

**STUDY ON AN IDEAL GAS REGULATING AND METERING
STATION FOR GAS SUPPLY TO A 50 MW POWER PLANT
(NAVANA CNG LTD.)**

**A Project and Thesis submitted in partial fulfillment of the requirements for
the Award of Degree of Bachelor of Science in Electrical and Electronic
Engineering**

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Certification

This is to certify that this project and thesis entitled “**DESIGN OF AN IDEAL GAS REGULATING AND METERING STATION FOR GAS SUPPLY TO A 50 MW POWER PLANT (NAVANA CNG LTD.)**” is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on November 2018.

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ABSTRACT

In gas transmission and distribution system, the gas pressure and flow rate are controlled by using CGS, TBS, DRS and RMS. It is important to supply uninterrupted gas at a desired pressure and flow rate to the customer premises. The Regulating and Metering Station (RMS) is generally used for controlling the gas pressure and measuring the gas volume for fiscal purpose. It is apparent that proper design of RMS is very important for a customer for supplying desired amount of gas at a required pressure as well as measuring the supplied gas accurately which is very much crucial for gas supplier in fiscal context. A large number of RMS's are used for gas supply to different customers in the Titas franchise area. The major objective of this project is to design an ideal gas Regulating and Metering Station for uninterrupted gas supply to a 50 MW power plant. In this project work, fluid characteristics, process data, gas safety rules, International codes and standards (ASTM, ASME ANSI, API) have been followed for the proposed RMS design. Design considerations, selection criteria and installation of RMS equipments are incorporated. Safety and Environmental issues have been considered in designing the gas facilities for the power plant. The negative effects on environment are negligible. The gas load of the power plant is calculated around 12 MMSCFD at minimum outlet pressure of 50 psig. Design has been checked allowing variation of some related variables such as inlet pressure, specific density, specific heat, compressibility factor and heating value. Variation of these parameters needs no change in the design. Instrumentation and piping diagrams of the proposed RMS are also shown in the report. Some recommendations have been made for improvement of the RMS design. Finally, cost estimation is performed for the project. The cost estimation of the project have been calculated on the basis of preconstruction expenditure, construction cost and material cost. The total cost of the project is estimated as Tk. 494.463 Lakh.

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CHAPTER 1

INTRODUCTION

A network of transmission pipeline system transports natural gas from producing fields to consumers. Gas transmission pipeline normally operates at high pressure of 1000/960/850/350 psig. The customers usually do not use gas at such high pressures. It is necessary to control the pressure and flow rate for supplying gas to a customer at desired pressure and flow rate. In gas transmission and distribution network, the gas pressure and flow rate are controlled at pressure reduction stations located at suitable places. There are known as City Gate Station (CGS), Town Bordering Station (TBS), District Regulating Station (DRS), Regulating and Metering Station (RMS). After reducing pressure through these stations, gas is supplied to different bulk customers like Power and Fertilizer Producer of Government Sector, Independent power producers (IPP), Small Power Plant (SPP), Captive Power Plants (CPP) and Non bulk customers such as industrial, commercial and domestic customers.

Regulating and Metering Station means a station comprising of Regulator, Meter and other equipments necessary for the delivery of specification gas to a customer. Pressure Regulator means all devices required to maintain a specified pressure at the outlet of the RMS under variable gas flow conditions. Meter means all devices to be installed, operated and maintained by the company for measuring, recording and computing the gas flow volumes delivered to the customer.

This study aims to undertake and estimate of design an ideal Regulating and Metering Station for gas supply to a 50 MW power plant in accordance with International codes and standards (ASTM, ASME ANSI, API). The design will be carried out according to the fluid characteristic and process data. Technical details of different equipments of the RMS will be studied. The findings can then be incorporated in designing an improved RMS. Cost estimation will be conducted for the proposed RMS design and construction for gas supply to the said power plant.

A schematic diagram of pipeline network is shown in the following:

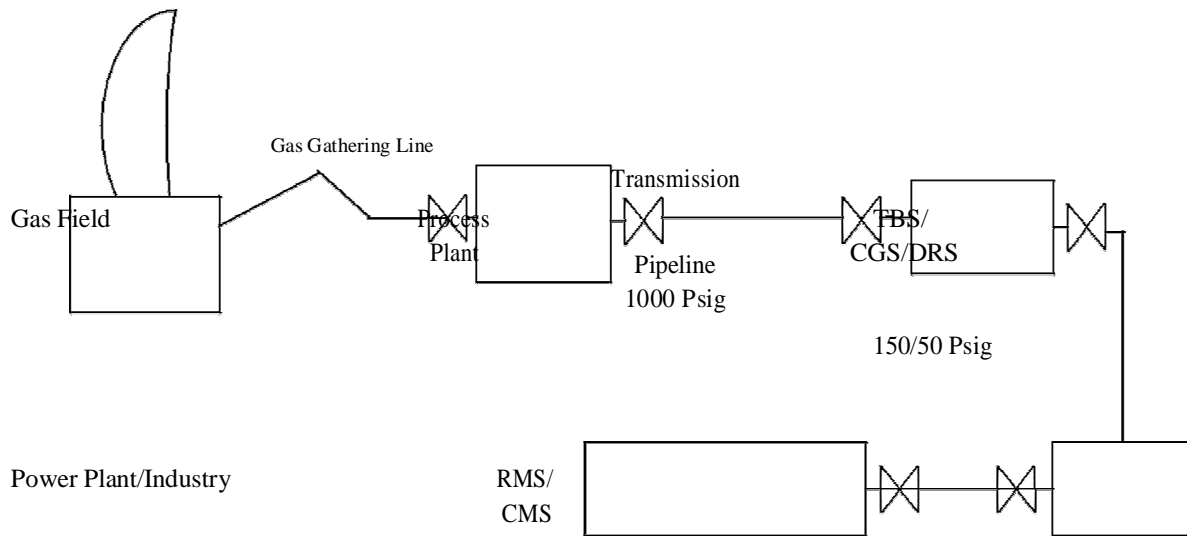


Figure 1.1: Pipeline Network

1.1 Objectives

The main objectives of this study are as follows

- Design of an ideal gas Regulating and Metering Station to supply conditioned gas at a desired pressure as per requirement of the power plant.
- Cost estimation of the proposed RMS.

1.2 Methodology

- Literature review of different equipments of the Regulating and Metering Station.
- Surveying of the proposed power plant RMS area including gas source such as CGS/TBS/DRS or any high pressure gas line.
- Gas load calculation as per catalogue of gas based power station.
- Consult International Standards and Codes (ASTM, ASME ANSI, API) and there practiced by Titas Gas Transmission and Distribution Company Ltd.
- Design of the proposed ideal RMS considering all criteria.
- Cost estimation of the proposed RMS based on preconstruction expenditure, construction cost and material cost etc.

CHAPTER 2

LITERATURE REVIEW

Regulating and Metering Station (RMS) means a station comprising of Regulator, Meter and other equipments necessary for the delivery of specification gas to the customer. Pressure Regulator means all devices required to maintain a specified pressure at the outlet of the RMS under variable gas flow conditions. Meter means all devices to be installed, operated and maintained by the company for measuring, recording and computing for fiscal purpose the gas flow volumes delivered to the customer.

In this chapter, typical gas regulating and metering system, different types of RMS equipments and their working principle, advantages and disadvantages will be discussed.

2.1 Typical Gas Regulating and Metering System

Typical gas regulating and metering systems are gas conditioning, regulating and metering which described below.

2.1.1 Conditioning

Natural gas quality has a strong effect on operation of the regulating and metering station and measurement system. The gas should be pipeline quality gas. Gas conditioning is the technique to remove surge of liquid, condensate, water and entrained solids from gas stream by using separator and rising up the temperature of gas at a desired level to prevent hydrate formation by using heater to prevent the damage of regulator and meter

2.1.2 Regulating

Regulating is the technique to control the flow of gas and maintain the system pressure and flow with certain acceptable limit of a regulating station.

2.1.3 Metering

Gas metering is the technique to measure the gas volumes for transmission system, CGS, TBS, DRS and RMS. The metering bank consists of meter runs according to AGA report for the computation of the gas volume. Different types of meters are used for gas metering.

2.2 Equipment of a Regulating and Metering Station

The Regulating and Metering Station (RMS) consists of inlet pipeline with filter separator pressure regulator, relief valve and meter. Details of the station are given below:

- (i) Insulating joint
- (ii) Inlet emergency shut down (ESD) valve
- (iii) Knock out drum (KOD)/ scrubbers and filter separators.
- (iv) Gas heaters or heat exchanger
- (v) Valves and valves actuators
- (vi) Slam shut valve
- (vii) Relief valves
- (viii) Pressure regulators
- (ix) Silencers
- (x) Meters
- (xi) Liquid separator.
- (xii) Pressure Gauge
- (xiii) Temperature Gauge
- (xiv) Chart recorder
- (xv) Differential pressure transmitter
- (xvi) Temperature transmitter
- (xvii) Density and specific gravity transducer
- (xviii) Gas Chromatograph
- (xix) Flow Computer
- (xx) Electronic Volume Corrector (EVC)
- (xxi) Supervisory Control and Data Acquisition (SCADA) System
- (xxii) Condensate tank
- (xxiii) Weld-neck Flanges, Blind Flanges, Metallic and Asbestos Gaskets, Tees, Elbows, End caps, Reducers, Saddle/weld-o-lets, Needle valves, Screwed gate and ball valves, Socket welded fittings (Flange, Tee, Elbow, Reducer etc.), Screwed Fittings, SS tubes, Compression Coupling and Stud Blots (As per requirements), etc.

2.2.1 Inlet and outlet connections

The piping to and from regulator should be supported adequately to minimize pipe strains. The piping should be designed to have adequate capacity for the expected maximum flow and the pressure conditions. Velocities in regulator valve passages can reach sonic velocity conditions. High velocities create noise so piping should be sized to keep gas velocities at a reasonable level. There are specific pipeline velocity limits used by many companies to maintain a relatively quiet pipeline system and to keep pressure losses low. Such limiting velocities range between 50 feet per second to a maximum of approximately 400 feet per second. There are situations where higher velocities may be required for short distances; however, the designer should calculate the pipe velocities to be encountered and determine the steps that may be necessary to maintain satisfactory noise levels.

2.2.2 Insulating joint

To protect eddy current producing from transmission and distribution network which damage the pipeline of RMS, insulating joints are used at station inlet and outlet of RMS.

2.2.3 Emergency shut down (ESD) valve

To isolate the RMS from transmission network in case of emergency, ESD valve is placed at inlet of the station.

2.2.4 Headers

A header is a way to combine multi sources or multi-outlets into a single source or outlet. Headers need to be designed to distribute the gas symmetrically. They are typically larger sized pipe, tees, and caps. Headers are used when more than one regulator or meter run are required. In sizing headers it is a rule of thumb that the cross sectional area of the header be 1.5 times larger than the sum of the inlet or outlet cross sectional area (which ever is larger).

2.2.5 Knock out drum (KOD)/ scrubbers and filter separators

Knock out drum (KOD) is one kind of liquid separator and two stage filter separator. Liquid, Condensate are separated through the KOD.

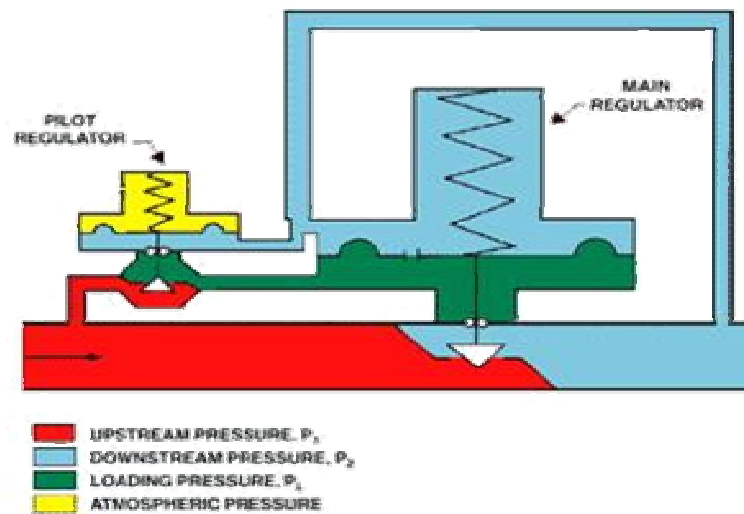


Figure 2.5: Pilot-operated regulator
(Source: Fisher Controls, 2005)

- Regulator Pilots
- Set point
- Spring Action

2.2.6 Regulator Pilots

The major function of the pilot is to increase regulator sensitivity. If it can sense a change in P_2 and translate it into a larger change in P_L , the regulator will be more responsive (sensitive) to changes in demand.

2.2.7 Set point

Set point and many performance variables are determined by the pilot. It senses P_2 directly and will continue to make changes in P_L on the main regulator until the system is in equilibrium. The main regulator is the "muscle" of the system, and may be used to control large flows and pressures.

2.2.8 Spring Action

Notice that the pilot uses a spring-open action as found in direct-operated regulators. The main regulator, shown in Figure 1, uses a spring-close action. The spring, rather than loading pressure, is used to achieve shutoff. Increasing P_L from the pilot onto the main diaphragm opens the main regulator.

2.2.8.1 Overpressure protection

To prevent personal injury, equipment damage or leakage due to escaping gas or bursting of pressure-containing parts, it is necessary to install adequate overpressure protection when installing a pressure reducing regulator. Adequate overpressure protection should also be installed to protect all downstream equipment in the event of regulator failure. Some regulators are made with internal overpressure relief, whereas others require the installation of a separate relief valve or an additional regulator to act as a monitor. There are also shut-off devices that are designed specially to handle overpressure.

2.2.8.1.1 Pressure relief valves

A pressure relief valve limits pressure buildup (i.e., prevents overpressure) at its location in a pressure system. The relief valve opens to prevent a rise of inlet pressure in excess of a specified value. The pressure at which the relief valve begins to open pressure is the relief pressure setting. Pressure relief valves can be direct-operated or pilot-operated.

Relief valve and backpressure regulators are the same devices. The name is determined by the application.

2.2.8.1.2 Automatic Shutoffs/Slam-Shuts valves

A pressure shutoff or slam-Shut device Shuts off the flow whenever the sensed control pressure violates a set limit. Depending on the capacity of the device selected, it may be able to shut off in response to a low-pressure condition only a high- pressure condition only or both.

2.2.8.1.3 Backpressure regulators

A backpressure regulator maintains a desired upstream pressure by varying the flow in response to change in upstream pressure.

2.2.8.2 Pressure switching valves

Pressure switching valves are used in pneumatic logic systems. These valves are for either two-way or three-way switching. Two way switching valves are used for on/off service in pneumatic systems. Three-way switching valves direct inlet pressure from one outlet port to another whenever the sensed pressure exceeds or drops below a preset limit.

2.2.9 Valve

A valve is a device that regulates the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways. Valves are technically pipe fittings, but are usually discussed as a separate category. In an open valve, fluid flows in a direction from higher pressure to lower pressure.

Valves are used in oil and gas, power generation, mining, water reticulation, sewerage and chemical manufacturing.

Valves may be operated manually, either by a hand wheel, lever or pedal. Valves may also be automatic, driven by changes in pressure, temperature, or flow. These changes may act upon a diaphragm or a piston which in turn activates the valve, examples of this type of valve found commonly are safety valves fitted to hot water systems or boilers.



Figure 2.2.9: Safety valve with compressore machine

2.2.9.1 Types of valve

There are different types of valves are used such as Gate valves, Globe valves, Ball valves, Plug valves, Diaphragm valves, Butterfly valves and Check valves.

Gate valves are generally used in systems where low flow resistance for a fully open valve is desired and there is no need to throttle the flow. Globe valves are used in systems where good throttling characteristics and low seat leakage are desired and a relatively high head loss in an open valve is acceptable. Ball valves allow quick, quarter turn on-off operation and have poor throttling characteristics. Plug valves are often used to direct flow

between several different ports through use of a single valve. Diaphragm valves and pinch valves are used in systems where it is desirable for the entire operating mechanism to be completely isolated from the fluid. Butterfly valves provide significant advantages over other valve designs in weight, space, and cost for large valve applications. Check valves automatically open to allow flow in one direction and seat to prevent flow in the reverse direction. A stop check valve is a combination of a lift check valve and a globe valve and incorporates the characteristics of both. Safety/relief valves are used to provide automatic over pressurization protection for a system.

2.2.10 Gas Heating System

The heating system is provided to prevent the possibility of gas freezing and hydrates formation, due to the pressure drop during the reducing step in regulating system and pipelines, caused by the Joule-Thomson effect. A convenient rule of thumb indicates that a 15 psig reduction in pressure of natural gas is associated with a 1°F decrease in temperature (Roy,1989). Preheating of the gas is necessary for smooth operation of the gas station and correct flow measurement. Pre heaters are installed to heat the gas after the gas has passed the filter and before pressure reduction.

There are several types of heaters which may be used in regulating and metering station. Water bath heater, Heat exchangers and electric heater may be used depending on the station capacity and design.

2.2.10.1 Water bath heater

Water bath heater is one kind of indirect fired heater. Water bath heaters are often used in regulating and metering stations. The purpose is to heat the gas so that after a pressure drop is taken across a pressure regulator, the gas will be above the hydrate point. It consists of tubular elements, carrying the gas immersed in a water bath, which is maintained at the required constant temperature by the use of a burner fitted with standard controls and safety devices to maintain the desired exit temperature in the gas stream. The capacity range of water bath heater within 15 kw to 1170 kw according to heat required for heating gas.

2.2.10.2 Heat Exchangers

Heat exchangers are used to increase the temperature (above the dew point) of natural gas. Their performance is based on the heat exchanger between water (or steam) and the gas to be

treated. Heat exchangers are designed to be suitable for an easy inspection and cleaning of all the parts.

2.2.10.3 Electrical Heater

This may take the form of a pressure vessel located in the gas stream in which are inserted electric immersion heaters. Such an arrangement would normally be confined to relatively small gas flow. A form of heating suitable for low input needs, such as impulse piping is that of heating tapes wrapped around the section of piping and thermally insulated on the outside.

2.2.11 Gas Metering System

Gas metering is very important for transmission and distribution system and metering station. Throughout the world, gas measurement utilizes two basic principles to measure gas volumes, positive displacement meter and inferential meters. Positive displacement meters comprise the large majority of measurement devices in use while inferential meters are used primarily for large volume measurement and thus fewer applications.

In RMS the metering bank consists of one meter runs design accordance to AGA report no.3 for the computation, of the gas volume flow delivered. Different types of meters are used for gas metering which describes as follows :

- Positive displacement - Diaphragm meter ,Rotary meter & Turbine meter
- Differential pressure measurement – Orifice, Venturi and nozzle meter
- Ultrasonic flow meter - Doppler flow meter
- Fluid oscillatory – Vortex meter, Swirl meter
- Electro magnetic flow meter – Magnetic flow meter
- Direct mass – Coriolis mass flow meter.
- Thermal - Thermal profile flow meter.



Figure 2.2.11: Pressure Gas with Metering System

2.2.11.1 Positive displacement Meter

Positive displacement meter measures gas volume passing through it by repeatedly filling and discharging one or more chambers in sequence. Each chamber's volume is known & the operating cycles are counted to get the volume passed. Meters incorporating the positive displacement principle of measurement are of the diaphragm and rotary type Meter.

2.2.11.1.1 Diaphragm Meter

In diaphragm meters there are two chambers alternately fill and empty, with slide valves at the top of the meters controlling the flow to the chambers. The gas volume is obtained through a mechanical linkage mechanism, which connects the diaphragm motion to the mechanical readout system, where the number of displacements is counted.

A basic characteristics of diaphragm meters is their capability to accurately measure flow rates varying from small pilot loads to the maximum capacity the meter. The capacity is termed the frangibility. Diaphragm meters have excellent rangeability. The operation of this meter is simple and proven. This type of displacement meters are available in sizes and it can also be used for commercial and small industrial applications. These meters are produced with a G-rating range from G – 1.6 to G – 10 with operating pressure 0.4 bars.

2.2.11.1.2 Rotary Meter

This type of meter contains two oppositely rotating impellers, which are the measuring mechanism. The volume of gas is directly related to the number of revolutions of one of the impeller shafts. The rotary meter's capacity rating is much greater than the diaphragm meter. Rotary meters are available in ranges of 800 to 102,000 CFH. It can be used in high pressure applications with up to an ANSI 600 rating available. These meters are compact and reliable, however since the operation depends on maintaining proper clearance between the impellers and the case, they can be susceptible to stress and if a malfunction occurs, then the gas flow could be stopped. The rotary meter is limited at high pressure. Therefore this meter although an excellent performance is not regarded as appropriate for large capacity, high pressure metering of natural gas.

2.2.11.1.3 Turbine Meters

The turbine meter is classified as a rotary inferential meter. These flow meters are used successfully in both liquid and gas measurement. Turbine meters are velocity sensing meters with the volume of fluid being derived from the rotations of the turbine rotor. The speed of this rotor is proportional to flow rate. Turbine meters has been established as a means of measuring fluid for nearly 80 years. Since the 1950s, they have been considered favorably for the measurement of large volume gas flows. The designs have proved receivable, accurate and repeatable. As well as being used as the primary measurement standard, axial flow gas turbine meters are increasingly being used as calibration and reference meters.

The turbine meter (Figure-2.6) has wide range ability (to 200:1 depending on meter size and line pressure), greater accuracy potential and more versatility in adding mechanical and electronic auxiliary devices. Like an orifice meter, a turbine meter does not impede flow if there is damage or failure. This is important when maintaining gas service to a downstream consumer is critical.

Two basic assumptions relate to the operation of the turbine meter:

- 1) The angular velocity of the rotor is proportional to the volumetric flow rate passing through the meter.

- 2) The pulsed output frequency of the pick-up is proportional to angular velocity of the rotor.

The axial flow gas turbine meter comprised of three main components:

- i. The body through which the gas passes.
- ii. A rotor with bearings and supporting structure.
- iii. A device to transfer the internal revolutions of the rotor to an external counter.

Gas flowing through the meter impinges on turbine blades located centrally along the axis of the unit. Turbine blades are free to rotate, and do so in a manner directly proportional to the velocity of the gas passing the blades.

The area of the rotor face as defined by the mean radius of the rotor can be determined. Permanent magnets installed in the hub of the rotor, turn with the rotor to produce a magnetic field, which passes through a coil. As each of the magnets pass the coil a separate and distinct voltage pulse is created. The frequency of these pulses is proportional to the velocity of the rotor is also proportional to the flow rate. Each pulse is also proportional to a small unit of volume. The pulses, the effective flow rate and total flow are transmitted by frequency and by counting the pulses. The output frequency has been conditioned into a square wave through a preamplifier. This conditioning allows it to be transferred to a remote flow computer. Each pulse represents only a small incremental volume of flow. Since the turbine meter measures volume at line conditions, the gas laws can be applied to change the register volume to base conditions.

3) Inferential Meters

Orifice and turbine meters operate on the inferential measurement principle. Here the flow rate is found by inferring from other measured variables.

i) Orifice Meters

Orifice Metering is the most common form of gas metering used throughout the world for the accounting of large volumes of natural gas. It is also used for the measurement of liquids.

Based on the differential pressure method, the rate of flow is computed on the basis of long established physical principles. The common equation used for determining the total flow volume being based on the current AGA or ISO Standard.

The orifice plate meter is classified as a differential pressure (dp) meter. There are a number of types of flow meters, with different shapes and sizes, which fit into this category of inferring flow rate from the pressure drop across a restriction. An Orifice plate flow meter system consists of three discrete components the meter tube, the orifice assembly, and the differential pressure gauge. The meter tube and orifice assembly are considered to be the primary element and the differential pressure gauge, pressure and temperature gauge or recorder are being referred to as secondary element.

Orifice meters must be designed, fabricated and installed according to AGA Report no 3 (ANSI/API 2530). When designing an orifice meter run, differential pressure should range between 10" and 90" of water column for a 100" chart and 20" and 180" of water column for a 200" chart. This avoids large measurement errors at low differential pressures and overhanging the chart. Although AGA Report no 3 does not specify upper or lower differential pressure limits, industry standard is 10" to 200" of water column. If the differential pressure falls below 10" of water column, it does not stabilize and measurement errors result.

The orifice plate meter is classified as a differential pressure (dp) meter. There are a number of types of flow meters, with different shapes and sizes, which fit into this category of inferring flow rate from the pressure drop across a restriction. An orifice plate flow meter system consists of two basic elements, namely the primary flow element, which is the orifice plate, and secondary elements which include the differential pressure transmitter, or differential pressure indicating device such as a manometer, and the associated pipe work and valves. The orifice plate meter relies on the principle of when a fluid is flowing a closed medium (a pipe) and encounters a restriction, a pressure drop is developed. This pressure drop is related to the flow rate of the fluid. By measuring the differential pressure across the orifice plate (upstream and downstream of the plate) and the condition at which the orifice is being used, then this pressure differential can be translated into a volume flow rate according to a formula. Accurate measurement is definitely possible with this type of flow meter, if malfunctions occur the flow of gas will not be stopped. Orifice meters are not limited by high pressure or high flow so they can therefore be considered for high flow, high pressure gas metering. Naturally the correct selection of orifice plate type is important.

The rangeability of a single orifice meter is about 3:1, by adding further orifice meter runs in parallel, this rangeability increases by the square. That is, a dual run meter station would have a theoretical rangeability of approximately 9:1. Rangeability is the term used with meters to express the flow range over which a meter operates whilst continuing to meet a given accuracy tolerance. The rangeability can also be expressed as 'turndown', which is a ratio of the maximum flow divided by the minimum flow, again over a given accuracy tolerance.

2.2.11.1.4 Ultrasonic Meters

Ultrasonic meters, as custody transfer devices, are relatively new to the gas industry. A.G.A. Report no-9 refers to the industry accepted standard for installation of an ultrasonic meter. Report no- 9 is vague compared to Report no-3. It leaves a lot of the design and installation up to the manufacture of the ultrasonic. This is due to the fact that there is not a good understanding of installation effects of Ultrasonic's yet. Choosing the appropriate meter, out of all the meters available, a designer must choose a meter to fit the need of the station. First look at the flow rates and pressures and decide what type of meter would best fit for the application. Positive displacement meters are usually used for low flow applications. Orifice

and ultrasonic meters are usually considered for large flow applications. After choosing a meter the regulators may be sized.

2.2.12 Auxiliary devices Used with Meters:

The following auxiliary devices can be used with meters.

2.2.12.1 Electronic Volume Correctors

The electronic volume corrector (EVC) accomplishes the same functions electronically as its mechanical counterparts.

Because they are microprocessor based, they are more versatile (perform more tasks) and flexible (in date retrieval, manipulation and transmission) than mechanical devices. They are also less subject to accuracy loss due to vibration, wear and other mechanical failures. Features include:

- pressure and temperature correction
- calculated super compressibility factor using fixed gas quality values
- various volume outputs: uncorrected, corrected, totals
- imperial or metric unit choice
- built-in alarms indicating battery condition, pressure and temperature over under ranges, etc.
- telemetry capability (with data transmission devices added)

EVCs are mounted above the meter's output drive shaft. They conserve battery power by remaining dormant between flow calculations, which are only performed on every complete revolution of this shaft. They are used on diaphragm, rotary and most turbine meters.

2.2.12.2 Flow Computers :

A flow computer has more program options than an EVC. Features include those listed for EVC's with the following:

- Calculated super compressibility factor using full gas composition data (if available)

- Wide variety of alarm settings
- Most are not approved for use in hazardous areas
- Continuously calculated flow using AGA Report no3 or 7 equations
- Reprogrammable for other applications
- Performs some logic functions
- Calculated flows for several meter runs simultaneously
- Differential pressure (in mA) or pulse input accepted
- Pulse output for an odorant injection system.

An orifice meter requires a flow computer with a differential pressure input. The unit usually used in this case is approved for use in a Class 1, Division 1, Group D hazardous area. All other flow computers can not be used in hazardous areas, so must be installed in a site control building.

2.2.12.3 Chart Recorder

Chart recorder is standard for accurate, reliable measurement and recording of pressure, differential pressure and temperature in a wide variety of applications.

Although very significant advances have been made in the direct processing of flow measurement data by means of microprocessor based equipment, a need still exists for the chart recorder because it is reliable. The use of the direct reading chart has the advantage that the measurement being recorded can be read at a glance. Some organizations retire charts as a permanent record for accounting purposes. The recording and calculation process is the final consideration for obtaining accurate flow measurement. In the evaluation of equipment, one significant factor tends to be overlooked in the selection process – that of the skill and training of operators. The proper operation of complex data processing equipment in many cases gets down to the skill.

Chart recorders are simple and fairly robust and therefore do not require highly skilled operators or expensive diagnostic equipment, however malfunctions can occur if they are not serviced properly or incorrect charts are used. Cost wise, the chart recorder can be an

attractive option. When a back correction is required or a prior event needs investigation, a chart recording can be invaluable.

By using the concept of Bellows, Bourdon tube and thermos well mechanical recorder are produced by the manufacturer of different ranges and sizes, which are used to measure the differential pressure, static pressure of gas with circular chart. The accuracy of their device is

- a) Differential pressure element: $\pm 0.5\%$ of full scale.
- b) Static pressure: $\pm 1\%$ of full scale.

Chart recorders are mainly two types one type is VPT recorder and another is flow recorders for orifice meters.

The flow recorders are a differential flow recorder for orifice meters. They are used as the primary record of flow through an orifice meter. The chart records static pressure, pressure differential and flowing temperature. Chart drives are available to turn the charts faster or slower, but in most installations 24 hour or 7 day charts are used.

Chart ranges are:

Static pressure : 0 to 3 450 kPa or 0 to 6900 kPa

Pressure differential : 0 to 25 kPa (0 to 100" WC) or 0 to 50 kPa (0 to 200" WC)

Flowing temperature: 0 to 38°C.

Flow recorders are no longer used for backup in new installations because EVC's have proven reliable and contain their own internal backup. Technical services, measurement and electronics' standard is Graphic Controls disposable pens for all recorders.

2.2.12.4 Pressure Gauge

There are a number of devices and instruments available for the measurement of pressure. The simplest pressure-measuring device is the pressure gauge, and the most

common of all the pressure gauges utilizes the 'Bourdon tube'. [The principle of operation of Bourdon tube, which is a thin metallic tube closed at one end, is that when pressure is applied to the tube internally the tube will tend to straighten out from its normal cylindrical form. The sealed top of the tube moves linearly with the applied internal pressure, therefore this movement can be translated to a scale. When the pressure is removed the tube will return to its normal state. Care must be taken not to over range a Bourdon tube type pressure gauge otherwise damage through distortion of the tube may occur]. An accuracy of about $\pm 1\%$ should be available for at least the upper range value of a good Bourdon tube type pressure gauge. These are some master pressure gauge with an accuracy of $\pm 0.25\%$. Pressure gauges also adopt bellows as the means of translating the pressure into a visual scale.

2.2.12.5 Temperature measurement

Two scales tend to be more commonly used these being the Celsius and the Fahrenheit scales. For the international system of units (SI), the Kelvin (K) is the unit used and for F. P. S. system it is Rankine (R). Among the process variables temperature is very difficult to control. Temperature must be measured without any interference. This can be achieved by a number of ways and includes expansion and contraction of liquids and metals. Changes in electrical resistance, change in intensity of emitted radiation and changes in volume or pressure of gas the most common temperature measurement devices are:

- a) Filled thermal system
- b) Thermocouples
- c) Liquid in glass thermometer
- d) Thermistors
- e) Resistance temperature detectors (RTD's)
- f) Radiation pyrometers
- g) Bimetallic devices
- h) Smart temperature transmitters.

Selection of the best sensor for a given application can be a function of temperature range, sensitivity, response time, initial cost, maintenance, accuracy, reliability and power requirements. Overall control requirements are also important. This can lead to the selection of a mechanically or pneumatically transmitted system, giving freedom from external power sources and simple maintenance requirements. On the other hand higher accuracy and sensitivity and multi sensing ability may make the electronic system more attractive. Temperature measurement and its conversion have a strong effect on measurement. Incorrectly measured temperature value can alter the actual flow quantity. Now we can discuss some of the potential error of temperature measurement.

2.2.12.6 Density measurement

Measurement of density is necessary not only for mass flow measurement system but also for a computerized volumetric flow measurement system.

The traditional methods for density measurement are to measure the mass of a fixed volume of fluid or the volume of a fixed mass. This usually involves taking a sample of the fluid from the process vessel or a pipeline to a laboratory for weighing. Although this method can produce accurate results, it is impractical for most process and pipeline applications. Due to the requirement for an in-site measurement device, the densitometer was developed. Densitometer sometimes shows higher value than the actual due to condensation of gas in the device. This may alter the value of actual gas used. So it has a strong effect on system loss.

2.2.13 Supervisory Control and Data Acquisition (SCADA) System

The Supervisory Control and Data Acquisition (SCADA) system allows users safety and efficiency operate RMS by providing remote monitoring and processing, control functions, data collection and analysis and report generations.. The system consists of electronic sensors and controls installed remotely on the pipeline system and that are linked via network to a set of computers.

From a SCADA terminal authorized users can

- Open and closed valves
- Monitor the flow, pressure and chemical composition of the gas
- View current conditions in the system
- View and print detailed information about the operation of the system and the data received by the system

SCADA makes it possible to

- Quickly access accurate information
- Detect and respond to problem conditions very quickly
- Effectively manage the system operation
- Maximize the efficient use of available human resources
- Carefully oversee operations in remote areas.

CHAPTER 3

RMS DESIGN CONSIDERATIONS

Sustained safety, accuracy and control are the primary considerations in the design of regulating and metering station. Many factors must be considered and assembled into specifications and drawings to ensure safety and to provide accuracy, accessibility and work space for operations. These factors can be combined into a piping structure with adequate foundation and a partial or complete shelter arranged to fit the site. The station should be designed with predicted load changes considered and to require a minimum of piping alteration with unpredicted load change. Most regulating and metering stations are likely to be in service for a long time.

After considering the safety, purpose and cost of a high pressure measuring and regulation station one can follow a few steps in selection of basic components to design a reliable, accurate, safe and cost efficient station. There are a variety of sources available for information details on all the components of a high pressure measuring and regulation station, including A.G.A. Report no-3, A.G.A. Report no-7, Bangladesh natural gas safety rules,1991(Amendment 2003), National Regulations, company policy and manufacturer's literature. Also consulting with the field operations personnel for ideas during the design will help give practical perspective to the design of a station.

In this chapter, the basic design considerations and procedures in designing a regulation and measuring station will be discussed. The equipment selection criteria are also elaborated here.

3.1 Design Parameters

To achieve safety, accuracy and dependability in a high pressure measuring and regulating station the following parameters must be considered in order to design RMS.

- The amount of gas that must flow through the RMS and expected future changes in volume requirements
- Inlet and outlet pressure

- In order to ensure supply continuously, alternate system must be taken for emergency and scheduled maintenance of important equipment (By pass system)
- Provision of filter separator to protect valuable and sensitive regulators and meters from dirt and condensate
- Provision of slam shut valve to protect down stream station from unexpected high pressure
- Provision of emergency shut down (ESD) valve to isolate main station from transmission network in case of any emergency situation
- Provision of heater to prevent the possibility of gas freezing due to the pressure drop during the reducing step and low atmospheric temperature
- Use of silencer to reduce the noise level due to gas de-pressurization
- Meter selection
- Control device selection
- The requirements for maintenance
- Establish sophisticated Flow computer/Supervisory Control and Data Acquisition (SCADA) System

Safety, cost, site location, constructability, operation and maintenance, environmental impact, government regulations. All of these will impact the design parameters.

3.2 Regulating and Metering Station Configuration

Regulating and Metering Station configuration has a strong effect on system loss if it is not installed or built as per the internationally recognized or prescribed standard with maintaining the entire requirement for filtering, regulating, metering and safety. At least minimum requirement should be met. In this regard Institution of Gas Engineers (IGE) recommendation, IGE/TD/9 and American Petroleum Institute (API) recommendation should be used as a guideline. The pipe and fittings should be installed in such a way that turbulence can be avoided.

3.2.1 Recommended Minimum Requirements

The overall design of Regulating and Metering Station (RMS) should comply as a minimum requirement as per Institution of Gas Engineer's recommendation IGE TD-9.

- Two or more high-pressure inlet filters with suitable valving and connections to permit design throughput to be maintained with one unit out of action. Means to avoid the entrainment of liquids in the gas entering a regulator assembly and, if necessary suitable provision made for their removal. It is particularly important that the gas supply to regulator control instruments should be free of liquids and dust and suitable filters or filter/separators should be installed as appropriate.
- Two or more streams of pressure regulators each stream to contain at least two regulators, so impure that if any one fails, the remainder will maintain safe conditions. Where the installation is not a major supply or is reinforcement off take, consideration may be given to the provision of a single stream of regulators only. Upstream slam-shut valves should be fitted on all streams of regulators. This requirement for the provision of slam-shut valves may be waived at the discretion of a responsible engineer in the case of very small installations where the potential gas release via a relief valve can be allowed.
- Installations should be designed to withstand inlet pressure conditions through to the final outlet valve. Where this is not reasonably practicable, the design should include inter-stage relief valves in each stream where more than one stage of pressure reduction is involved. Such relief valves should be at least of sufficient capacity to off-set the effects of gas passing due to tail use of regulators to "lock-up" at times of no flow. Protection may also be afforded by providing an auxiliary trip switch for the slam shut valve.
- In certain circumstances failure of a pressure reduction installation to "lock-up" at periods of low flow may cause the normal working pressure of the system into which it delivers to be exceeded. The use of a relief valve and vent of sufficient capacity to offset this failure to lock-up may be considered if the operation of the slam-shut system is unacceptable.

- It is necessary to consider whether or not preheating of the gas is required to avoid unacceptable low temperature in the down stream pipe work and auxiliary systems following pressure reduction. If heater is installed then they should be controlled in such a way as to avoid high gas temperatures, which can damage any seals, diaphragms or valve seats in equipment such as regulators, meters, relief valves etc.

3.3 Station specifications

There are many details to assemble in the development of station specifications. These details are basically volume and pressure data with many other considerations to ensure safe and proper operation.

3.3.1 Volume

The gas volume passing through a station is a very important factor to design a regulating and metering station.

The design should be based on peak load requirements and not the daily average. regulating and metering station. The peak load conditions must be considered in sizing meters and regulators. Peak loads will be different from average volumes determined by the average daily load.

3.3.2 Pressure conditions

The pressure conditions for each installation are the inlet pressure to the station and the outlet pressure of the station. Each condition influences the design of the station.

3.3.2.1 Inlet pressure

The inlet or supply pressure to a station will vary depending on the system feeding the particular station. The minimum inlet pressure is the basic factor in sizing regulators and the metering equipment for the maximum demand rate. The maximum pressure will be the factor determining the shell strength of the regulation and measurement equipment and is also needed to size over-pressure protection equipment. The pressure condition may vary between winter and summer and these variations must be considered in the design.

3.3.2.2 Outlet pressure

The outlet pressure of a regulating station will be set by operational requirements. Metering station without regulating equipment will have an outlet pressure rating equal to the inlet pressure. The regulating station specifications should indicate the quality of outlet pressure control required and the minimum and maximum outlet pressure acceptable to the system. The amount of pressure reduction is a major indication of whether a single stage pressure regulator will be satisfactory or if multiple stage reduction is required.

3.3.3 Type of load

The type of load, economics of meter selection and the variation in station inlet pressure may dictate that the metering pressure be held constant at some value below the minimum inlet pressure and a second cut be made to supply the proper outlet pressure level for the system. Load characteristics also influence the type of meter selection for the installation.

3.3.4 Gas conditions

Usually the gas contract will specify the minimum BTU content of the gas and may specify the maximum allowable amount of H₂O in the gas. Other conditions concerning the gas such as amount of H₂S, CO₂, N₂ etc, may also be specified in the contract. Most pipeline quality gas is dry and clean but dust conditions could cause severe velocity erosion of regulator trim. If dust or other particular matter is present, filtering equipment should be installed upstream of the station.

3.3.5 Ambient conditions

The maximum, minimum and average ambient temperatures for the area should be known. Very low temperatures will require special considerations to prevent freezing of the equipment. Likewise, the station site elevation will indicate the average barometric pressure to be used in measurement calculations. If orifice meter measurement is used, the latitude of the station should be determined to permit the use of the location factor in the orifice meter calculation. High relative humidity can cause external ice formation on piping if the piping temperature reaches 32⁰ F due to the temperature drop caused by pressure reduction.

3.3.6 Site condition

The characteristics of the station site or proposed area should be considered to determine the type of external station design. A regulating station creating noise levels of greater than 85 db will not be tolerated in a populated area, while the same station in a rural area may be satisfactory. If population growth is in the direction of the site, then this should be considered early in the design because it will have an influence on what protective measures must be taken to make the station satisfactory over a long period of time. Prior to design, in addition to becoming familiar with local ordinances and regulations concerning site improvements, consideration should be given to flooding, ease of access to the site during adverse weather and outlet lines crossing roadways and presenting frost-heaving problems. These and many other details should be considered when gathering facts to prepare the station design.

3.4 Pipe sizing

3.4.1 Velocity formula

Pipe sizing is generally done by using the velocity of the gas through the pipe. Higher gas velocities create greater pressure drops per foot and generate excessive noise. The velocity through a pipeline should be 35-50 feet per second with above ground facilities of velocities of 100 feet per second.

The sizing of pipe is performed by the following formula:

$$V = (0.75*Q)/(P*D^2) \text{ ----- (3.1)}$$

Where,

V = Limiting velocity of gas, feet per second

Q = Maximum flow rate, cfm

P = Minimum operating pressure, psia

D = Internal diameter, inches

3.4.2 Panhandle formula

For high pressure and long distance pipeline the Panhandle formula is suitable.

The Panhandle formula is given below.

$$Q_{\text{mmscfd}} = 0.00128084 ((P_1^2 - P_2^2)/L)^{0.51} * d^{2.53} \text{ ----- (3.2)}$$

Where,

Q_{mmscfd} = Flow rate, MMSCFD

P_1 = Up stream pressure, PSIA

P_2 = Down stream pressure, PSIA

d = Inside diameter of pipe, Inches

L = Length of pipeline, Miles

3.4.3 Wall thickness of pipe

Now it is time to determine the pipe wall thickness. Pipe wall thickness for each nominal pipe size commercially available, the outer diameter (OD) is specified. For each OD a variety of wall thicknesses are available. For above ground pipe it is generally recommended that a minimum of standard wall thickness be used.

3.4.3.1 Yield strength

Pipeline steel is available in many strengths. The designer must choose a pipe grade and wall thickness together to meet the pressure requirements of the station. Barlow's Formula is used to determine steel pipe selection.

Using Barlow's Formula one can determine the size and strength of pipe needed for the station.

Below is Barlow's Formula :

$$P = (2St/D) \times F \times E \times L \times T \text{ -----(3.3)}$$

Where,

P = Design pressure, PSIG

S = Yield strength, tensile strength of the metal, PSI

t = Nominal wall thickness, Inches

D = Outside diameter, Inches

F = Construction type design factor (safety factor)

E = Longitudinal joint factor

L = Location factor

T = Temperature de rating factor

Where,

F - above ground pipe = 0.5 or 0.4

E - seamless or electric resistance welded pipe = 1

T - temperatures between 20 °F and 250 °F = 1

3.4.3.2 Minimum yield strength (Y)

The properties of steel used in the construction of pipeline are divided into two API specification. 5L for normal quality steel and 5LX for high strength steels. These specifications are now accepted throughout the world. Table 3.1 gives the strength properties of most widely used steels.

Table 3.4.3.2 Strength of Line pipe Steel

Specification	Grade	SMYS (psi)
5L	A	30,000
5L	B	35,000
5LX	X 42	42,000
5LX	X 46	46,000
5LX	X 52	52,000
5LX	X 56	56,000
5LX	X 60	60,000
5LX	X 65	65,000
5LX	X 70	70,000
5LX	X 75	75,000

(SMYS = Specified Minimum Yield Strength)

3.5 Headers

A header is a way to combine multi sources or multi-outlets into a single source or outlet. Headers need to be designed to distribute the gas symmetrically. They are typically larger sized pipe, tees, and caps. Headers are used when more than one regulator or meter run are required. In sizing headers it is a rule of thumb that the cross sectional area of the header be 1.5 times larger than the sum of the inlet or outlet cross sectional area (which ever is larger).

The following equation is used for header sizing

$$\pi D^2/4 = [(\pi d_1^2/4 + \pi d_2^2/4 + \dots + \pi d_n^2/4) * 1.5] \quad (3.4)$$

Where,

$\pi D^2/4$ - Cross sectional area of the header, square inches

$\pi d_1^2/4$ - Cross sectional area of the 1st inlet or outlet pipe line, square inches

$\pi d_2^2/4$ - Cross sectional area of the 2nd inlet or outlet pipe line, square inches

$\pi d_n^2/4$ - Cross sectional area of the nth inlet or outlet pipe line, square inches

Headers may be placed above ground or below ground. One must consider noise when placing a header above ground and liquid removal when placed below ground. A straight or U-shaped header may be used, but it is a good idea to know the gas velocity through the header after sizing.

3.6 Filtering system

The vessel of filters separator will be designed and manufactured in accordance with ASME section-8, Division1 and welding the vessel with AP1-1104 Code. The followings are important matter in order to design filter separator:

1. Permissible particle size (5 micron is allowable)
2. Filtering efficiency
3. Pressure should not be reduce with filtering operation.

Maximum gas velocity for filtering system.

Up stream filtering system : 60 feet per second

Down stream filtering system : 120 feet per second

3.6.1 Liquid separation system

The liquid separation system is composed by two identical filtering lines to provide separation of liquid condensate mist from gas down stream pressure reduction . Each of them is designed for the maximum station flow rate, so that during the normal operation of the plant one filter will be in service and the second will be stand-by. Each filter will be put in/on of service only manually operating through the inlet/outlet filter gear operated ball valves. The liquid separation system is designed for the following operating condition.

3.6.1.1 Criteria of a well designed separator

To perform efficiently, a well designed separator should meet the following criteria –

- Control and dissipate the energy of the well stream as it enters the separator, and provide low enough gas and liquid velocities for proper gravity segregation and vapor-liquid equilibrium. For this purpose, a tangential inlet to impart centrifugal motion to the entering fluids is generally used.
- Remove the bulk of the liquid from the gas in the primary separation section. It is desirable to quickly achieve good separation at this stage.
- Have a large settling section, of sufficient volume to refine the primary separation by removing any entrained liquid from the gas, and handle any slugs of liquid (usually known as “liquid surges”).
- Minimize turbulence in the gas section of the separator to ensure proper settling.
- Have a mist extractor (or eliminator) near the gas outlet to capture and coalesce the smaller liquid particles that could not be removed by gravity settling.
- Control the accumulation of froths and foams in the vessel.
- Prevent re-entrainment of the separated gas and liquid.
- Have proper control devices for controlling the back-pressure and the liquid level in the separator.
- Provide reliable equipment for ensuring safe and efficient operations. This includes pressure gauges, thermometer, liquid level indicator, safety valve etc.

3.6.2 Filter separator design criteria

The separator sizing is depends on gas capacity, liquid capacity of separator and pressure drop through it.

3.6.2.1 Gas capacity design of separator

The Souders- Brown Equation is used for calculation of gas capacity of gas-liquid separator (Kumar,1987).

$$v_g = K_1 [(\rho_l - \rho_g)/\rho_g]^{0.5} \text{-----} \quad (3.5)$$

Where, v_g = allowable gas velocity at the operation conditions, ft/sec

ρ_l = liquid density at the operation conditions, lbm/ft³

ρ_g = gas density at the operation conditions, lbm/ft³

K_1 = coefficient of separator

Table 3.6.2.1: Values of separator coefficient, K_1 (Kumar,1987)

Separator type	Range of K_1	Most commonly used K_1 Value
Vertical	0.06 to 0.35	0.117 without mist extractor
		0.167 with a mist extractor
Horizontal	0.40 to 0.50	0.382 with a mist extractor
Spherical	0.40 to 0.50	0.35 with a mist extractor

The gas capacity at the operation conditions ρ_g , in ft³/sec is given below:

$$\rho_g = Av_g = (\pi D^2/4) K_1 [(\rho_l - \rho_g)/\rho_g]^{0.5} \text{-----} \quad (3.6)$$

Where,

A = cross sectional area of the separator, ft²

D = internal diameter of the vessel, ft

Here the gas velocity, v_g is based upon the total separator area and it is therefore more appropriate to refer to it as the superficial gas velocity. The gas capacity at standard condition

(14.73 psia and 60⁰F), generally reported in units of MMSCFD is thus given by:

$$q_{gas} = 2.40D^2 K_1 [p/Z(T+460)][(\rho_l - \rho_g)/\rho_g]^{0.5} \text{-----}(3.7)$$

Where,

q_{gas} = Gas capacity at the operation conditions,

MMSCFD p = Operating pressure, PSIA

T = Operating temperature, ⁰F

Z = Gas compressibility factor at the operation conditions.

Above two Equation can be used to calculate the separator diameter required to handle a given gas rate or to calculate the gas rate that a separator of a given size can to handle.

The area of the mist extractor A_m can be obtained as follows.

$$A_m = q_g/v_m \text{-----} (3.8)$$

Where, v_m is the gas velocity through the mist extractor, determine using the first Equation with $K = 0.35$ for mist extractor (wire mesh type).

3.6.2.2 Liquid capacity design of separator

The liquid capacity of a separator depends upon the volume of the of separator available to the liquid and the retention time of the liquid within the separator (Kumar,1987).

$$w = 1440 (V_L)/t] \text{-----} (3.9)$$

t = retention time, min (1440 is the conversion factor to convert bbl/day into bbl/min)

The liquid setting volume, V_L can be used to calculate as follows:

$$V_L = 0.1399D^2h \text{ for vertical separators}$$

$$V_L = 0.1399D^2 (L/2) \text{ for horizontal single tube separators}$$

$$V_L = 0.1399D^2 L \text{ for horizontal double tube separators}$$

$$V_L = 0.0466D^3 (D/2)^{0.5} \text{ for spherical separators}$$

Where, h = height of liquid column above the bottom of the liquid outlet in the vertical separators, ft

L = separator length (height), ft

For good separators, a sufficient retention time, t must provide. From field experience, the following liquid retention times have been suggested (Kumar,1987).

Oil-gas separation : 1 min.

High pressure oil water gas separation : 2 to 5 min.

Low pressure oil water gas separation : 5 to 10 min. at > 100 oF

10 to 15 min. at > 90 oF

15 to 20 min. at > 80 oF

20 to 25 min. at > 70 oF

25 to 30 min. at > 60 °F

3.6.3 Vessel design consideration

For designing separator some basic factors that must be consider are point out bellow (Kumar,1987):

- The length to diameter ratio, L/D , for a horizontal or vertical separator should be kept between 3 and 8, due to considerations of fabrication and foundation cost.
- For a vertical separator, the vapor-liquid interface (at which the feed enters) should be at least 2 ft from the bottom and 4 ft from the top of the vessel. This implies a minimum vertical separator length (height) of 6 ft.
- For horizontal separator, the feed enters just above the vapor-liquid interface that must be off-centered to adjust for a greater gas (or liquid) capacity as needed. The vapor-liquid interface must be kept at 10 inch from the bottom and 16 inch from the top of the vessel. This implies minimum horizontal separator diameter of 26 inch.

3.7 Regulators

The regulator is a component of the system and therefore its selection and installation should be based on the system requirements. After these have been selected the designer must then determine how many pressure cuts are needed to meet the design requirements. Due to large pressure drops across the station there may be a need for multiple pressure cuts to eliminate freezing and maintenance problems. The making of multiple pressure cuts will reduce or eliminate noise caused by large pressure drops across a control valve. Another way to eliminate noise is to increase the wall thickness of the piping. Next, a regulator or control valve should only be sized for 75% of its capacity at the maximum volume and minimum inlet pressure of the station. Properly sizing the regulator is essential to the design of the station in order to reduce maintenance cost and operational problems.

It is recommended that regulators be installed with 5 pipe diameters upstream and 8 pipe diameters downstream. This will allow time for the control valve or regulator to sense and react to a change in the process.

The selection of a regulator requires some consideration of the following

- Maximum volumes
- Site location
- Operation and Maintenance
- Environmental impact
- Safety

The first step in selecting a regulator is to know what type of control is desired

- Volume
- Pressure

The second step is to determine what type of regulator is needed

- Spring operated
- Pilot operated
- Controller operated

In the RMS both axial flow valve (AFV) and on line maintenance type regulators are used .



Figure 3.7: Regulators with compersore machine

3.7.1 Regulators installed

It is recommended that regulators be installed with 5 pipe diameters upstream and 8 pipe diameters downstream (AGA Report 7). This will allow time for the regulator to sense and react to a change in the process.

3.7.1.1 Parallel installation of regulators

Although many regulator designs can operate over a wide flow and pressure range often it is necessary to consider parallel runs to provide proper control. A regulator required to operate nearly closed over long periods of time will have more valve and seal damage than a unit that is sized to have the valve open at least ten percent. A small regulator can be installed in the one line to handle low flows and a large regulator installed in the parallel line to handle large flows up to the required capacity for the station. Good practice would also dictate the use of

parallel regulators for the purpose of redundancy. Since there are different types and sizes of regulators.

3.7.1.2 Pressure sensing point

All regulators have a pressure sensing point and those with an external control line should have a sensing pressure tap several pipe diameters downstream of the regulator on a straight run of pipe. Each regulator should have a separate sensing tap and control line. A common practice is to use ten pipe diameters downstream for the sensing pressure tap with five pipe diameters usually considered to be minimum. The control line may be $\frac{1}{4}$ inch, $\frac{1}{2}$ inch or $\frac{3}{4}$ inch pipe or tubing, depending on the type of regulator and the distance from the pressure sensing point to the regulator. Long sensing lines should be adequately supported and should slope slightly toward the point of connection to the pipe. Pressure taps should not be located on elbows, expanders or other fitting that would introduce false or unstable pressure registration. At the pressure sensing connection, a valve should be installed to enable isolation of the sensing line, thus permitting the regulator to be taken out of service without shutting down the station. In addition to the sensing line connection, another tap with a valve for checking or recording pressure should be located as near as possible to the sensing line connection. A single tap with a tee can be used to provide the attachments.

3.7.2 Inlet and outlet connections

The piping to and from regulator should be supported adequately to minimize pipe strains. The piping should be designed to have adequate capacity for the expected maximum flow and the pressure conditions. Velocities in regulator valve passages can reach sonic velocity conditions. High velocities create noise so piping should be sized to keep gas velocities at a reasonable level. There are specific pipeline velocity limits used by many companies to maintain a relatively quiet pipeline system and to keep pressure losses low. Such limiting velocities range between 50 feet per second to a maximum of approximately 400 feet per second. There are situations where higher velocities may be required for short distances; however, the designer should calculate the pipe velocities to be encountered and determine the steps that may be necessary to maintain satisfactory noise levels.

3.7.2.1 Regulator sizing

The following must be consider in order to sizing regulator :

- Inlet pressure
- Outlet pressure
- Gas flow rate
- Over pressure protection device such as monitor, relief valve and slam shut valve
- No. of pressure staging.

Two Equations are used for sizing regulator all over the world :

1. Universal gas sizing Equation and

2. ISA gas sizing equation.

ISA gas sizing equation is more precisely used for pressure control valve. But Universal gas sizing Equation is popular in natural gas industries. This Equation is described as follows:

1. Subsonic Flow ($P_1 - P_2 / P_1 \leq 0.55$)

$$C_g = Q / P_1 [\sqrt{520/GT} \sin [(3417/C_1) \sqrt{(P_1 - P_2)/P_1}]^{\text{Degrees}} \text{-----} \quad (3.10)$$

2. Sonic Flow ($P_1 - P_2 / P_1 \geq 0.55$)

$$C_g = Q / (P_1 * 1.29) \text{-----} \quad (3.11)$$

Where,

Q= Flow rate (SCFH)

C_g = Gas sizing co-efficient

P_1 = Inlet Pressure (Psia)

P_2 = Outlet Pressure (Psia)

$C_1 = C_g/C_v$ = Valve recovery co-efficient

G = Specific gravity

T = Temperature, $^{\circ}$ Rankine ($460+F^{\circ}$)

In order to choose the best type of regulator for a particular application it is need to know the outlet pressure (delivery pressure) and C_g value. The following Table 3.6 is used for conversion of C_g value to regulator size. Then refer to the regulator selection chart (Fig. 3.1) to determine the type of regulator that is best for the application.

Table 3.7.2.1: C_g value of regulator

Regulator Size (Inch)	Fisher EZR		Tartarini FL		Mooney	
	C_g	C_1	C_g	C_1	C_g	C_1
1	509	32.5	550	29	450	34.0
2	2030	36.1	2300	27	1600	35.0
3	3830	37.2	5200	29	3450	36.0
4	6000	37.9	8300	27	6500	38.0
6	12360	35.5	17500	28	12500	40
8	20700	38.8	30600	30	20200	38
10	-	-	-	-	22000	40
12	-	-	-	-	40400	38

(Source : Fisher Controls, 2005 and Richard J. Mooney,1999)

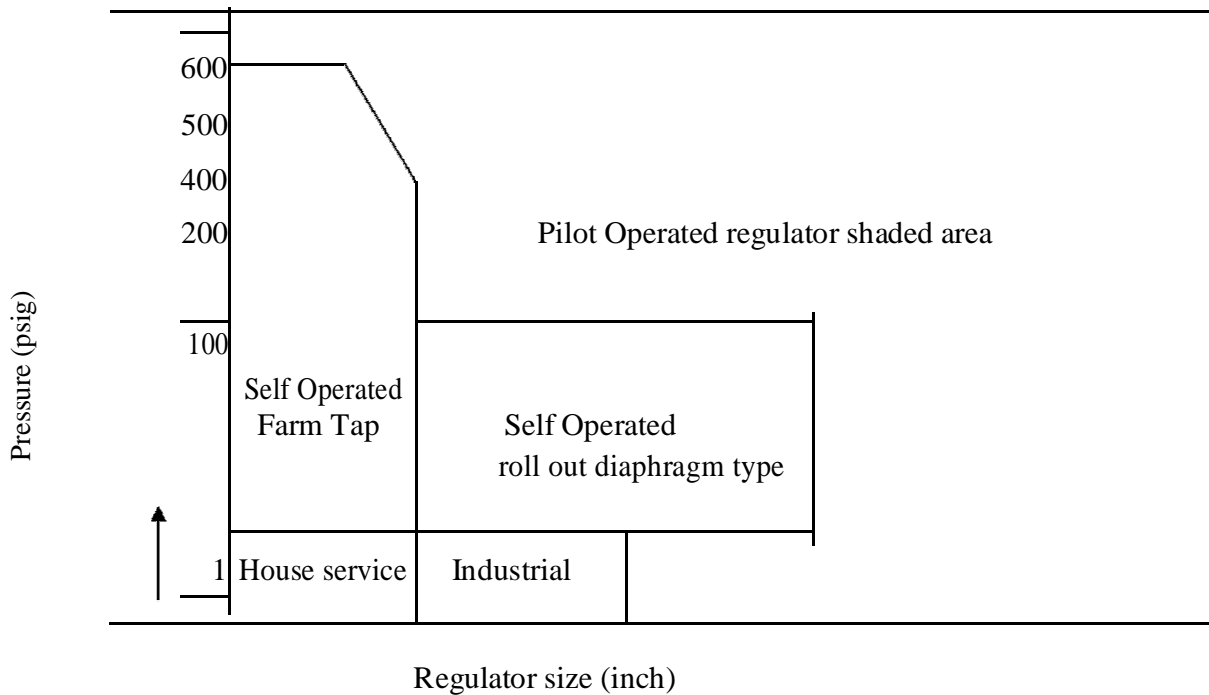


Figure. 3.7.2.1 : Regulator selection chart
 (Source: Richard J. Mooney,1999)

Outlet velocity and noise

Another consideration in selecting a regulator size is outlet velocity, especially when noise is a concern. Velocities in excess of 0.5 of mach or sonic velocity will increase the noise produced and can cause excessive vibration and subsequent valve and piping damage in extreme cases. The following Table 3.7 lists the approximate maximum flow rates by regulator sizes and outlet pressure for 0.5 mach (50% of sonic velocity). Sonic velocity for natural gas at 60 °F is 1400 feet/sec but recommendation is not to exceed 70% of sonic velocity.

Table 3.7.2.2: Maximum flow rates of regulator

Regulator sizes (Inch)	Approx. Maximum flow (MSCFH) if outlet velocity is 0.5 Mach (0.5 Mach = 700 feet/sec for natural gas)					
	7 Inch. W.C	15 Psig	30 Psig	125 Psig	250 Psig	500 Psig

1	14.3	28.2	42.3	132	249	484
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Table 3.7.2.3: Maximum flow rates of regulator(cont'd)

Regulator sizes (Inch)	Approx. Maximum flow (MSCFH) if outlet velocity is 0.5 Mach (0.5 Mach = 700 feet/sec for natural gas)					
	7 Inch. W.C	15 Psig	30 Psig	125 Psig	250 Psig	500 Psig
2	57.4	113	169	526	996	1936
3	129	253	381	1184	2242	4357
4	229	451	677	2106	3986	7746
6	516	1015	1523	4738	8968	17428
8	918	1804	2707	8422	15942	30982
10	1434	2820	4230	13160	24910	48410
12	2065	4060	6091	18950	35870	69710

(Source : Richard J. Mooney,1999)

Inter stage pressure

When the station is a two or more stage pressure reducing station, it should be determine the inter stage pressure to optimize noise abatement or to optimize capacity. The following formula gives the inter stage pressure that is equalize the $(P_1 - P_2)/P_1$ values for the first and second stage pressure reduction. This pressure will be very close to the optimum pressure for quietest operation.

$$P_i = [\sqrt{(P_1 \cdot P_2)}] \text{-----} (3.12)$$

Where,

P_i = Inter stage pressure, PSIA

P_1 = Inlet Pressure, PSIA

P_2 = Outlet Pressure, PSIA

The following steps are required to size and select a pilot operated regulator

- Calculate the C_g required form the service conditions. Adding 20-25 % with C_g value to ensure good performance.

- Dividing the C_g value by 0.70 or multiplying by 1.43 to determine the size of monitor and active regulator. Because when two regulators are used in series their capacity is approximately 70% of a single regulator of the same size.
- Select a body class rating for the inlet pressure requirements.
- Select a body size based on published C_g values or sizing tables.
- Select a pilot pressure range for the outlet pressure desired.

3.7.2.2 Pressure setting

Regulator can be used as a single or jointly as Active-Monitor. The relief valve is installed at outlet portion of the regulating run. The setting pressure of relief valve is higher than regulator pressure. The setting of Active regulator, monitor regulator, relief and shut off valve are described as follows:

Active Regulator = X psig

Monitor Regulator = (X +5% of X) psig

Relief valve =(X +10% of X) psig

Slam shut off valve = (X +20% of X) psig

3.8 Heating capacity of gas heater

The heaters are designed on the basis of maximum inlet pressure, maximum outlet pressure, minimum inlet temperature and maximum flow expected after ten years of installation. Heat (Enthalpy) required to rise up the temperature of a specific density gas with different pressure is the main criteria of heater design. For a gas of specific density , ρ (kg/m^3); flow rate, Q (m^3/s) and enthalpy change, E (kJ/kg) for rise up temperature to two different pressure, rate of heat absorption, W (kJ/s or kw) is written (Roy,1989) by.

$$W = E.Q. \rho \text{ ----- (3.13)}$$

Heat required for preheating the natural gas can also be calculated by using the Joule-Thomson effect Equation (McAllister,1998).

$$W = q_n \cdot \Delta t_{\text{gas}} \cdot \rho_n \cdot C_p \text{ ----- (3.14)}$$

Where, W = heat quantity, kJ/h

q_n = gas volume or flow rate, m^3/h

Δt_{gas} = total temperature = $\Delta t_1 + \Delta t_2$ in K

Δt_1 = Joule-Thomson effect = $(P_i - P_o) 0.5$ in K

Δt_2 = temperature different between minimum gas inlet temperature and temperature required after gas pressure reduction in K

ρ_n = Specific density of natural gas, kg/m^3

C_p = Specific heat of natural gas, kJ/kg

P_i = Inlet pressure of natural gas, bar

P_o = Outlet pressure of natural gas, bar

On the basis of the heat required to rise up the temperature of gas a suitable capacity heater is designed. The vessel size of heater will be design in accordance with ASME section 8, Devission-1.

3.9 Meter selection

For custody transfer application, it is very important to select a proper meter considering the load nature of the RMS. In regulating & metering station design, both orifice and turbine meters are used. The orifice meter is simple, accurate, relatively inexpensive rugged and reliable but hence a limited rangeability (3:1) and are difficult to adapt to automation. For this reason very low and very high quantity of volume are not measured by the same orifice plate. Low quantity of volume is measured by small size of orifice plate. Accuracy and rangeability (20:1) is very high for turbine meter.

3.10 Optional short-coupled installation

In those instances where the required space for the recommended installation of Figure 3.4 is not available, a short-coupled installation may be employed as shown in Figure 3.5 This configuration utilizes minimum of four nominal pipe diameters upstream with straightening vanes located at the inlet of piping. The distance between the straightening vane outlet and the meter inlet should be a minimum of two nominal pipe diameters. The meter is connected to the vertical risers using a standard Tee or elbow. The maximum pipe reduction to the risers is one nominal pipe size, valving, filters or strainers may be installed on the risers.

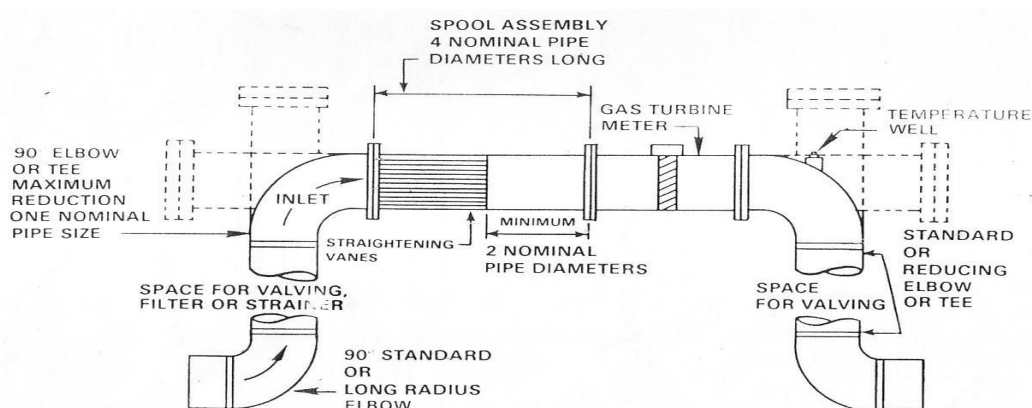


Figure 3.10: Short coupled installation of an in-line gas turbine meter (Minimum Length)

3.11. Straightening vanes

The purpose of a straightening vane is to eliminate swirls and cross currents set up by the pipe fitting valves or regulators preceding the meter inlet piping. While the specifications which follow up particularly to the type of vanes shown in figure 3.6, vanes of other designs can be used if they meet the specifications.

In construction of vanes the maximum transverse dimension, “a” of any passage through the vane should not exceed one-fourth the inside diameter, “D” of the pipe. Also the cross sectional area, “A” of any passage within the assembled vanes should not exceed one-sixteenth of the cross sectional area of the containing pipe. The length, “L” of the vanes should be at least 10 times the maximum inside dimension, “a”.

The vanes may be built of standard weight pipe or thin-walled tubing either welded together securely attached into the meter inlet piping or mounted into two end-rings small enough to slip in the pipe. Square, hexagonal or other shaped tubing may be used in making the vanes. It is not necessary that the vane passages be of the same size, but their arrangement should be symmetrical.

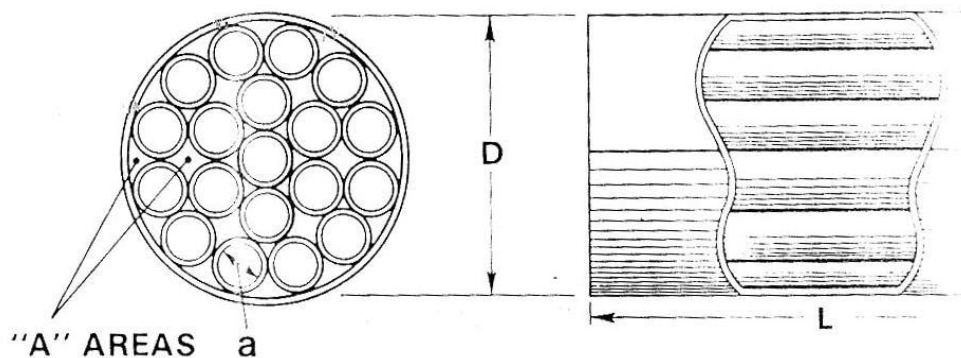


Figure 3.11. Straightening Vanes

(Source : AGA Report 7)

3.12 Strainers or Filters

Foreign substances in a pipe line can cause serious damage to turbine meters. Strainers are recommended when the presence of damaging foreign material in the gas stream can be anticipated. Strainer should be sized so that at maximum flow there is a minimum pressure drop and flow distortion.

A greater degree of meter protection can be accomplished through the use of dry-type or separator type filter installed upstream of the meter inlet piping. It is recommended that the differential pressure across a filter be monitored to maintain it in good condition so as to prevent flow distortion and possible customer outage.

3.13. Over-range protection

Sudden rotor over speeding caused by extreme gas velocities encountered during pressuring m, venting or purging can cause sever damage. Some meters and readout devices may be damaged when they are run backwards. Therefore, the pressure blow-down valve should be located downstream of the meter. While turbine meters can be operated up to 150% of rated capacity with no damaging effects for short period of time, over-sized blow-down valves can cause rotational speeds greatly in excess of this amount. Therefore, the blow-down valve should be sized as follows (Source: AGA Report No.7):

Meter run	Valve size
2"	1/4"
3"	1/2"
4"	1/2"
6"	1"
8"	1"
12"	1"

As a rule of thumb, the blow-down valve should not be larger than one-sixth of the meter size. In those installations where adequate pressure is available, either a critical flow orifice or sonic venture nozzle may be installed in the piping downstream of the meter and should be sized to limit the meter to approximately 120% of its maximum rated capacity. A critical flow orifice so designed will result in a 50% permanent pressure loss and a sonic venture nozzle will in a 10-20% permanent pressure loss.

3.14 By- pass

It is good practice to provide a by-pass so the meter can be maintained and calibrated without a service interruption. This should include proper valving relative to the type of calibrating equipment to be used.

3.14.1 Additional installation requirements

- The meter and meter piping should be installed so as to reduce strain due to pipeline stresses.
- A concentric alignment of the companion pipe flanges with the meter inlet and outlet connections should be obtained. This concentric alignment will eliminate any appreciable effect upon the meter accuracy that might be caused by an offset in the internal diameters that may occur in some installations.
- A gasket protrusion into the bore or flow pattern at the meter connections should not be permitted.
- Pipe interior should be of commercial roughness, and the flange I.D. should be the same as that of the pipe. Welds on piping at the meter inlet and outlet should be ground to the I.D of the pipe.
- Installations where liquid can be encountered should be designed to prevent liquid accumulation in the meter.
- No welding should be done in the immediate area of the meter to prevent possible internal meter damage.

3.15 Accessory installation

Accessory devices used for integrating uncorrected volume to base conditions or for recording operating parameters must be properly installed and their connections made as specified herein.

3.15.1 Temperature measurement

Since upstream disturbances should be kept to a minimum, the recommended location for a thermometer well is downstream of the meter. It should be located within five pipe diameters of the meter outlet and upstream of any valve or flow restrictor. The thermometer well should

be installed to insure that the temperature is not influenced by heat transfer from the piping and well attachment.

3.15.2 Pressure measurement

A pressure tap as provided by the manufacturer on the meter body should be used as the point of pressure sensing for recording or integrating instruments.

3.15.3 Density measurement

In the use of densitometers, while it is desirable to sample the gas as close as possible to the rotor conditions, care must be exercised not to disturb the meter inlet flow or to create an unmetered by-pass. Reference should be made to manuals on the various densitometers for further information.

3.16 Flow conditions:

The pipe line or installation conditions, which can be made up of a number of variables can have a major influence on the operation and accuracy of an orifice plate metering system. It is very important to understand the influence of these variables for accurate flow measurement through orifice or turbine meter. Before the fluid measurement process is initiated, some fundamental characteristics of fluid to be measured and most common field conditions must be determined. Some of these are as follows:

- Velocity profile and distortion
- Swirl
- Reynolds number
- That fluid is Newtonian in behavior
- the composition
- influence and/or presence of foreign material

CHAPTER 4

GAS LOAD CALCULATION

4.1 Gas source

The location of the proposed 50 MW Power plant is at Sreepur in Gazipur district. A 4"DN×500 psig Off take point of Dhanua TBS exists at a approximate distance of 0.5 km from the plant site. The Dhanua TBS is presently receiving gas through Monohordi-Elenga 24" DN ×1000 psig pipe line (Appendix O). A 0.5 km 4" DN ×500 psig pipe line can be constructed to transmit gas to the Power plant through the RMS at a required quantity and pressure.

A schematic line diagram of 4" DN ×500 psig pipe line network from Dhanua TBS to power plant RMS is shown in Fig 4.1.

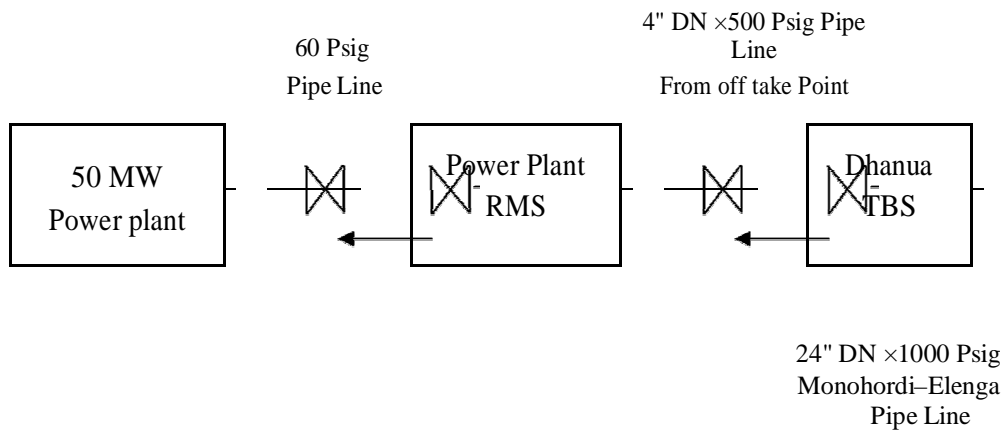


Figure 4.1. Schematic diagram of 4" DN ×500 psig pipe line

4.2 Gas based Power Plant

Bulk electric power is produced by special plants known as generating stations or power plants. A generating station essentially employs a prime mover coupled to an alternator for the production of electric power. Depending upon the form of energy converted into electrical energy, the power plants are classified various classes such as Steam power plants, Hydro- electric power plants, Diesel power plants and Nuclear power plants. The

Power Generating Station that generate electricity by using natural gas is called gas based Power Plants. These type of Power Plants are Gas Turbine, Steam Turbine and gas generator.

4.2.1 Gas load for 50 MW power plant

The proposed power plant considered as gas based power plant has an installed capacity of 50 MW. The plant will produce electricity using gas generators. Six gas generators, each having 8.425 MW capacity will be required for the power plant.

Considering Rolls-Royce generator for proposed power plant, the required data is given as follows (Appendix D).

Engine Type- B 35 :40 V 20 AG

- Generating capacity of each generator = 8425 KW or 8.425 MW (Mega watt)
- Thermal overall efficiency = 42 %
- Fuel type = Natural gas
- Minimum gas feed pressure to engine inlet = 50 Psig
- Gas feed temperature to engine inlet = 20⁰ C
- Lower calorific value of natural gas = 915 Btu/SCF (Appendix C)

For 50 MW power generation = $50/8.425 = 6$ (Six) generating sets are required

The gas load for 50 MW power plant is calculated is as follows:

Gas load calculation on the basis of electrical output :

Electrical output of each generator = 8425 KW

Heat input of each generator = $8425/0.42$ KW (Thermal overall efficiency, $\eta = 42\%$)
= 20060 KW

Input heat of each generator = (20060×1000) W
= (20060×1000) Joule/See
= $[(20060 \times 1000)/4.2]$ Cal/See
= $[(20060 \times 1000)/(4.2 \times 252)]$ Btu/See
= $[(20060 \times 1000 \times 3600)/(4.2 \times 252)]$ Btu/hr
= 6,82,31,293 Btu/hr

Lower calorific value of natural gas = 915 Btu/SCF (Appendix C)

$$\begin{aligned} \text{Gas required for each generator} &= (6,82,31,293/915) \text{ SCFH} \\ &= 74,570 \text{ SCFH} \\ &= 1.8 \text{ MMSCFD} \end{aligned}$$

$$\begin{aligned} \text{Gas required for 6 (Six) generators} &= 1.8 \times 6 \text{ MMSCFD} = 11 \\ &\text{MMSCFD} \end{aligned}$$

Therefore, the gas consumption for the 50 MW power plant is 11 MMSCFD.

The selected type of gas generators requires minimum 50 psig pressure for their operation. Therefore, the total gas will be required around 11 MMSCFD at pressure of above 50 psig for the power plant.

For designing, the gas flowing capacity of the RMS should be consider as the sum of power plant consumption, heater RMS consumption and decreasing the efficiency of the power plant.

From the above discussion, it is recommended 10% additional load for RMS design.

Assume, 10% additional load for RMS design

$$\text{The gas flowing capacity of the RMS} = 11 \text{ MMSCFD} \times 1.1 = 12 \text{ MMSCFD}$$

From the data, it is seen that the maximum flowing capacity of the RMS is 12 MMSCFD and the minimum flowing capacity of the RMS is 1.8 MMSCFD. Therefore, the turn down ratio of the RMS is 12:1.8, which should be consider for proper size selection of the RMS equipments.

CHAPTER 5

SAFETY AND ENVIRONMENTAL ASPECT OF RMS

Safety and environmental impacts are the first considerations in the design of regulating and metering station. Many factors must be considered in the design to ensure safety of pipeline and RMS operation.. International codes and standards (ASTM, ASME, ANSI, API), A.G.A. Report no-7 and Bangladesh natural gas safety rules,1991(Amendment 2003) have been followed for design of gas pipelines and RMS. In this chapter, safety and environmental aspects in designing a regulating and metering station will be discussed.

5.1 Environmental impacts of proposed gas facilities for the power plant

The impacts of a gas facilities project can be direct, such as the effect of toxic discharge on air, noise and water quality or indirect, such as the effect on human health from exposure to particulates or contaminants. It increases the possibility of explosion and leakage due to accidents, malfunction of joints or corrosion and lack of skillness and carefulness of related persons. These negative effects on the environment will be negligible due to implementation of the project.

Taking proper precautions, these negative effects can be mitigated. The positive impacts of the project will out weigh the negative one.

The negative impacts of the power plant are much more compared to that of RMS and pipeline. Running of power plant will produce more noise, vibration, wear and rear compared to RMS, so more protection should be taken to reduce the negative impacts of power plant. The negative impacts of RMS and pipeline are less likely.

5.2 Environmental Consideration

For environmental reasons in addition to the necessary reliability the station should be of the smallest practicable size with a high degree of safety against leakage and as silent as possible in operation. The generated sound level shall not exceed 85dBA (DoE Report,1991). In this regard, all of the equipments and instruments have been selected as per ASTM, ASME, ANSI, API, A.G.A. Report no-7 and Bangladesh natural gas safety rules,1991 (Amendment 2003), so that sound level dose not exceed 85dBA .

5.3 Safety Consideration

In order to enhance the occupational health and works safety of gas pipeline and RMS project, the following monitoring works have been done.

5.3.1 Gas quality

Gas quality should be maintained to minimize the possibility of any kind of corrosion, wear and tear, burning quality, so gas should be dust, water and sulfur free. In this view, liquid separator, filter separator and heater have been used to maintain the gas quality of the proposed RMS.

5.3.2 Wall thickness of pipe

Pipe is selected with sufficient wall thickness or installed with adequate protection to withstand anticipated external pressures and loads that will imposed on the pipe after installation. Due consideration is given to the safety of life and property while selecting a valve and pipe. For this purpose the American code (ASME B 31.8) has been followed.

5.3.3 Pressure rating of materials

Considering the safety and environmental aspects, the pressure rating of RMS materials have been selected as per maximum allowable operating pressure in accordance with National Standards Institute (ANSI) pressure class and API (Appendix H, I).

5.3.4 Control of overpressure in the system

To prevent personal injury, equipment damage or leakage due to bursting of pressure-containing parts, it is necessary to install adequate overpressure protection when installing a pressure reducing regulator. Overpressure protection equipment should be installed to protect all downstream equipments in the event of regulator failure.

To prevent accidental over pressure, the flowing protective devices are used in the proposed RMS.

- Pressure relief valve is used to prevent a rise of inlet pressure in excess of a specified value in the pressure system..
- Slam shut valve: Slam shut valve is installed in series with active regulator.
- Active Monitor regulator : A monitoring regulator is installed in series with active regulator.
- Non return valve is used to prevent flow in the reverse direction.

5.3.5 Installation of valves

Block valves install in transmission lines, distribution system and service lines at intervals and at locations.

- Valves are installed above ground and above highest flood level.
- Valves are installed in accessible locations of the systems in order to reduce the time to shut down a section of main in an emergency.
- A valve is installed on the inlet piping of each regulator or station controlling the gas flow in the system. The distance between the valve and the regulator or regulators should be sufficient to permit the operation of the valve during an emergency, such as a large gas leakage or fire in the station.

5.3.6 Location of meters and regulators

Meters or regulators have been installed or located in easily accessible and ventilated place and the distance should be at least five meter far and invisible from any source of heat or ignition such as hearth, furnace, electric heater or open flame of any sort.

5.3.7 Safety distance of pipeline

The following safety distances of pipeline have been maintained for all pressure pipelines to be operated above 150 Psig or above pressure of all high pressure pipeline which is shown in Table 6.1.

Table 5.3.7 Safety distance of pipeline

Pipe size	Pressure 150 Psig to 350 Psig	Above 350 Psig
Up to 20"	2.00 Meter	2.50 Meter
Above 20"	3.00 Meter	3.50 Meter



5.3.8 Controlling Hazards

Some control measures to prevent hazards are as follows:

- Marking hazards with signs, flags, lights, alarms, barricades, fences, labels, placards or other materials.
- Providing personal protective and other safety equipments to workers.
- Using engineering controls to reduce the impact of hazards.

Whenever possible, hazards should be eliminated. If elimination is not possible, other control measures should be used to protect workers.

5.3.9 Prevention of eddy current

Insulating joints (IJ) have been used at station inlet and outlet of RMS to protect eddy current producing from transmission and distribution network that may damage the RMS.

5.3.10 Leak detector

Pipe line leak detectors should be used in the gas system. Generally odorant is used to detect the line leakage. A leak detector is suggested for the proposed RMS.

5.3.11 Fire Extinguisher

There is a provision of fire extinguisher in the RMS premises for controlling of small fires due to leakage of gas.

5.3.12 Protection against corrosion

Natural gas pipelines are laid below the ground surface. These pipelines are susceptible to corrosion by various subsoil environments. As the pipelines are growing old, it is becoming more difficult to protect them from the damage caused by corrosion. Major cause of the supply interruptions is leakage in the pipeline due to corrosion. To control corrosion of pipeline combined system of coating and cathodic protection should be used. Within one year of construction of pipeline, cathodic protection is applied to the pipeline in accordance with BS CP 1021 or American National Association of corrosion Engineers code RP 01-72 as far as practicable.

A safe and leak free pipeline network is essential for uninterrupted gas supply to the power plant. For this reason a Cathodic Protection (CP) station is recommended for the 0.5 km 4" DN ×500 psig pipe line network of the power plant RMS within one year of the construction of the pipeline.

5.3.13 The lighting arrangement

The lighting arrangement for the RMS area should be explosion proof and suitable for hazardous area. Lighting fixtures are mounted on a pole above the suitable height for proper illuminations.

5.3.14 Major activities of a Project

The major activities of a gas facilities project are pipeline routes survey, Clearance from DOE, Design and Drawing, procurement of materials, construction, fabrication and installation, testing, Tie-ins with live line and Commissioning.

Hydrostatic test

Hydrostatic test is performed after mechanical completion of the pipeline. For hydrostatic test, water is poured into the pipeline section. Then the pipeline is pressurized by injecting small amount of water through hand pump. As per API standard minimum hydrostatic test pressure should be 1.5 times of design pressure.

Commissioning of pipeline and facilities

Commissioning is the flowing of natural gas through the newly constructed pipeline for first time. Pipeline, valves, fittings, meters and regulators are checked and rectified if necessary before Commissioning.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Based on the objectives of this project to design an ideal gas Regulating and Metering Station and cost estimation of the project, the following conclusions are made from this study.

- Gas flow capacity, maximum inlet pressure and outlet pressure of the RMS are 12 MMSCFD, 500 psig and 60 psig respectively for uninterrupted gas supply to the 50 MW power plant.
- In this project work, fluid characteristics, process data, gas safety rules, International codes and standards (ASTM, ASME ANSI, API) have been followed for proper design.
- All the equipments of Regulating and Metering station have been selected and arranged as per internationally recommended standards (IGE TD 9, AGA 7 and API) maintaining the entire requirements for filtering, regulating, metering to prevent various operational difficulties and measurement error.
- The pipe and fittings have been chosen in such a way that turbulence can be avoided or made minimum.
- Meter type and size have been selected considering variation of flow rate and pressure to measure the gas volume accurately because the revenue earning for the company is related to measurement.
- The RMS has been proposed to be well furnished with modern flow computer for gas measurement and online gas chromatograph for continuous gas analysis for smooth, quantitative and accurate measurement of gas flow.
- Variation in different variables such as inlet pressure, specific density, specific heat, compressibility factor and heating value within the allowable limit do not require any change in the proposed design.

- The cost estimation of the project has been calculated on the basis of preconstruction expenditure, construction cost, material cost etc. The total cost of the project is estimated as Tk. 494.463 Lakh.

6.2 Recommendations

- A Regulating and Metering station should be designed to meet the present and future demand under variable gas flow and pressure conditions and decreasing efficiency of the power plant.
- The RMS should be kept under a SCADA system for remote controlling of the system such as the valves, regulators and also for monitoring the status of flow rate and pressure for the case of operation as per international practice of the gas industry.
- After construction of the pipe line of RMS, cathodic protection (CP) system should be installed in the pipeline network and RMS for safe and leak free network in accordance with the requirements of British standard specification code BS CP 1021 or American National Association of Corrosion Engineers code RP 01-72.
- RMS equipments, piping and inlet outlet direction of gas flow should be painted as per colour coding of pipes and equipments.
- Before commissioning of the pipeline and RMS, both the pipeline and RMS should be tested by means of standard hydrostatic test for ensuring the safety and integrity of the pipeline and RMS.

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