+CMGF=1"); // set SMS mode to text
 delay(100);
 Serial.println("AT+CNMI=2,2,0,0,0");
 // just to get a notification when SMS arrives &direct out SMS upon receipt to
the GSM serial out
 delay(100);
}

void loop()
{
 //If a character comes in from the GSM...
 if(Serial.available() >0)
 {
  inchar=Serial.read();
  if (inchar=='$')
```

```
    {
     delay(10);

     inchar=Serial.read();
     if (inchar=='v')
     {
      delay(10);
      inchar=Serial.read();
      if (inchar=='0')
      {
    digitalWrite(Relay, LOW);
    Serial.println("Relay OFF");
      }
      else if (inchar=='1')
      {
       Serial.println("Relay ON");
       digitalWrite(Relay, HIGH);
      }
      delay(100);
     Serial.println("AT+CMGD=1,4"); // delete all SMS
     delay(2000);
     }
    }
  }
}
```

Example:

If you want to automate the ½ inch pipe valve that is allowing the flow of gas to the gas burner so that you can remotely on/off the valve.

- The method is similar as mentioned in the above case study, and with some minutes changes, we can automate the valve.
-
- Now we need to replace the solenoid valve shown in the above case study with the valve ½ inch valve shown below and the valve can be placed between the gas meter and hose nozzle female connection valve.

- As well as we need to connect the relay output to the solenoid valve shown below.

- And if the valve is normally closed type then a constant electric current is required to keep it open, or else if the valve is normally open type then electricity is only required at the time of closing the valve.

- Different sizes valve as well as with different voltage ratings are available in the market, if the required valve operating voltage is different from that mention in the case study then you are advised to use a different relay that suits the valve voltage.
- Just follow the above steps and surely you will get the result.

(Figure 39: ½ inch solenoid valve)

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