System Loss Reduction Plan Of Titas Gas Transmission And Distribution Co. Ltd.

by

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January 2005

The thesis titled System Loss Reduction Plan of Titas Gas Transmission and Distribution Co. Ltd. Submitted by Md. Sumsuddin Al Azad Roll No. 100013019 (P) Session October 2000 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of MASTER OF ENGINEERING IN PETROLEUM AND MINERAL RESOURCES on Department of Petroleum and Mineral Resources Engineering

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(Md. Sumsuddin Al Azad)

This thesis is dedicated to Engr. M. Kamal Uddin Ahmed

ACKNOWLEDGEMENT

I would like to express my deep respect to Dr. Mohammad Tamim, Professor and Head of the Department of Petroleum and Mineral Resources Engineering, for his valuable guidance, encouragement and supervision through the entire work.

I would also like to express my profound gratefulness to Dr. Ijaz Hossain, Professor of the Department of Chemical Engineering for his cooperation, continuous inspirations and extended support to complete this work.

I would also like to express my profound gratefulness to Dr. Mohammed Mahabubur Rahman, Assistant Professor of the Department of Petroleum and Mineral Resources Engineering, for his cooperation, continuous inspirations and extended support to complete this work.

I sincerely appreciate the cooperation and the time of Md. Rakibul Hashem Sarker, Lecturer of the Department of Petroleum and Mineral Resources Engineering (PMRE) and Md. Basirul Haque of PMRE Department.

I thank the Managing Director, Titas Gas Transmission and Distribution Company Limited (TGTDCL) for his co-operation and providing me to complete the course with necessary facilities in collecting the required data.

I feel grateful to Engr. M. Kamal Uddin Ahmed Deputy General Manager, Transmission Department of TGTDCL for his extended support and cooperation in completing this work.

ABSTRACT

Titas Gas Transmission and Distribution Company Limited (TGTDCL) is a gas marketing company, which purchases gas from Bangladesh Gas Field Company Ltd. (BGFCL) and Sylhet Gas Field Company Limited (SGFCL). This gas is transmitted through its own and Gas Transmission Company Ltd's (GTCL) transmission lines to various bulk customers such as Power and Fertilizer Producing Company and distribution network through various City Gate Station (CGS), Town Border Station (TBS), District Regulating Station (DRS) and Metering Regulating Station (RMS) to industrial, commercial and domestic users. In marketing the gas, the company is now facing a major problem, which is known as system loss.

System loss is that portion of gas purchased, which is not accounted for by sales. transfer and company uses or otherwise accounted for. At present the net system loss is approximately 9%. Area wise in some places like Narayangonj, this figure is near about 50%. The present level of system loss needs some reduction to bring it to an acceptable limit.

The main objective of this study is to reduce the unaccountable gas. Identification of various factors related to system loss is carried out. These factors can be classified into two broad classes as a) technical loss, b) non-technical loss. Technical losses are inevitable and the level of the same depends on physical and operating condition of the customer metering stations. Non-technical losses are the man made loss can be many and varies with different factors. The main part of it is pilferage loss through various illegal means like meter tampering. regulator tempering, by pass or un-metered usage etc.

This study covers the definition, classification, calculation, background and present status of system loss Some of the special causes of system loss with respect to Bangladesh are also discussed. The action program and extended action program to reduce system loss undertaken by TGTDCL and the future plan or recommendation in this regard are also discussed.

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CHAPTER – 1

INTRODUCTION

A greater awareness of system loss in natural gas transmission and distribution system has taken place over the past decade. This development is due to the demands for increased system reliability and efficiency, environmental and accountability issues as well as extremely important criteria to minimize the loss of revenue.

The system loss for transmission system is basically the difference between the measurement of gas input to the summation of gas outputs, with a corresponding adjustment for changes in total line pack and other known pipeline usage and loss for a given period.

For a distribution system the basic concept of determination of gas balance is same as for a transmission system. however the magnitude of gas outlets coupled with the variability in demand and complexity of distribution systems, means that a number of parameters need to be taken into consideration. One of the major parameters is the understanding of customer load profiles, including seasonal factors and ability to use alternative energy sources coupled with an appreciation of the plant process. A transmission system will tend to be a 'tight' system with respect to leakage, whereas a distribution system can suffer from significant natural leakage, averaging and estimation of gas sales, significant load/lag effects with respect to account and theft or unauthorized usage.

The study of the system loss in a distribution system cannot be conducted in isolation of the transmission system from which it sources the gas supply. This is because the transmission supplies points are the datum or reference point for the input volume of gas. As any measurement has some uncertainty it must be accounted for and fully appreciated if a meaningful study is to be made for the distribution system loss. The volumetric measurement of natural gas is complex due to the dependence on the accurate measurement of pressure, temperature and composition.

Titas Gas Transmission and Distribution Company Limited (TGTDCL) is a gas marketing Company, which purchase gas from Bangladesh Gas Field Company Ltd. (BGFCL) and Sylhet Gas Field Company Ltd (SGFCL). This gas is transmitted through the companies own and Gas Transmission Company LTD's (GTCL) transmission line to various bulk customer such as power and fertilizer producing company and distribution network through CGS, TBS, DRS and RMS to industrial, commercial and domestic users.

System loss is that portion of gas purchased, which is not accounted for by sales, transfer, and company uses or otherwise accounted for. This is also known as Unaccounted For Gas (UFG). The factors affecting system loss all groped under two broad heads: technical and non-technical. Based on operational experience and available operational data, component-wise contributions of each of the technical and non-technical factors of system loss can be estimated. The technical factors are estimated at about 1.25% and the non-technical factors are account for about 8.11%, the total system loss being 9.365% of net throughput. This is shown in Table – 1.1].

Table – 1.1: Estimation of Various Components of system loss estimated in year 1993

SL. No.	Item of system loss	System loss estimated as percent of net throughput	
1.	Technical system loss		
1.1	Transmission loss	0.49%	1.25%
1.2	Distribution loss	0.75%	
2.	Non-Technical system loss		
2.1	Pilferage loss	6.67%	8.11%
2.2	Loss due to inconsistent domestic tariff	1.44%	
3.	Total system loss		9.36%

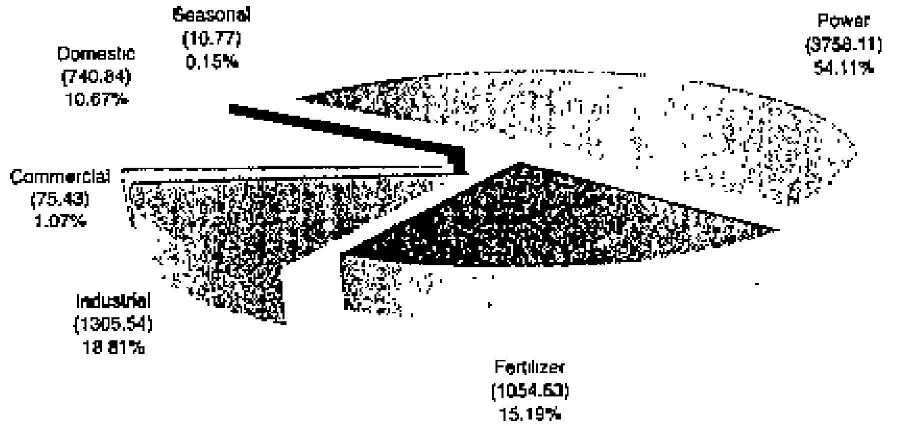
Of the customers supplied gas by the company in the non-bulk sector, the industrial and commercial customers are metered customers whereas the domestic customers are still un-metered. Each type of customers (and the subtypes) has their characteristic patterns of gas consumption. The associated ways and means of gas pilferage by different types of customers are also different. In the case of domestic customers, it is apprehended that there are a good number of hidden or unregistered customers (ghost customer, so to say). It is also apprehended that there is significant excess unauthorized appliances installed by the registered non-bulk customers of all categories, which are contributing system loss.

Although detail survey and analysis are essential for the determination of customer category wise contribution to the overall non-bulk system loss, the same is yet to be carried out. But a general assessment in this regard indicates that the domestic customers are no less responsible than the industrial customers for the overall non-bulk system loss. It is already evident that the system loss caused by non-bulk sector comprising of industrial, commercial and domestic customers. The category wise sales of the company are shown in Table – 1.2. Also a pie diagram for the same is also shown in Figure – 1.1

Table – 1.2: Sector wise Gas Sales (FY 2002 – 2003)

Sector	Sales (MMSCM)	% Total
Domestic	740.84	10.30%
Commercial	75.43	1.04%
Industrial	1305.54	18.15%
Industrial (Seasonal)	9.822	0.14%
Fertilizer	1300.78	18.09%
Power	3758.11	52.25%
Condensate equiv. Gas	1.151	0.016%
Total	7191.68	100%

CATEGORY-WISE GAS CONSUMPTION
(IN MMCM)



Category	Consumption during 2002-2003 (In MMCM)	Percentage
Power	*3758.11*	*54.11%*
Fertilizer	*1054.63*	*15.19%*
Industrial	*1305.54*	*18.81%*
Commercial	*75.43*	*1.07%*
Domestic	*740.84*	*10.67%*
Seasonal	*10.77*	*0.15%*
Total	**6945.32**	**100.00%**

Figure 1.1: Category-wise Gas Consumption

From the sales figures shown in Table – 1.2, the non-bulk sector accounts for about 29.63% of total sales. The current level of 8% overall system loss on net through put means about 28% system loss is in the non-bulk sector. Applying 1.25% of system loss caused by technical reason as estimated, the system loss of the non-bulk sector arising out of non-technical factors is 6.75% which in turn means 23.7% system loss against non-bulk input. Bulk system loss is only the technical component of system loss and it is estimated as 1.25%. The system loss of TGTDCL system at present is very high; which needs improvement of the existing system to reduce it to an acceptable limit.

The main objective of this present study is to identify measures reducing unaccountable gas. In doing this identification of various contributing factors related to unaccountable gas of the existing TGTDCL gas transmission and distribution system can be classified as technical and non-technical loss. Technical losses are inevitable and the level of the same depends on physical and operating condition of gas. Non-technical losses can be many and varied with various factors. The main part of it is pilferage losses through various illegal means like meter tampering, regulator tampering, by pass or un-metered usage, unauthorized connection etc. At present pilferage loss is a very acute problem and this needs reduction to an acceptable limit.

CHAPTER – 2

LITERATURE REVIEW

2.1 Gas Law

The simple gas law is widely used in gas measurement work, and closely approximates to the behavior of gases under atmospheric temperatures and pressures. The simple gas law is based on the work of Robert Boyle in the 17th century and Jacques Charles some 100 years later.

2.1.1 Boyle's Law

Working with air, Boyle determined that if the temperature of a given quantity of gas remained constant, the volume of the gas varies inversely with the absolute pressure. This can be written as:

$P \propto \frac{1}{V}$ Where, V = volume of air or gas

PV = constant P = Absolute pressure of air or gas

2.1.2 Charle's Law

Charles law state that if the pressure on a particular quantity of gas is held constant, then with any change of state, the volume will vary directly as the absolute temperature. This can be written as

$V \propto T$ where, V = volume of gas

$\frac{T}{V} = const.$ T = Absolute temperature of gas

2.1.3 Ideal Gas Law

The concept of ideal gas is a hypothetical idea, but it serves as a useful tool to explain the more complex real gas behaviour. An ideal gas is defined as a gas in which the molecules occupy negligible volume; there is no interaction between the molecules, that is, no attractive or repulsive forces exist between them; and collisions between the molecules are purely elastic, implying no energy loss on collision. At low pressure most gases exhibit an almost ideal behavior. The ideal gas law that applies to such gases can be stated as follows (Reference – 5):

$$PV = nRT$$

Where,

P = Absolute pressure of gas

T = Absolute temperature of gas

V = volume occupied by the gas

n = Numbers of moles of gas

R = Universal gas constant.

In general gases do not exhibit ideal behaviour. The reasons for the deviation from ideal behavior can be summarized as follows:-

a) Gas molecules occupy a finite volume.
b) Intermolecular forces are exerted between the molecules.
c) Molecular collisions are never perfectly elastic.

The deviation from ideal behaviour is greater for heavier gases because of the larger size of their molecules. To correct the non-ideality, the simplest equation of state uses a correction factor known as the compressibility factor, z: Then the equation of state for real gas become

$$PV = nZRT$$

The Z-factor can therefore be considered as being the ratio of the volume occupied by a real gas to the volume occupied by it under the same pressure and temperature conditions if it were ideal. This is the most widely used real gas equation of state

The major limitation is that the gas deviation factor, z, is not constant. This formula is very important for gas flow calculation especially for Turbine Meter, Rotary Meter, & Diaphragm displacement Meter.

2.2 Measurement Quality

A measurement system is an information system that presents an observer with a numerical value corresponding to the variable being measured A given element may contain four types of elements sensing, signal conditioning, signal processing and data presentation elements. These elements are now briefly described as presented in Gas Flow Measurement, Quality and Control by GASCOR Consulting International Australia (Reference – 9).

2.2.1 Sensing Element

This is in contact with the process and gives an output that depends in some way on the variable to be measured. An example of a sensing element would be an orifice plate where the differentials pressure value is a function of flow rate.

2.2.2 Signal Conditioning Element

This takes the output of the sensing element and converts it into a form more suitable for further processing, usually a D.C voltage, current or frequency signal

2 2.3 Signal Processing Element

This takes the output of the conditioning element and converts it into a form more suitable for presentation. An example would be an analogue to digital converter, which converts a voltage into a signal form for input into a computer.

2.2.4 Data Presentation Unit

This presents the measured value in a form, which can be easily recognized by the observer. An example would be a visual display unit. Each of these elements has certain characteristics that can affect the overall performance of the system. These characteristics can be classified into systematic and statistical characteristics. The systematic characteristics are those that can be quantified such as range, span, linearity, non-linearity, sensitive, environmental effects, hysteresis, resolution. wear any aging and error band. The statistical characteristics are the variations seen over a period of time for a single element with a constant input For many observations in output, some spread of results around an expected value termed a lock of repeatability in the element. A number of terms have been introduced, and some basic definitions of these terms are now given.

2.2.4.1 Repeatability

Repeatability is the ability of an element to give the same output for the same input. Lack of repeatability is due to random effects in the element and its environment.

2.2.4.2 Range

The input and output of an element is specified by the minimum and maximum values that can be sustained. For example a pressure transmitter may have an input range of 0 to 2000 psia and an output of 4 – 20 mA.

2.2.4.3 Span

Span is the maximum variation in input an output therefore the span for the pressure transmitter example would be

Input Span: 2000 psia – 0 = 2000 psia

Output Span: 20 mA – 4 mA = 16 mA.

2.2.4.4 Linearity

An element is said to be linear if corresponding values of input and output lie in a straight line. The ideal straight line connects the minimum points to the maximum points.

2.2.4.5 Sensitivity

This is the rate of change of output with respect to input

2.2.4.6 Environmental Effects

In general, the output of an element depends not only on the signal input but also on a number of environmental inputs such as atmospheric pressure, supply voltage, ambient temperature and relative humidity. These elements tend to have varying influences on measuring elements.

2.2.4.7 Hysteresis

For a given value of input, the output may be different depending on whether the input is increasing or decreasing. The difference between these two values of output for a given input is termed the hysteresis for the value.

2.2.4.8 Resolution

Some elements are characterized by the output increasing in a series of discrete steps or jumps in response to a continuous increase in input. Resolution is defined as the largest change in input that can occur without any corresponding change in output.

2.2.4.9 Wear And Ageing

These effects can cause the characteristics of an element to change slowly but systematically throughout its life.

2.2.4.10 Error Bands

Non-linearity, hysteresis and resolution effects in many modern sensors and transducers are so small that it is difficult and not worthwhile to exactly quantity each individual effect. In these case the manufacturer defines the performance of the element in terms of error bands.

2.2.4.11 Reproducibility

Reproducibility is the closeness of the agreement between the results of measurements of the same measurand carried out under changed conditions of measurement.

The changed conditions may include

- Principle of measurement
- Method of measurement
- Observer
- Measuring instrument
- Reference standard
- Location
- Conditions of use and
- Time.

2.2 4.12 Accuracy Of Measurement

The quality of a measurement is termed the accuracy, which is the closeness of the agreement between the results of a measurement and a true value of the measurand.

Flow meters can have accuracy statements expressed as

a) Percent of actual flow rate
b) Percent of full scale flow
c) Percent of maximum differential pressure

The equation for each is

a) $\text{Percentage of Rate accuracy} = \pm \frac{\text{Flow Uncertainty}}{\text{Instantaneous Flow rate}} \times 100$

This statement applies to turbine meters, pulsed D.C magnetic meters, coriolis meters, vortex meters, flow integrators and some special meters or instruments that have logarithmic flow scale characteristics.

b) $\text{Percentage of Full scale accuracy} = \pm \frac{\text{Flow Uncertainty}}{\text{Full scale Flow rate}} \times 100$

This type of statement of accuracy is most suited to describing primary meters such as rota-meters, A.C – excited magnetic flow meters, and components such as linear flow recorders, square root extractors and linear transmitters.

c) $\text{Percentage maximum dp accuracy} = \pm \frac{\text{dp Uncertainty}}{\text{maximum dp}} \times 100$

This type of accuracy statement usually applies to the differential pressure flow transmitters and recorders having square root graduations on the chart or scale.

Accuracy statements of percent of actual flow rate mean that the measurement uncertainty is within the given percent value within the stated range for the flow meter. All other types of statements mean there is a fixed quantity of uncertainty in the measurement regardless of the flow range.

2.2.4.13 Error Of Measurement

This is the result of a measurement minus a true value of the measurand.

2.2.4.14 Uncertainty of Measurement

This is the parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand.

2.3 Commercial Gas Measurement

The most common measurement of large volumes of Gas is passing it through a meter. In this chapter a discussion are carried on various Gas Meters, its working principle, advantage and disadvantage. And these are quoted from 'Gas Flow Measurement, Quality Control' by GASCOR Consulting International, Australia (Reference – 9).

2.3.1 Meter Type

The following types of meters may accomplish gas flow measurement: -

1) Differential pressure measurement – Orifice, Venturi and nozzle meter.

2) Positive displacement - Diaphragm meter.

3) Rotary inferential –Rotary meter, Turbine meter.

4) Fluid oscillatory – Vortex Shedding, Swirl meter.

5) Electromagnetic – Magnetic flow meter.

6) Ultrasonic - Doppler flow meter.

7) Direct mass – Coriolis mass flow meter.

8) Thermal - Thermal profile flow meter.

2.3.2 Meter Selection

There is no universal meter; each type has given limitations. Some meters may only be useful for specific applications, where as others can be widely adopted. It is important not only from a measurement requirements, but also from economic, supply, security, safety and even customer confidence, that the correct meter is selected for the given application. Certain parameters must be tested against to ensure the meter selection is optimal. Some of these parameters are:-

a) Maximum and minimum flow rate
b) The extremes of pressure and temperature at measurement conditions
c) The ranges of chemical and physical properties of the fluid
d) Duration of operation of the meter (continuous, or intermittently)
e) The consequences of the gas flow being stopped by meter malfunction
f) Available space for the installation of such meters
g) The economic consequence of uncertainties in the measurement
h) The legal metrology requirements
j) Cost effectiveness of the meter.

At present TGTDCL uses the following types of gas meters

1) Diaphragm Displacement Meters.
2) Rotary Displacement Meters.
3) Turbine Meters.
4) Orifice Meter.

The commercial gas sales and customer are interested in both accurate and quality measurement. A commercial contract will state the units of measurement in Imperial or Metric system and the base temperatures and pressures that are to be used in the calculations. The contact will also relate the price to the quality of the gas and the heating value. In this chapter a brief discussion of the above mentioned four types meter would be discussed.

2.3.4 Positive Displacement meter

Positive displacement meters are used for measurement of gas. This class of meter measures total flowing volumes by repeatedly filling and discharging fixed volumes. Many different designs are available, however they are divided into three broad classes. In the first class is the meter in which one wall is of a flexible material that moves to displace the volume with no leakage into another chamber. An example of this type is the diaphragm meter. In the second class are meters in which a mechanical seal is used between movable and stationary walls. The rotary meter is an example of this class. The third class employs a capillary element, an example being the capillary seal meter used for liquid measurement

2.3.5 Diaphragm Displacement Meter

The most common example of this meter is the domestic gas mater. These meters are produced with a G – rating range from G – 1.6 to G – 10 with operating pressure 0.4 bars. And this is the most widely used positive displacement meter for gas applications. The operation of this meter is simple and proven, having been in service for over 100 years. In this type of meter there are two chambers alternately fill and empty, with slide valves at the top of the meters controlling the flow to the chambers as shown in Figure – 2.1. 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 are counted. Mechanical reliability is very high. In TGTDCL system this type of meter is being used over 30 years. Due to their production in large quantities they are inexpensive to purchase. The positive displacement meter can also be used for commercial and small industrial applications, however they are used for low to medium flow rates and are limited to low pressure.

2.3.5.1 Advantages

1) Cheap.
2) Well tried and proven.
3) High reliability.
4) Very good rangeability.

2.3.5.2 Disadvantage

1) Malfunction will stop flow.
2) Low-pressure operation.
3) Bulky for large volume flows.
4) Pulsations introduced into the flow.
5) Vary easy for gas pilferage by making a leak or hole into the diaphragm..

2.3.6 Rotary Meter

This type of meter consists of two oppositely rotating impellers, which are the measuring mechanism as shown in Figure 2.2. The volume of gas is directly related to the number of revolutions of the impeller shafts. Good rangeability can be obtained for the rotary meter. 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.

2.3.6.1 Advantages

1) Good range ability.
2) Compact design
3) Good accuracy.
4) Insensitive to upstream flow conditions.

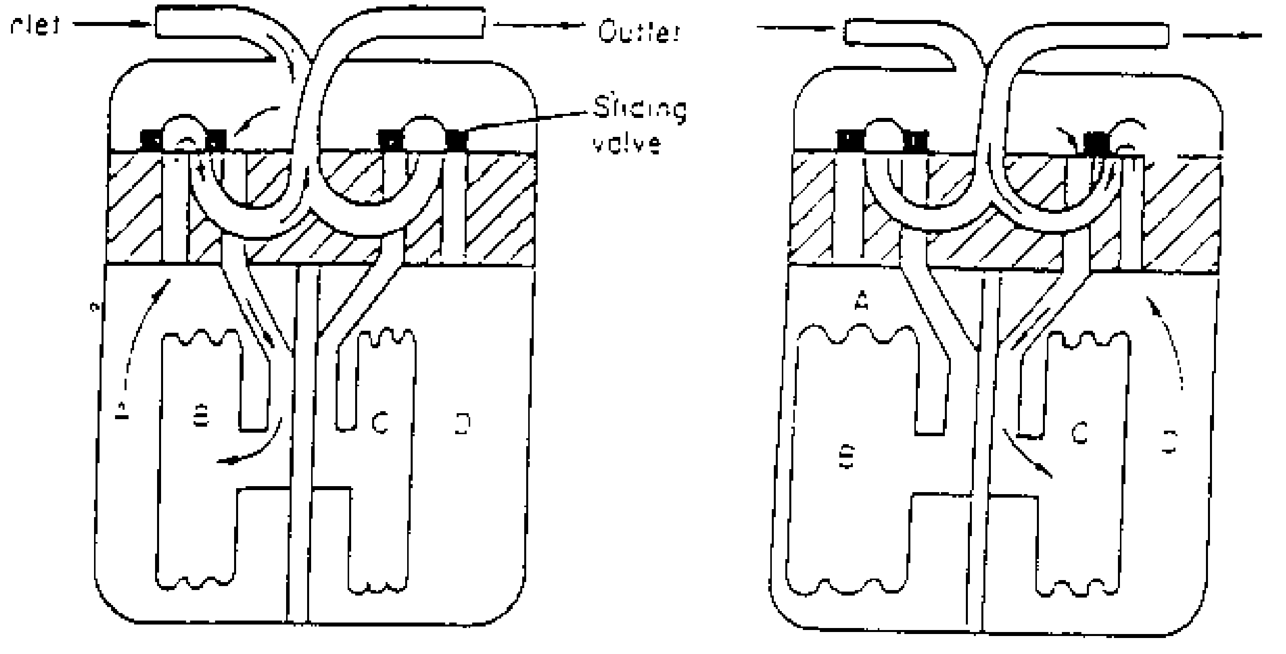


Figure 2.1: Diaphragm Meter (Courtesy GASCOR Consulting International, Australia)

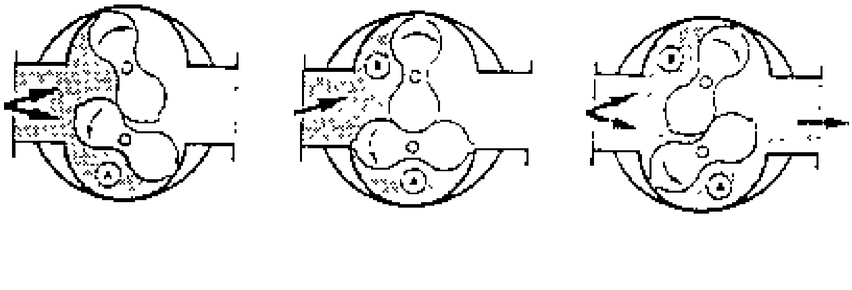


Figure 2.2: Rotary Meter (Courtesy GASCOR Consulting International, Australia)

2.3.7 Turbine Type Gas Meter

Turbine type gas meters have been manufactured since the early nineteen hundreds. Since early fifties these meters have been considered favourably for the measurement of large volume gas flow 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 meter.

2.3.7.1 Working Principle

Two basic assumptions relate to the operation of the turbine meter and these are shown in Figure – 2.3.

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

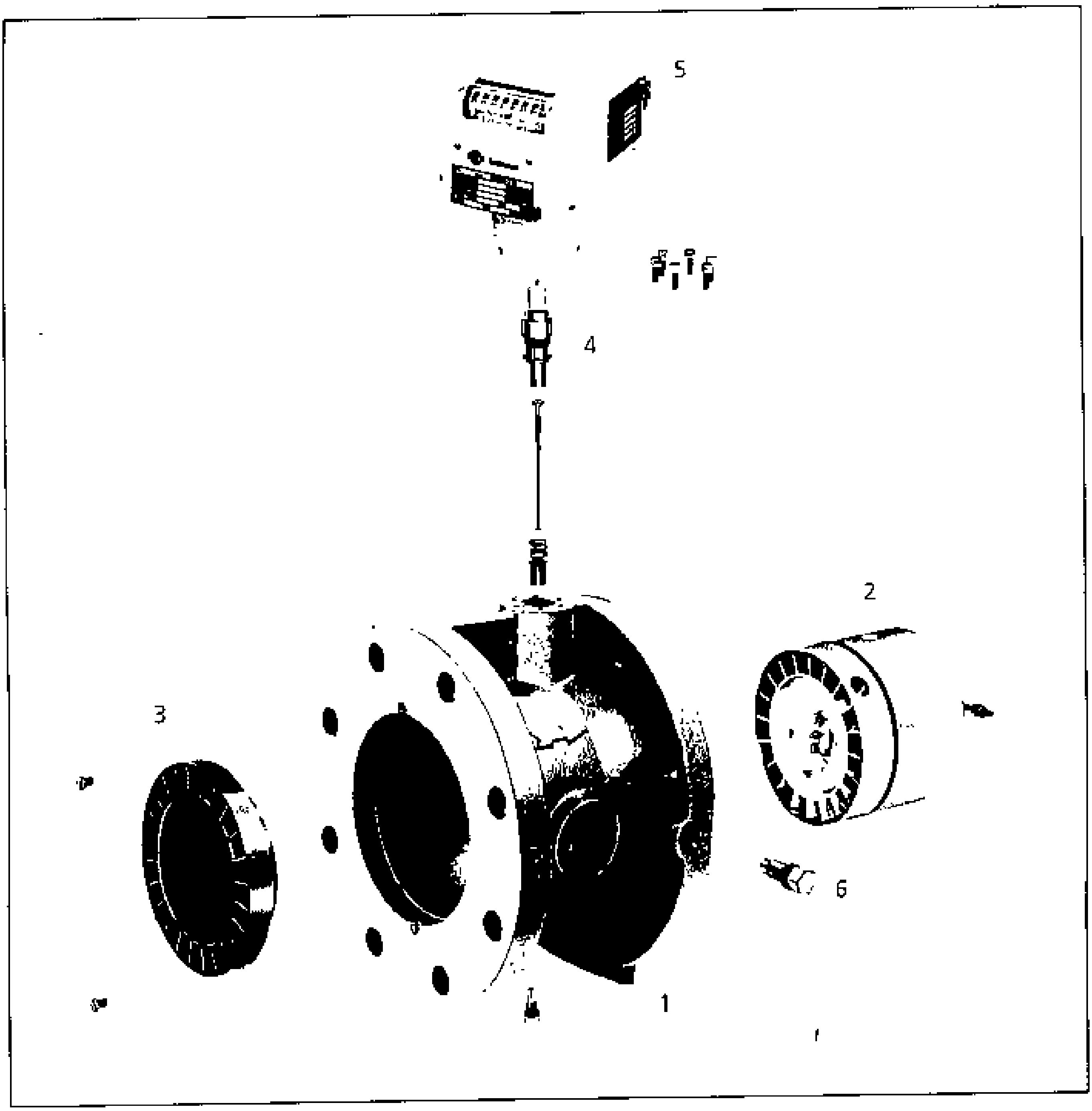
2) The pulse output frequency of the pick-up is proportional to angular velocity of the rotor.

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

a) The body through which the gas passes.
b) A rotor with bearings and supporting structure.
c) 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



CONSTRUCTION

The main parts of the Q - 75 turbine gas meter are:

1. Meter body
2. Measuring mechanism and turbine wheel
3. Inlet flow conditioner
4. Mechanical drive and magnetic coupling to transmit turbine wheel rotation outside the pressure vessel
5. Mechanical counter for registering the volume measured
6. Oil lubrication system for the turbine wheel shaft bearings

Figure 2.3: Turbine Meter (Courtesy Instromet International, N.V. Belgium)

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.

2.3.7.2 Gas Calculation

The basic gas law relationship is expressed as follows:

$P_f V_f = Z_f NRT_f$ for following conditions

$P_b V_b = Z_b NRT_b$ For base conditions.

Where,

P = Absolute pressure of gas.

V = Volume of gas.

Z = Compressibility factor of gas.

N = Number of moles of gas.

T = Absolute temperature of gas.

R = Universal gas constant.

f = subscript at following condition of gas.

b = subscript at base condition of gas.

Since R is a constant for the gas regardless of pressures and temperature, and for the same number of moles of gas N. the two equations can be combined to yield.

$$V_b = V_f \left(\frac{P_f}{P_b}\right)\left(\frac{T_b}{T_f}\right)\left(\frac{Z_b}{Z_f}\right)$$

$$V_B = V_f \,.\, F_{pm} \,.\, F_{Pb} \,.\, F_{tm} \,.\, F_{tb} \,.\, S$$

Where,

V_b = Volume at base conditions.

V_f = Volume at flowing conditions.

F_{pm}= Pressure factor.

F_{pb}= Pressure base factor.

F_{tm}= Flowing temperature factor.

F_{tb} =Temperature base factor.

S = Compressibility ratio.

Likewise, flow rate $Q_f = V_f/t$.

Where,

Q_f = Flow rate at flowing conditions

V_f = Volume timed at flowing conditions.

$= \text{Total pulses} * \frac{1}{K}$.

where,

K = Pulses per volume.

t = time.

2.3.7.3 Application

The turbine meter is basically recommended for applications involving the measurement of clean gases. However, it can have limited applications for dirty gases. Turbine meters generally come in sizes ranging from nominal diameters of 50 mm to 600 mm, although larger sizes can exist. Operating temperature ranges are generally within the range of $-10\ ^0$C to $+50\ ^0$C. Some of the manufactures will provide meters with extended temperature ranges. Operating pressure ranges from 14.4 bar to 80 bars.

A number of factors must be considered when sizing a turbine meter for a given application. Turbine meters are sensitive to both gas viscosity and inlet flow profile. With the actual magnitude of the resulting degradation being a complex function of body geometry and blade shape. Generally the smaller meters are more viscosity sensitive, and they also do not have the rangeability of the larger meters, even in low viscosity gas. This is due to bearing friction being proportionally higher since the bearing diameter is large compared to pipe diameter. It is usually good practice to have an appropriate upstream flow conditioner installed with a turbine meter system

2.3.7.4 Advantage

The advantages of a Turbine meter flow measurement system are:-

a) Excellent rangeability on gas at high pressure.
b) Malfunction will not cause gas flow to stop.
c) Presents good accuracy over full linear range of meter.
d) Electronic out put available directly at high resolutions.
e) Has good pressure and temperature operating capabilities.
f) Has legal metrology status for custody transfer applications.
g) Cost of meter is medium, overall installation cost low to medium.
h) Small weight to capacity ratio.
i) Can be calibrated for actual operating conditions.

2.3.7.5 Disadvantage

a) Viscosity effects liquid meters may require separate calibration curves for different viscosity.
b) Sensitive to upstream flow profiles
c) Calibration can be expensive.

2.3.8 The Orifice Meter

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 liquid.

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 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, pressure and temperature gauge or recorder are being referred to as secondary element.

2.3.8.1 Meter Tube

The meter tube is an important component and contributes greatly to the overall accuracy of the primary element There is a downstream section and an upstream section. The tube must be specially selected for dimensional accuracy and for concentricity.

To determine the length of the meter tubes four aspects must be considered:-

a) Maximum beta ratio (β), which is numerically orifice diameter divided by pipe diameter.
b) Position of the pressure taps.
c) Use of straightening vanes.
d) Upstream fittings.

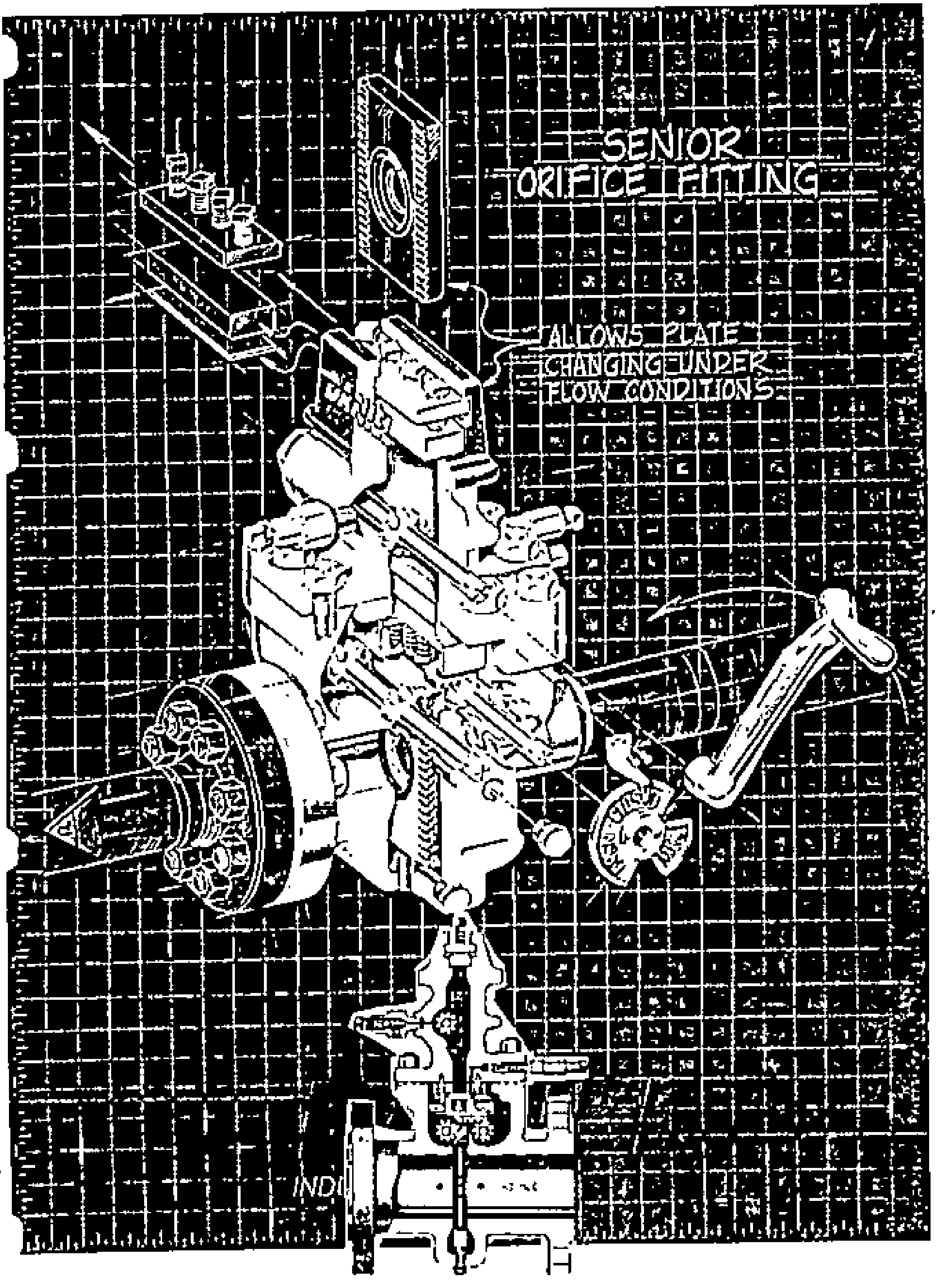


Figure 2.4: Orifice Meter (Courtesy Daniel Senior Orifice Meter, U.S.A.)

The AGA report no. 3 provides tables to enables selection of the correct length to be made. It can be seen that the installation of straightening vanes considerably reduces the length of straight pipe required upstream of the orifice plate. The function of the vanes is to eliminate the effect of swirl and crosscurrent caused by pipefittings and valves preceding the meter tube.

2.3.8.2 Orifice Assembly

There are two main types of orifice assembly. These are double chamber and single chamber. Both types of assembly can be supplied with flanges each side. or with a flange on the downstream end and a weld preparation on the upstream inlet side.

a) Single Chamber

Single chamber orifice assemblies, sometimes referred to, as dead line types require the flow to be stopped and the pipeline depressurized before the orifice plate can be removed.

b) Double Chamber

Double or dual chamber orifice assembly allows the removal of the orifice plate without the necessity to stop the flow or depressurize the pipeline These assemblies save the need for costly bypass piping and valves, and Annabel one person to remove and replace an orifice plate in a relatively short time.

2.3.8.3 Orifice Plate

The orifice plate, possibly the most important component of the primary element is also very expensive. Care must be taken in designing machining. handling, storing and installing the orifice plate.

Usually the orifice plate is manufactured from the stainless steel plate. Care is taken during machining to prevent the formation of stresses, which could cause bowing. The plates are finished after machining, and inspected to confirm the square edge on the bore remains sharp and burr free. Orifice plate sealing units are molded in a variety of synthetic rubber materials.

2.3.8.6 Pressure Taps

Pressure taps may be positioned in either the flange or the pipe. Flange taps are positioned 1" from the upstream and downstream faces of the orifice plate.

2.3.8.7 Gas Calculation

Gas flow rate of a square edge orifice plate can be calculated as

$$Q_b = F_n (F_c + F_{sl}) \gamma_1 F_{pb} F_{tb} F_{tf} F_{gr} F_{pv} \sqrt{P_{f1} h_w}$$

F_n = Numeric conversion factor.

$C_D(F_T) = (F_C + F_{SL})$ = Flange – tapped orifice meter co-efficient of discharge.

γ_1 = Expansion factor.

F_{Pb} = Pressure base factor.

F_{tb} = Temperature base factor.

F_{tf} = Flowing temperature factor.

F_{gr} = Sp. Gravity factor.

F_{pv} = compressibility factor.

$F_n = 338.196\ E_V\ D^2 \beta^2$

Where,

$$E_v = \frac{1}{\sqrt{1-\beta^4}}$$

$$\beta = \frac{d}{D}$$

d = orifice diameter

D = pipe internal diameter

$C_d(F_T) = (F_C + F_{SL}) = 0.60$ approx.

$$\gamma_1 = 1\left(0.41 + 0.35\beta^4\left(\frac{X_1}{k}\right)\right)$$

$$X_1 = \frac{h_w}{27.707\, p_{f1}}$$

$$F_{pb} = \frac{14.73}{P_b}$$

$$F_{tbb} = \frac{T_b}{520}$$

$$F_{tf} = \sqrt{\frac{520}{460+T_f}}$$

$F_g = \sqrt{1/G}$ where, G = sp. gravity

$$F_{pv} = \sqrt{\frac{Z_b}{Z_f}} = \sqrt{\frac{1}{Z_f}}$$

The orifice plate meters 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 the formula that was discussed earlier. 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 using a series of differential element read out device this can be raise to 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.

While there is much progress in flow metering, the orifice plate meter is still in wide use owing to its robustness and simplicity. This is particularly the case in North America. There is no doubt that a contributing factor to the continued popularity of the orifice plate is the 'comfort factor' it gives, that is it is a tried, proven and reasonably diverse flow meter.

Although the orifice plate does not normally require calibration, the differential pressure transmitter does require regular verification if the best standards of accuracy are to be maintained.

The orifice plate has been used for flow measurement applications for about 100 years; therefore considerable data has been collected on its performance and applications. A number of variants have been developed where the profile of the plate and the location of the differential taps can be significantly different. The orifice plate meter is designed for uni-directional flow. Should reverse flow occur, or the plate installed in reverse, a substantial flow error in the order of – 20% may be occurred

Important features of the plate are the requirements for, a sharp square upstream edge, that the plate itself having sufficient thickness to withstand the expected flow characteristics and have a beveled downstream edge for applications where a thin plate can be used, the downstream bevel requirement may not be possible. There are generally three types of pressure taps used, being corner, flange and pipe.

The discussion so far has been centered on most common types of flow meters used universally on natural gas transmission systems and within process plant. Of course the most common gas meter by far is the Diaphragm or positive displacement meter, as used for domestic gas meters and small commercial and industrial application. This type of meter is robust, cheap and has good rangeability, however it has limited high-pressure capability and is not available with high capacities. It is likely the orifice plate meter and turbine meter will maintain their status for some time. The orifice plate meter is slowly yielding to the turbine meter and the more recently introduced non-intrusive meters.

Although a variety of alternative volume metering systems are available, only probably one is mounting a serious challenge to these established gas flow meters. This meter is the ultrasonic meter, however it should be acknowledge that the vortex meter has also gained substantial popularity in some countries, but not universally. There is still considerable effort, particularly in North America and Europe, being devoted to the better understanding of the orifice plate and turbine meter, including enhancement in traceability chains and calibration procedures.

2.4 Standards

Standards contain a vast store of human knowledge; which are a product of past experience and present knowledge and a guide for the future. Standards can cover many aspects, such as how an article is made, the characteristics of the raw materials the product is made from, or how an instrument is applied and calibrated. Within flow measurement, standards are commonly used and or referenced in test procedures, in the specification of instruments, and for primary calibrations. The quality of gas delivered to customers is referenced to an appropriate standard. Many standards that are used are internationally applied and recognized. Principles of standards related to measurements standard is quoted from Gas Flow Measurement, Quality and Control by GASCOR Consulting International, Australia (Reference – 9).

2.4.1 Principle And Features Of Standard

The standard terminology will identify the principle and features of the device and the type and efforts on the performance. The standard will describe the test procedures used to determine the magnitude of the environmental, application, and installation effects, and it will enable the potential user to understand the application limits listed by the supplier. It will describe the mechanical and electrical interfaces that need to be meet. Certification will ensure the performance; it assists with dealing with new vendors.

Standards enable purchasing from multi-sources. By comparing the literature from several competitors, using the standard as references, the user can select between interchangeable devices. Standards minimize training of personnel. With common terminology and test procedures, the instruments people will have an easier job shifting from manufacturer to another and using the next generation devices to obtain more useful features. Standards enable updating system parts with advancing technologies. With common terminology and standard interfaces, the newer devices or system parts will be understood more easily and with less training requirements.

Standards enable lower system and product costs. The process of writing the standard by many experts will standardize on more common designs and avoid the proliferation found in a disorganized market when each supplier uses his own way to describe products and their features. Product manufacturers will find a need for fewer product variations and thus, lower working cost, better delivery, and fewer special designs.

Standards give guidance for application and installation to achieve the performance required. For mature technologies standards can state the effects will be on accuracy due to variations of application, and installation conditions. For new technologies they will refer the user to the manufacturer with specified test procedures. Instructions and precautions are given to enable the user to obtain the performance needed for a particular application.

Standards provide instructions so that the flow meter may be tested. The test procedures and a list of environmental and installation conditions will enable the user to test the performance under expected application conditions or have a third party testing laboratory perform the testing.

Standards provide the precautions for the safety of people and protection of equipment under hazardous conditions. Standards will provide design requirements and test procedures to establish the maximum internal pressure/temperature that the device will safely withstand. They will specify the designs and test procedures governing installation in hazardous locations and the definitions of various classes of hazardous locations.

Some standards describe information the manufacturer should be prepared to supply, some of which may be mandatory. Some standards require specific information on labels (such as flow direction, material of construction, etc.) and for the manufacturer to be prepared to answer user questions regarding effects of environmental variations (such as corrosive atmospheres, vibration, motion etc). Some provide guidance instruction manual (such as installation and troubleshooting instructions). Some standards will include a list of the information that a manufacturer can expect users to request. Standards ensure interchangeability and compatibility.

2.4.2 Standards Related To Flow Measurement

Significant development has been made over the past couple of decades with respect to flow measurement. The impact of microelectronics has been dramatic, and no doubt many further advances are yet to come. Materials enhancement has also significantly assisted in the determination of more accurate flow measurement, especially with the elimination of some temperature and pressure constraints.

One problem that has developed through the rapid introduction of new technology is the delay in the generation of adequate standards and codes of practice. Unfortunately standards can take many years to develop and verify, especially international standards.

A number of standards exist for the established flow meters such as the orifice plate, positive displacement and turbine meter. However useable and universal standards are still either in draft form, or do not exist for the newer type meters such as ultrasonic and coriolis. Even meters that have been in service for a number of years still may not have an agreed international standard applicable to them. Therefore this section will concentrate on existing standards, which are readily available and applicable to the orifice plate and to the ISO standard pertaining to gas quality. It is important that personnel engaged in flow measurement activities have some appreciation of relevant standards. Discussion will be limited to the following standards, (Table – 2.1) all of which are widely referenced and applied with in gas industry.

Standards tend to be derived from the many US organizations, as listed, or are of European origin. Within the European sphere, the International Organization of Legal Metrology (OIML) looks at training and legal aspects of flow measurement and produces 'recommendations'. As International Standard Organization (ISO) membership is made up of representation from many countries, it can claim to be the official international organization.

Study of standard related to gas flow measurement is important for accurate measurement. The standard should follow accurately and fully to achieve goal in measurement and safety purposes.

Table – 03: Standard Relating to Installation, Operation, Measurement

AGA – 3	Orifice Metering of Natural Gas
AGA – 5	Fuel Gas Energy Metering
AGA – 7	Turbine Metering of Natural Gas
AGA NX – 19	Compressibility of Natural Gas
AGA – 8	Compressibility of Natural Gas
ISO – 5167	Orifice Metering of Natural Gas
ISO – 6976	Calculation of Density, Relative Density and calorific Value
ISO – 9951	Turbine Metering of Natural Gas
ISO – 5168	Uncertainties of the Flow Measurement
AGA PART-9	Design Of Meter and Regulator Station
OIML R-6	General Provision for Gas Volume Meter
OIML R-32	Rotary Piston Gas Meters and Turbine Meters
IGETD-9	Recommendation for Transmission System
IGETD-10	Recommendation for Distribution System.

CHAPTER – 3

STATEMENT OF THE PROBLEM

Titas Gas Transmission and Distribution Company Limited (TGTDCL) is a Public Limited Gas Marketing Company, which works under Bangladesh Oil Gas and Mineral Corporation (BGOMC) or Petrobangla and the Ministry of Energy and Mineral Resource, Bangladesh. It purchases gas from Bangladesh Gas Field Company Ltd. (BGFCL) and Sylhet Gas Field Company Limited (SGFCL). This gas is then transmitted through the company's own and Gas Transmission Co. Ltd's (GTCL) Transmission lines to various bulk customers such as power and fertilizer producing company and distribution network through various City Gate Station (CGS), Town Border Station (TBS), District Regulating Station (DRS) and Regulating and Metering Station (RMS) to industrial, commercial and domestic users.

In marketing the gas, the company is now facing an acute problem, which is known as system loss. It is that portion of gas purchased, which is not accounted for by sales, transfer and company uses or otherwise accounted for. At present the net system loss is about 9%. In some areas like Narayanganj this figure is near about 50%. The present level of system loss cause a revenue loss of Taka 200 crores per year and most of the losses are due to pilferage of gas by dishonest customers in collation with the dishonest officials of TGTDCL. For the progress of our national development, this needs urgent reduction to an acceptable limit.

3.1 Objective Of The Study

The main objective of this study is to identify measures in reducing the system loss. In doing this there are several objectives in terms of analysis. These are: -

1) To define the problem.

2) To study the background and present status of the problem.

3) To classify the system loss.

4) To classify the gas users.

3.2 Analysis Of The problem

1) To analyze the TGTDCL transmission and distribution network.

2) To analyze the contributing factors related to system loss for a gas transmission system.

3) To analyze the contributing factors related to system loss for a gas distribution system.

3.3 Study

1) To study the system loss – A case study (year 2002-2003).

2) To study the measurement uncertainty in a gas calculation procedure – A case study.

3) To study the existing metering system of TGTDCL.

3.4 Identification

1) To identify some special problem of TGTDCL gas transmission system regarding system loss.

2) To identify some special problem of TGTDCL gas sales/distribution system regarding system loss.

3.5 Action Programme

1) To study the action program to reduce system loss by TGTDCL.
2) To study the extended action programme to reduce system loss by TGTDCL.

CHAPTER – 4

SYSTEM LOSS

To study the system loss of Titas Gas Transmission and Distribution Co. Ltd. (TGTDCL) it is very important to define the terms in respect to TGTDCL system and this definition should be consistent with the Gas Engineering. In this chapter, definition of system loss is carried out with respect to TGTDCL system. Also an internationally accepted formula to calculate system loss is introduced in this chapter to make a comparison with the presently used formula.

4.1 Definition Of System Loss

System loss also called Unaccounted For Gas abbreviated as UFG of gas transmission and distribution system. This is the difference between the net purchase or throughput to the total sales. Net throughput can be written as the total purchase minus own operational use of the system. In TGTDCL system, UFG are equated as,

UFG = net throughput – total sales.

Net throughput = Purchase – Operational uses of the system.

But internationally the recommended formula for UFG can be written as,

± Unaccounted For Gas (UFG) = Gas flow in – Gas flow out – Gas used/vented/lost ± change in line pack ± measurement uncertainty,

The units of calculation for the above shall be 'thousand (M) or million (MM)" standard cubic meter (SCM) as may seem convenient for calculation/presentation.

The system loss or UFG shall be generally referred and reported on yearly basis for accounting purpose. Operational, monitoring and periodic reviews by all concerned may however be done on monthly, quarterly or half yearly basis as required. Some calculation forms for this purpose are attached herewith (Appendix – A). To realize the system loss, it is important to define the term properly. If the system loss can be define properly then it will be easy to identify all sort of system loss.

4.2 Classification Of System Loss

System loss in a gas transmission and distribution system may arise out of two principals sources I) technical or operational factors and II) various non-technical factors Much of the technical or operational factors of losses are inevitable and the level of the same depends on such things as conditions of physical facilities, methods of operation, and quality of gas handle, skill ness of the operating people, climatic/environmental conditions and so forth. The other losses arising out of non-technical sources can be many and varied in nature and often have a direct bearing on social environment of operation. Looked from the above point of view the system loss in TGTDCL system may be classified as follows:-

4.2.1 Technical Losses

a) Transmission losses due to such factors as pigging, purging, testing, venting, relief blowing, commissioning, leakage, base condition variation in flow volume calculation and condensate accumulation etc.

b) Distribution losses are due to such factors as above and network leakage, service line leakage, customer internal line leakage, metering loss, base condition variation etc.

c) Bulk metering loss in gas receiving and major delivery points such as gas fields, pipe lines tie-ins, power station, fertilizer plants etc.

d) Non-bulk metering loss in delivery points to industrial commercial and domestic consumers.

4.2 2 Non-Technical Losses

Pilferage of gas by customers through various illegal means including but not limited to meter bypassing, meter tampering, regulator tampering, unauthorized connections, higher pressure consumption, unauthorized use by disconnected customers, under-billing by suppressed meter reading etc are in this class. Other losses existing at present are due to improper flat rate domestic tariff.

Non – technical losses are the pilferage of gas by customers through various illegal means including but not limited to the following:-

1) Meter by pass.
2) Meter tampering.
   i) Slowing the index.
   ii) Reverse rotation of index.
   iii) Changed the gear train system.
   iv) Changing the index.
   v) Reversing meter inlet – outlet.
3) Regulator tampering
4) Unauthorized connection.
5) Higher pressure consumption.
6) Unauthorized use by disconnected customer.
7) Unauthorized use by the disputed customer.
8) Under billing by suppressed meter reading.
9) Improper domestic tariff rate.

Item wise share of individual elements can be estimated. The overall system loss is a matter of comprehensive study. Some efforts have already been given in this regard by TG TDCL. Currently the item wise contribution of various factors in the overall system loss is estimated as follows subject to more realistic identification/analysis under the activities of Revised Time Bound Action Programme (RTAP)in this regard are given in Table – 4.1 and Table – 4.2.

Table – 4.1: Technical (System/Operational) loss estimated in year 1993

a)	Transmission Loss	Component wise distribution of total UFG	Share of total UFG
a.1	Pigging/purging/testing/venting/blowing/ commissioning	0.003%	0.032%
a.2	Line packing	0.002%	0.021
a.3	Leakage	0 001%	0.011%
a.4	Metering error at purchase point, off-transmission DRS and Bulk RMSs	0.235%	2.511%
a.5	Base condition variation	0.215%	2.297%
a.6	Condensation	0.034%	0.363%
	Sub – Total =	0.490%	5.235%
b)	Distribution Loss	Component wise distribution of total UFG	Share of total UFG
b.1	Pigging/purging/testing/venting/blowing/ commissioning	0.025%	0.267%
b.2	Line packing	0.010%	0.108%
b.3	Net work leakage	0.100%	1.068%
b.4	Service line leakage	0.025%	0.0267%
b.5	Customer internal line leakage	0.100%	1.068%
b.6	Metering error at customer's RMSs	0.400%	4.274%
b.7	Set pressure variation	0.100%	1.068%
	Total Technical loss:	1.250%	13.355%

Table – 4.2: Technical (System/Operational) loss estimated in year 1993

Non-Technical losses	6.670%	72.61%
a. Pilferage comprising:		
Meter tampering		
Meter by pass		
Unauthorized extension from approved connection		
Unauthorized new connection		
Unauthorized use by disconnected customers		
Regulator tampering		
Under billing by suppressed meter reading		
b. Loss due to inconsistent flat rate tariff base	1.440%	15.384%
Total non technical loss =	8.110%	86.645%
Total UFG (technical + non -technical) =	9.360%	100.00%

It may be noted that the figures given in Table – 4.1 and 4.2 are only estimated ones and the estimated 9.36% of UFG is net of company's gas input. The level of company's own use of gas was not erstwhile properly recorded because in most locations necessary facilities did not exist and the detail accounting was not also considered. But from now onward TGTDCL is setting up all necessary facilities as far as practicable to record the consumption of gas for company's own operational uses.

4.3 Background Of System Loss

Unaccounted For Gas (UFG), generally referred to as 'system loss'. In Titas Gas Transmission and Distribution Co. Ltd. (TGTDCL), system loss has increased over the last few years to an alarming level. From well below 1% in the FY – 1982-83, UFG jumped to almost 2% in the FY – 1983-84 and to about 4% in the FY – 1984-85. The increase in the gap between the gas purchase and sales by TGTDCL continued and shot up to a level of 6% in the following year 1985-86 The level remained in the range of 6 to 7% up to FY – 1991-92. From 6 to 7% increases 9.21% in FY – 1992-93. From 9.21% system loss decreases to about 8% in the year 1993-94 and remain 8% till FY – 1998-99 and it increases about 8.5% in FY – 1999-2000 and remain near about constant till FY – 2002-2003. The system losses for the 35 years lifetime of TGTDCL are shown in Table – 4.3. A bar graph (Figure – 4.1) and a curve (Figure – 4.2) are also shown in this respect.

The increase in the level of UFG naturally becomes a matter of great concern for all who are involved in the gas sector management. The Government attached utmost importance on the matter and directed Bangladesh Oil, Gas and Mineral Corporation (BOGMC) or Petrobangla and TGTDCL to take all necessary steps to control deterioration of the situation. In a bid to assess the real position, TGTDCL undertook necessary steps for the identification of the factors responsible for the UFG increase and to find ways and means for effective reduction of the same. The first major step in this direction was the submission of a report to Petrobangla on the subject in February 1991. In August 1993 TGTDCL launched a time bound action programme to bring down the then level of UFG 7-8% to 2.8% within FY 1994-1995, which was known as Revised Time Bound Action Programme (RTAP). Soon after the launching of the RTAP elaborate activities were initiated in all areas of system operation and customers level. The activities yielded initially positive results and monthly system loss reduced to 6%. This improvement however could not sustained and UFG became a raising concern for the company.

Although major areas of gas losses, resulted ultimately in revenue loss for the company, only identification and estimation of relative contribution of the individual factors are being made but no vigorous action program could however be launched in the past. Routine activities continued which however failed to yield expected results and the system loss of the company was over 8.35%.

TGTDCL has launched a number of multi directional activities in March 1993 with intimation of Asian Development Bank (ADB), the major donor agency, under the guidance of the Government and Petrobangla. These efforts have resulted in the collection of sizeable useful data and formulation of an elaborate action program that was forwards to ADB and submitted concurrently to Petrobangla. ADB fact-finding missions have meanwhile conducted necessary reinvestment activities for the proposed Third Natural Gas Development Project (TNGDP) that which includes a number of system development works for TGTDCL.

The action program submitted earlier by TGTDCL has been meanwhile discussed at various levels. The discussions on various items and sub items of the factors responsible for system loss in TGTDCL system suggest some modifications of the earlier program. The previous program has been accordingly revised and rescheduled.

4.4 Present Status of System Loss

At present the gross overall system loss is 8.28% and for non-bulk sector it is 24.08%. So much activity are needed to initiate in all areas of system operation as well as customers level. The activities include inspection and improvement of region wise input metering, customer meter inspection, meter testing, meter replacement, customer RMSs sealing, disconnection, load increase etc.

The system loss in terms of revenue loss for the company is substantial. In the context of scarce domestic resource available for development of the sector, the loss on account of this is by no means acceptable. Keeping in view the future investment needs in system development and operational improvement TGTDCL has left with no alternative other than immediately reducing the growing rate.

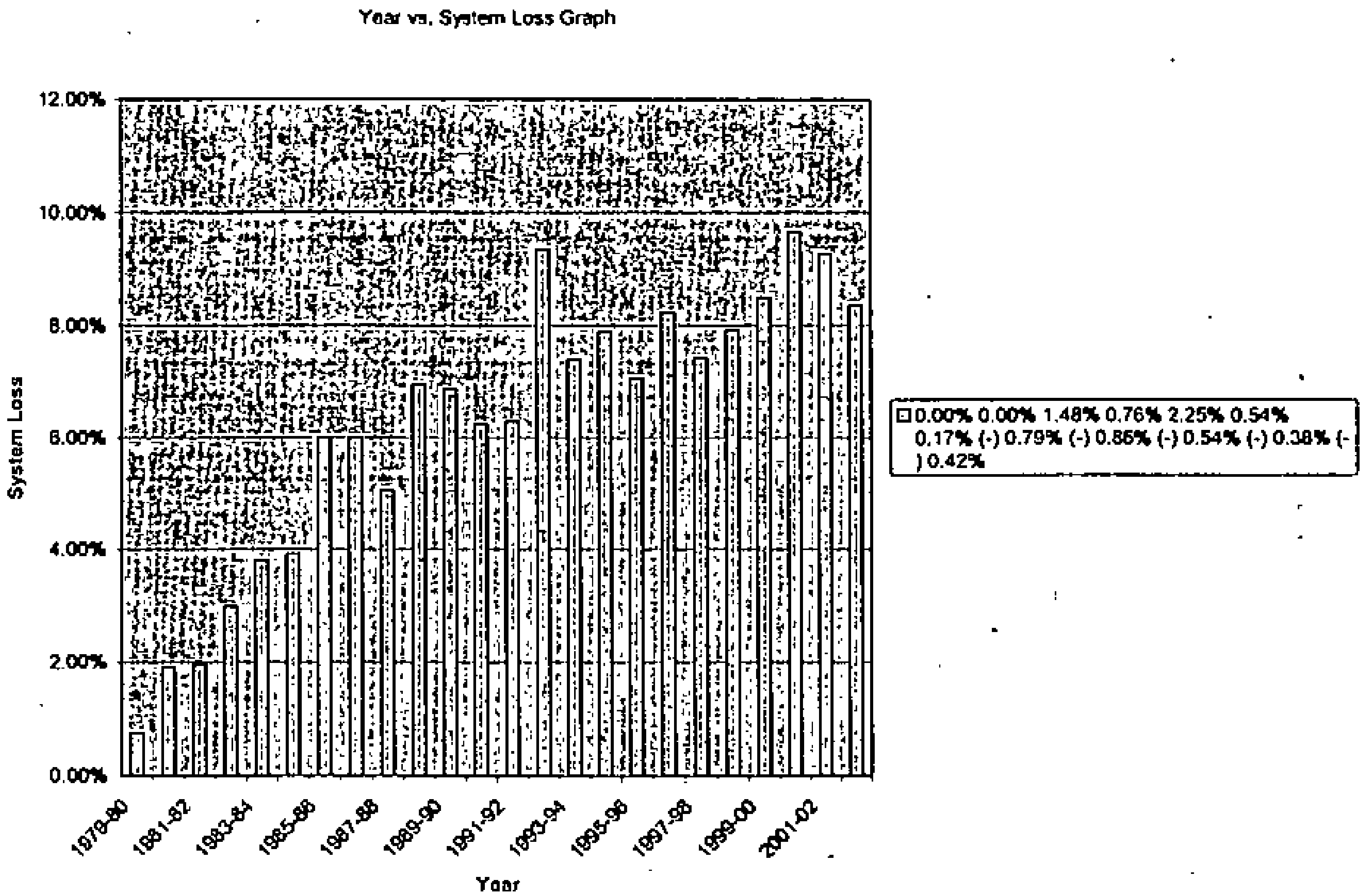
Table – 4.3: Year wise overall system loss

Fiscal year	Gas purchase	Gas sales	UFG as percent of purchase	Remark
1967-68	6.37	6.37	0.0%	No loss
1968-69	29.27	29.27	0.0%	No loss
1969-70	89.62	88.29	1.48%	Loss
1970-71	227.18	225.45	0.76%	Loss
1971-72	118.65	115.98	2.25%	Loss
1972-73	426.99	429.29	0.54%	Gain
1973-74	558.80	557.86	0.17%	Loss
1974-75	292.26	294.57	(-) 0.79%	Gain
1975-76	579.53	584.51	(-) 0.86%	Gain
1976-77	631.15	634.57	(-) 0.54%	Gain
1977-78	649.62	652.07	(-) 0.38%	Gain
1978-79	771.89	775.17	(-) 0.42%	Gain
1979-80	896.17	889.40	0.75%	Loss
1980-81	1003.72	984.40	1.92%	Loss
1981-82	1458.00	1429.43	1.96%	Loss
1982-83	1619.16	1570.70	2.99%	Loss
1983-84	1900.37	1828.16	3.80%	Loss
1984-85	2216.92	2129.14	3.92%	Loss
1985-86	2273.67	2137.24	6.00%	Loss
1986-87	2688.12	2527.04	5.99%	Loss
1987-88	2977.88	2827.32	5.05%	Loss
1988-89	3171.63	2951.66	6.94%	Loss
1989-90	3474.70	3235.00	6.88%	Loss
1990-91	3667.04	3439.67	6.25%	Loss
1991-92	4092.32	3834.97	6.29%	Loss

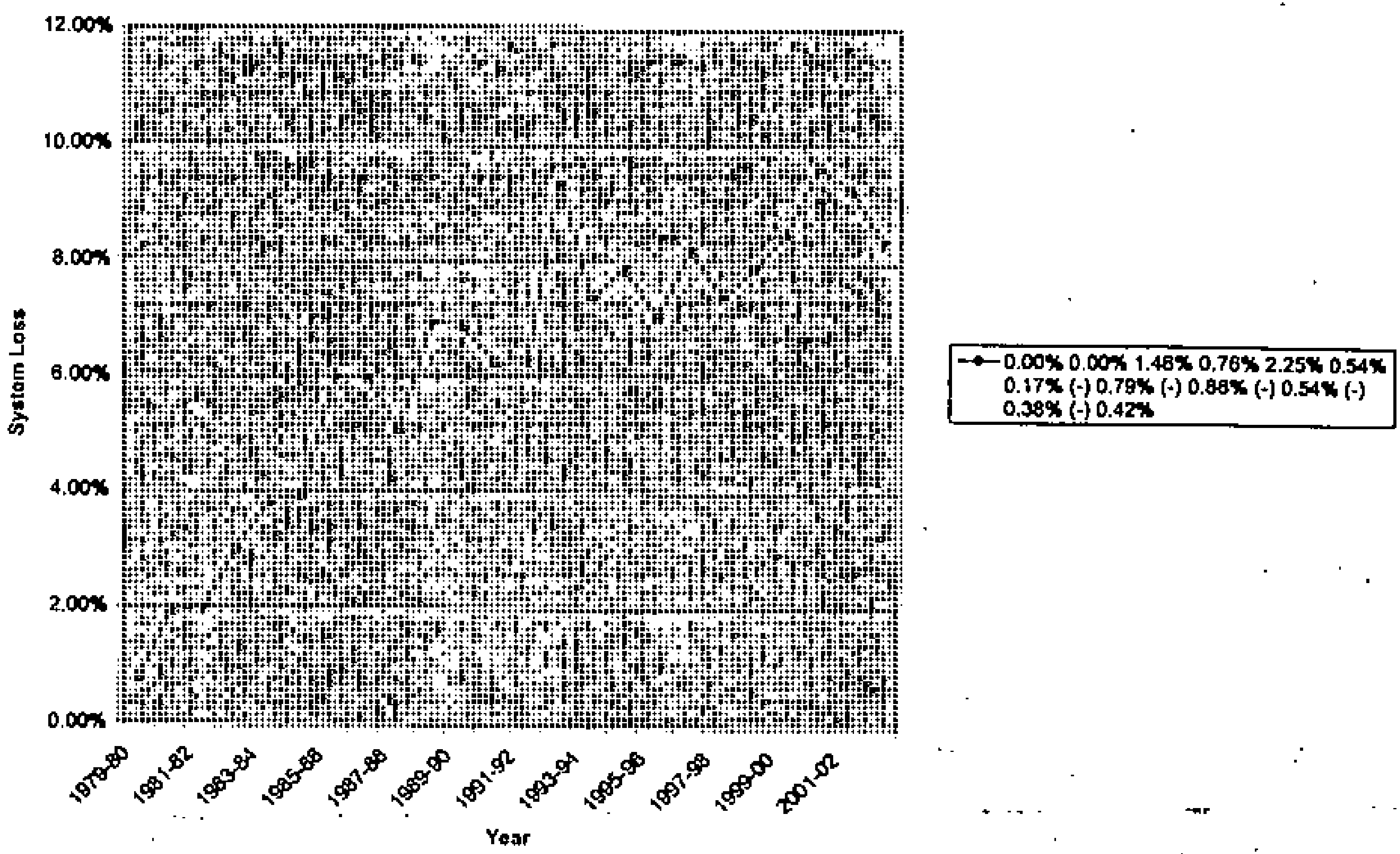
Contd.

Contd. (Table 4.3)

Fiscal year	Gas purchase	Gas sales	UFG as percent of purchase	Remark
1992-93	4742.00	4298.39	9.35%	Loss
1993-94	4661.89	4316.71	7.40%	Loss
1994-95	4877.94	4493.31	7.89%	Loss
1995-96	5280.57	4907.59	7.06%	Loss
1996-97	5447.51	4999.31	8.23%	Loss
1997-98	5534.29	5123.67	7.42%	Loss
1998-99	6106.15	5622.72	7.92%	Loss
1999-00	6658.01	6091.51	8.50%	Loss
2000-01	7188.673	6494.82	9.65%	Loss
2001-02	7568.118	6503.81	9.26%	Loss
2002-03	7586 088	6594.82	8.35%	Loss


Year vs. System Loss Graph
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
System Loss
1979-80
1981-82
1983-84
1985-86
1987-88
1989-90
1991-92
1993-94
1995-96
1997-98
1999-00
2001-02
Year
0.00% 0.00% 1.48% 0.76% 2.25% 0.54% 0.17% (-) 0.79% (-) 0.86% (-) 0.54% (-) 0.38% (-) 0.42%

Year vs. System Loss Graphs



4.5 Classification Of Gas Users

To study the system loss of Titas Gas Transmission and Distribution Company Ltd. (TGTDCL), it is very important to know the types of gas users and their load pattern. It is also important to know the moral and ethical value of the customer and ability to pay gas bill. In this chapter various types of customers will be classified according to pressure, flow rate and type of gas uses.

4.5.1 Domestic Customer

a) Used as a residence.

1. Home/Building.
2. Residential building of Defense Department.
3. Residential quarters of Bangladesh Rifles (BDR), Police, Anser, and Village defense party.
4. Residential quarters of jail.
5. Residential quarters of various department/Directorate Agencies.

b) Operated/used for non-commercial purposes:

1. Hostel, laboratories, Canteen of the educational institution.
2. Orphanage, Hospital, Guesthouse, Circuit house, Inspection Bangloo/Dac-Bangloo.
3. Canteen of jail, prisoner kitchen.
4. Canteen and Messes of Bangladesh Rifles, Police and Anser.
5. Government child home, graves, trust, charitable organization.
6. Canteen and mess/kitchen of labor adjacent to industry.
7. Personal owned mess.
8. Canteen of various offices.
9. All type of mess and canteen of defense department.

4.5.2 Industrial Customer

Machinated small and cottage industries situated in Bangladesh Small and Cottage Industries Corporation (BASIC) industrial state, machinated brick, refractory, sanitary, electric good and others commodity-producing industries, servicing center and big industries are within this class.

4.5 3 Seasonal Customer

Those organizations do not use gas during the twelve-month of the year but seasonal basis (less than six month) are within this class.

4.5.4 Tea-State Customer

Tealeaf drying processing and additional works (except generator load used for power producing) gas using customers is within this class.

4.5.5 Power Station Customer

Government and non-Government Power station that are using gas as a feedstock for power production are within this class.

4.5.6 Fertilizer Producing Customer

Government and non-Government fertilizer factories, which are using gas as a feedstock for fertilizer production, are within this class.

4.5.7 Captive Power Customer

Customer those who produce power by using gas with their own use are within this class.

4.6 Rearrangement Of Customer Classes

To bring the consistency with the nature and objective of the gas users customer classes are rearranged.

1. Non-Bulk Customer.

    a) Domestic customer.

        (i) Domestic metered.

        (ii) Domestic un-metered.

    b) Commercial customer.

    c) Industrial customer.

    d) Seasonal customer.

    e) Tea-state customer

2. Bulk customer.

    a) Power producing customer.

    b) Fertilizer producing customer.

    c) Captive power producing customer.

4.6.1 Definition And Characteristics Of Various Type Of Customer

Definition and characteristics of various types of customers are discussed below:-

a) Domestic customer

House/Building used as a resident, Flat/Colonies of various Government/Semi Government/Autonomous organization and Hostel, Laboratories, Canteen, Hospital, Mess, Child home, Hermitage, Tomb, Charitable organization are within this class. Domestic customer can be divided into two classes.

(i) Domestic metered.

(ii) Domestic unmetered.

b) Commercial Customer

Commercial organizations those are acting for trade and hundoperated/non machined small and cottage industries, servicing centers are with in this class. A list of commercial customers are given below:-

1. Hotel and Residential Hotel.
2. Shop/Factory, which are producing sweet.
3. Restaurant/Chinese Restaurant, Canteen and Tea-stall.
4. Chira/Mori producing factory.
5. Private clinic/laboratory/Hospital.
6. Community Center.
7. Snakes/Cababghour.
8. Bakery/ Confectionery/ Logences/ Chanachure/ Shemaie/ Biscuit producing factories (Hand operated).
9. Shop/Pottery/Ceramic/Paint/Medicine producing factories (Hand operated).
10. Distilled water/Dicing and Printing/Laundry/Tannery/Shari producing factory (Hand operated).
11. Ice/Ice cream producing factory (without machine).

c) Industrial Customer

1. Small and Cottage industries situated in BASIC industrial estate.
2. Machine operated factory installed personally or with the help of various money-lending organizations like Shilpa Poridaptar, BASIC.
3. Large scale industry/factory/organization and hotel, which are using boiler, generator etc.

4. Factories, which are producing brick, tiles, ceramic, refractories, sanitary, electrical and others goods by machine.
5. Machine operated ice/ice-cream producing factories.

d) Seasonal Customer

1. Seasonal manual brick producing factories.
2. Seasonal tobacco leaf drying factory.
3. Seasonal sugar cane and fruit processing industries.

e) Tea-State Customer

1. Tea-state those who use gas for tealeaf drying processing and related works (except generator for power generation).

f) Power Generating Customer

Power station owned by Bangladesh Power Development Board and large scale any other Government and non-Government electricity generating plants that are using natural gas.

g) Fertilizer Producing Customer

Government and Non-Government fertilizer producing factories that are using natural gas as a feedstock.

h) Captive Power Customer

Customers who are producing power with their own use with gas generator using natural gas as fuel.

The number of various customers and their average daily use of gas are shown in Tables – 4.4 and 4.5. It is thought that the actual numbers of customers are higher than those are recorded. This is because no customer survey is conducted in the 35 years life of the company. So to reduce system loss customer survey is very important and for customer survey classification of various customer is also an important issue.

Table – 4.4: Present Customers and Average Daily Sales (May 2003)

Sector	Customer Nos.	Avg. Daily Sale (MMSCF)	% of Total Daily Sale
1. Bulk Sector			
1.1 Power	16	379	48.1%
1.2 Fertilizer	4	145	18.4%
Sub Total:	20	524	66.5%
2. Non-bulk-sector			
2.1 Domestic	891,432	89	11.3%
2.2 Commercial	7,413	8	1.0%
2.3 Industrial and Captive Power	2,842	105	13.3%
		62	7.9%
Sub-total:	901,687	264	33.5%
Total:	-	788	100%

Table – 4.5· Daily Sector Wise Gas Input and Sales (May 2003 Averages)

Sector	Avg. Daily Gas Input (Operational) (MMSCF)	Avg. Daily Sale (Billed) (MMSCF)	Diff. Between Input and Sale (MMSCF)	% Gross System Loss on Input
1. Bulk Sector				
1.1 Power	379	379	-	-
1.2 Fertilizer	146	145	1	0.07%
2. Non-Bulk-sector	321	264	57	17.75%
Total:	846	788	58	6.85%

CHAPTER – 5

NETWORK ANALYSIS

Starting with the gas supply of Shidderganj 10 MW power station in 1968 a 14"Φ transmission pipeline was built from Ghatura, Brahmmonbaria to Demra City Gate Station (CGS), Demra, Dhaka and a distribution Pipeline was built from Demra CGS. to Shidderganj, Narayanganj, by the former Shell Pakistan Ltd. Which is now named as Titas Gas Transmission and Distribution Co. Ltd. (TGTDCL), the biggest gas marketing company of Bangladesh. This company is now marketing gas with a very wide network that is from B-Baria to Ancha and from Munshiganj to Sherpur. The company supplies gas to various bulk customers like power and fertilizer producer of Government sector, Individual Power Producer (IPP) through bulk RMS and industrial, commercial and domestic customer through various City Gate Station (CGS), Town Border Station (TBS). District Regulating Station (DRS), Regulating and Metering Station (RMS).

5.1 Transmission Network

These are those portions of the gas pipelines, which are connected from source (Gas field) to the various CGS, TBS and bulk RMS. In TGTDCL transmission system the regulated pressure is 1000 PSIG. These types of line can be seen in the eastern part of the TGTDCL network from Habiganj, B-Baria, Narsingdhi, Dhaka, Joydevpur and in greater Mymensingh area. A table (Table – 5.1) regarding the diameter, length and capacity of the transmission pipelines are attached in this respect. Also a diagram for the TGTDCL network and franchise area is shown in Figures – 5.1 and 5.2. The company also uses GTCL's transmission pipelines (Ashuganj – Elenga 24"Φ inch and Bakhrabad – Demra 20"Φ inch) to feed some bulk customers and distribution network. At present the gas supply to transmission network is insufficient. Every day shortage is near about 50 MMSCFD. Due to this shortage low pressure remains all over the transmission network.

5.1.1 Problems In Transmission Network

The transmission network constructed early seventies became undersized in its capacity in the context of the increased gas demand in the residential, commercial and industrial sectors. Unplanned expansion and modification of the transmission network increases operational abnormalities. At present main problem of the transmission networks are:-

1) Inconsistent pressure variation in the network.
2) Severe pressure drops in various part of the network.
3) Pressure drop during peak hours.
4) Interruption of gas flow to some location at the peak hour.

5.2 Distribution Network

Distribution pipeline starts from the outlet of a CGS, TBS, TBS cum DRS and ends to the customer's premises. From the outlet of CGS, TBS or TBS cum DRS gas enters into the distribution network through the distribution main lines and ends to the inlet of a DRS. From the outlet of a DRS gas enters distribution lines, feeder lines, branch lines and service lines. A table (Table – 5.2) regarding the main distributions lines with diameter, length and capacity are attached in this respect. Through the distribution network gas are supplied to non-bulk customers, which are also subdivided into five areas as described in Tables – 5.3 and 5.4.

5.2.1 Problem Of Distribution Network

In 1970 the city of Dhaka had a population of about one million and the network was designed on this population with a forecasting of population growth of 25 years. But the populations of Dhaka city increased more than the forecast figure. Today the mega-city Dhaka is facing a tremendous public pressure and this is increasing day by day. As a result present population of the metropolitan Dhaka stands at over 10 million.

Table – 5.1: List of Major Transmission Pipelines

Sl No	Description of Pipelines	Specification	Completion Year
1	Ashuganj ~ Elenga	24" DN × 1000 PSIG × 125.00 KM	1991
2	Monohordi ~ Narsingdi	20" DN × 1000 PSIG × 25.00 KM	1997
3	Narsingdi ~ Siddirganj	20" DN × 1000 PSIG × 41.00 KM	1998
4	Haripur vs. ~ AES Haripur RMS	20" DN × 1000 PSIG × 1.50 KM	2000
5	Titas Gas Field - Narsingdi vs 12	16" DN × 1000 PSIG × 46.31 KM	1985
6	Narsingdi~Ghorasal, third parallel line	16" DN × 1000 PSIG × 12.00 KM	1999
7	Ghatura M & R Station~Narsingdi vs 12	14" DN × 1000 PSIG × 49.39 KM	1968
8	Narsingdi vs 12~Demra CGS	14" DN × 1000 PSIG × 32.41 KM	1968
9	Narsingdi vs 12~Ghorasal	2×14" DN × 1000 PSIG × 23.31 KM	1985
10	Ghorasal~Joydevpur CGS	14" DN × 1000 PSIG × 24.50 KM	1985
11	Dewanbagh (on the BKB-Demra transmission line) ~ Haripur Power Stn. RMS	14" DN × 1000 PSIG × 1.58 KM	1987
12	Titas Gas Field ~Ghatura M & R Station	12" DN × 1000 PSIG × 1.07 KM	1968
13	Habiganj Gas Field~Ashuganj vs 3	12" DN × 1000 PSIG × 57.75 KM	1981
14	Elenga~Tarakandi	12" DN × 1000 PSIG × 43.00 KM	1991
15	Dhanua~Mymensingh	12" DN × 1000 PSIG × 56.00 KM	1992
16	Ashuganj vs 3 ~ APS Complex	10" DN × 1000 PSIG × 0.69 KM	1968
17	Ashuganj vs 3 - ZFCL Complex	12" DN × 1000 PSIG × 3.43 KM	1980
18	Char Raghurampur (Mymensingh) ~ RPCL Power Stn. Complex	8" DN × 1000 PSIG × 5.00 KM	1998
19	Belabo Gas Field ~ Narsingdi vs 11	8" DN × 1000 PSIG × 13.00 KM	1997
20	Tarakandi ~ Sarishabari ~ Jamalpur	8"/6" DN × 1000 PSIG × 31.00 KM	1993
21	Mymensingh ~ Netrokona	8"/6" DN × 1000 PSIG × 40.00 KM	1994
22	Kamta Gas Field ~ Joydevpur CGS	6" DN × 1000 PSIG × 19.32 KM	1983
23	Jamalpur ~ Sherpur	4" DN × 1000 PSIG × 16.00 KM	1993
24	Monohordi ~ Kishoreganj	6" DN × 1000 PSIG × 35.00 KM	1994

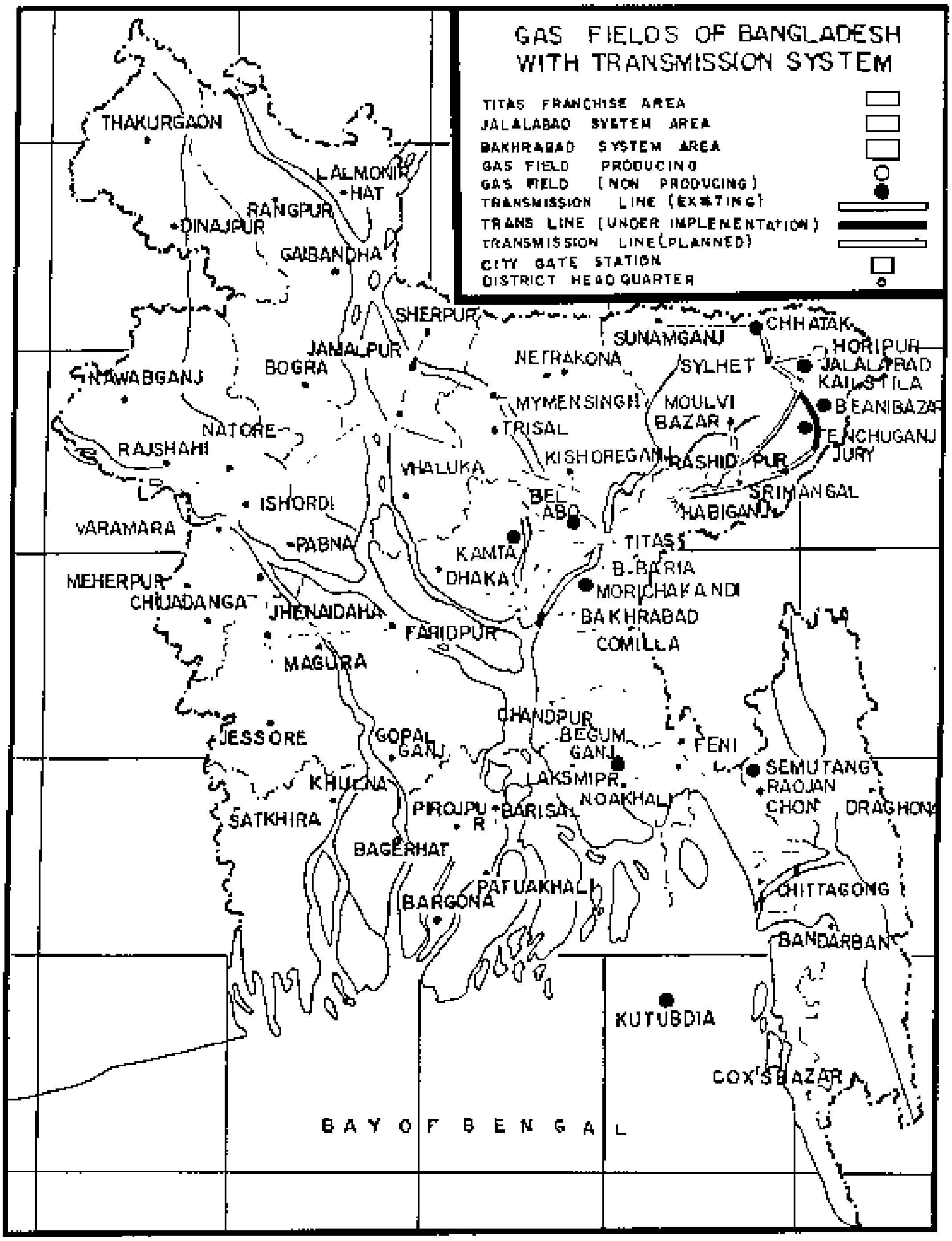


Figure 5.1: Transmission Pipeline

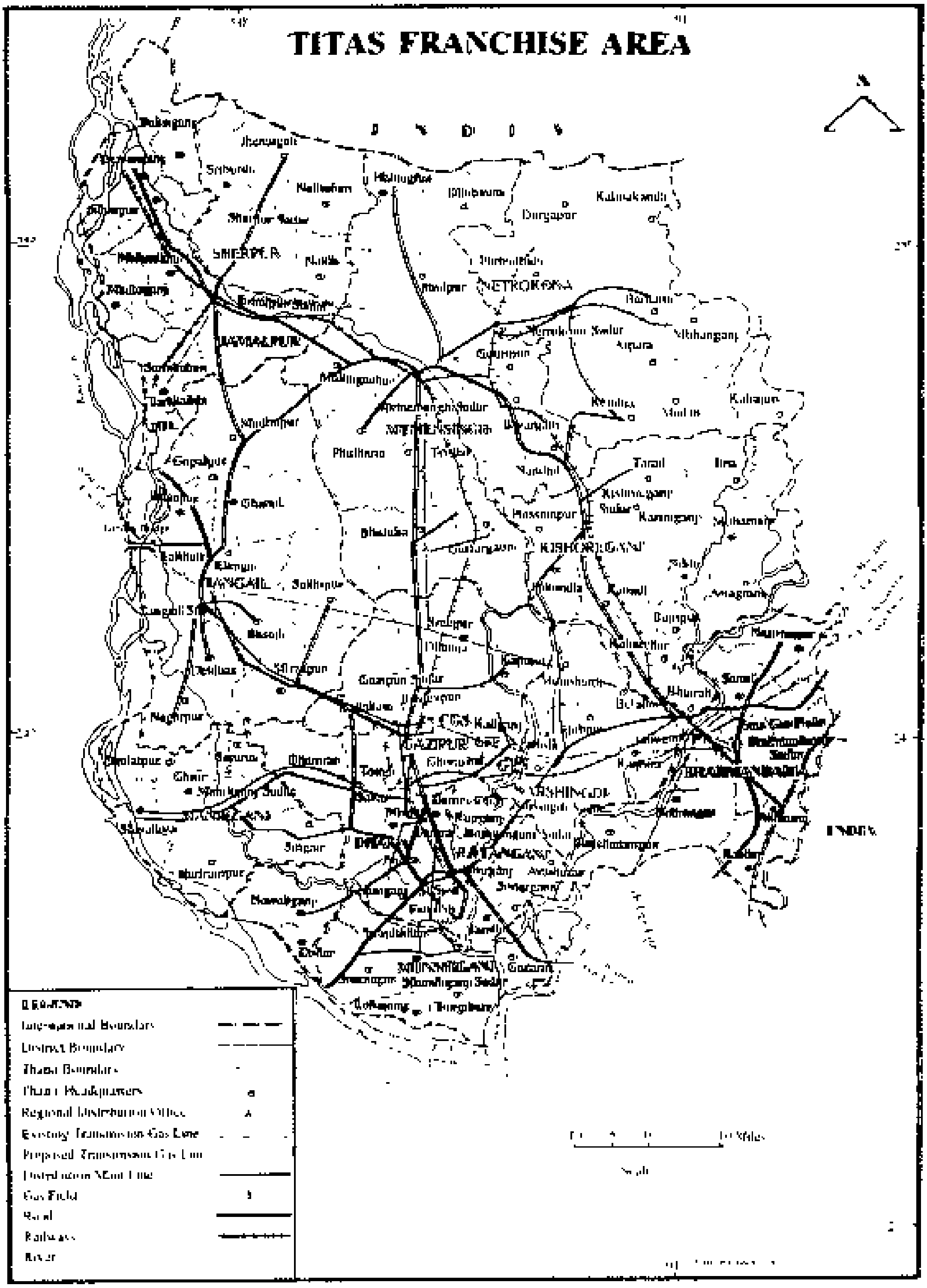


Figure 5.2 Titas Franchise Area

The distribution network constructed during early seventies in the old part of the city and Narayanganj became undersized in its capacity in the context of the increased gas demand in the industrial, commercial and domestic sectors. Unplanned growth of the gas network creates operational problem. At present the main problems of the distribution networks are:-

a) Inconsistent pressure throughout the distribution networks.
b) Severe pressure drops in various part of the network.
c) Pressure drop during peak hours.
d) There are random leakage in distribution mains feeder lines and service lines.

Network analysis is very important to diagnosis the source and demand of the gas transmission and distribution system. To calculate region or area wise gas flow it is very important to isolate that region. Non-isolation of network can increase system loss.

Table – 5.2: List of Major Distribution Pipelines around Dhaka City

SL. No	Description of Pipelines	Specification	Completion Year
1	Dhanua vs – Dhamrai CGS (Prop.)	30" DN × 1000 PSIG	Proposed
2	Dhanua vs. ~ Elenga vs	24" DN × 1000 PSIG × 51.7 KM	Proposed
3	Elenga TBS ~ Tangail DRS	12" DN × 150 PSIG × 12.4 KM	1989
4	Joydevpur ~ CGS Chandra (ASIA auto Bricks) DRS	10" DN × 150 PSIG × 25 KM	1987
5	Chandra DRS ~ Cadet College DRS	10" DN × 150 PSIG × 9.2 KM	1987
6	Cadet College DRS ~ Mirzapur DRS	10" DN × 150 PSIG × 14.8 KM	1987
7	Mirzapur DRS ~ Koratia DRS (Prop.)	10" DN × 150 PSIG × 14 KM	1987
8	Koratia DRS (Prop.) ~ Tangail DRS	10" DN × 150 PSIG × 8 KM	1987
9	Joydevpur CGS ~ Tongi DRS (Prop.)	16" DN × 300 PSIG × 12.5 KM	1999
10	Joydevpur CGS ~ Tongi DRS	12" DN × 150 PSIG × 12.5 KM	1977
11	Tongi TBS ~ Ashulia TBS (Prop.)	16" DN × 300 PSIG × 8.5 KM	1999
12	Ashulia TBS ~ Dhamrai TBS (Prop.)	16" DN × 300 PSIG	Proposed
13	Ashulia Junction ~ Tongi DRS	12" DN × 150 PSIG × 8.5 KM	1976
14	Ashulia Junction ~ Savar DRS	12" DN × 150 PSIG × 2.9 KM	1986
15	Savar DRS ~ Dhamrai DRS	12" DN × 150 PSIG × 6.2 KM	1987
16	Dhamrai DRS ~ Manikganj DRS	12" DN × 150 PSIG × 23 KM	1987
17	Manikganj DRS ~ Aricha DRS	12" DN × 150 PSIG × 17.3 KM	1987
18	Tongi TBS ~ Tejgaon TBS	30" DN/ 24" × DN × 300 PSIG	Proposed
19	Tongi DRS ~ Uttara DRS	12" DN × 150 PSIG × 5.8 KM	1982
20	Uttara DRS ~ Joarshahara DRS	12"/6" DN × 150 PSIG × 1.22 KM	1997
21	Joarshahara DRS ~ Junction Point	12" DN × 150 PSIG × 7.6 KM	1997
22	Junction Point ~ Gulshan DRS	12" DN × 150 PSIG × 1.8 KM	1997
23	Junction Point ~ Mirpur DRS	12" DN × 150 PSIG × 4 KM	1997
24	Junction Point ~ Cantonment DRS	8" DN × 150 PSIG × 1 KM	1997
25	Cantonment DRS ~ Mirpur DRS	8" DN × 150 PSIG × 3 KM	1968
26	Gulshan DRS ~ Tejgaon TBS	12" DN × 150 PSIG × 4 KM	1967
27	Dhamrai TBS - Hazaribagh DRS	30" DN / 24" DN × 300 PSIG	Proposed
28	Hazaribagh TBS ~ Jinjira TBS	30" DN / 24" DN × 300 PSIG	Proposed
29	Ashulia Junction ~ Aminbazar DRS	12" DN × 150 PSIG × 11.3 KM	1984
30	Aminbazar DRS ~ Hazaribagh DRS	12" DN × 150 PSIG × 9.2 KM	1997
31	Hazaribagh TBS ~ Jinjira DRS	12" DN × 150 PSIG	2002
32	Tejgaon TBS ~ Nandipara TBS/DRS	12" DN × 300 PSIG × 5.5 KM	1967
33	Nandipara TBS/DRS ~ Demra CGS	12" DN × 300 PSIG × 6.7 KM	1967
34	Demra CGS ~ Postagola DRS	14" DN × 150 PSIG × 0.25 KM; 10" DN × 150 PSIG × 6.4 KM	1967
35	Postogala DRS ~ Kadamtali DRS	10" DN × 150 PSIG × 2 KM	1967
36	Kadamtali DRS - Godnail DRS ~ Panchabati	24" DN × 150 PSIG × 9 KM	2002
37	Kadamtali DRS ~ Jinjira DRS	8" DN × 150 PSIG × 8 KM, River Crossing (14" DN × 150 PSIG × 457 m)	1981
38	Demra CGS ~ Dhania DRS	16" DN × 300 PSIG × 6 KM	2002
39	Dhania TBS ~ City Central DRS	16" DN × 150 PSIG × 6 KM	2002
40	Demra CGS ~ Siddirganj RMS	14" DN × 150 PSIG × 4.6 KM	1969
41	Siddirganj RMS ~ Godnail DRS	10" DN × 150 PSIG × 3.4 KM	1969

Table – 5.3: Area Wise Division of Non-Bulk Sector

Sl. No	Name of the region	Area
01	Metro Dhaka Sales Division (MDSD)	Dhaka City corporation (DCC) and zone adjoining non-DCC area like Jinjira and Demra
02	Regional Sales Department 1 (RSD – 1)	Sitalakhya, East Bank, Sonargaon, Haripur, Rupganj, Narayanganj, Bandar and Munshiganj
03	Regional Sales Department 2 (RSD – 2)	Savar, Manikganj, Dhamrai, Tongi, Joydevpur and Tangail
04	Regional Sales Department 3 (RSD – 3)	Bramman-Baria, Ashuganj, Bhairab Bazar, Narsinghdi, Ghorashal, Madhobdi
05	Regional Sales Department BR (RSD – BR)	Mymensingh, Bhaluka, Netrokona, Jamalpur, Sherpur, Trishal, Gafforgaon, Dhanua, Tarakandi

Table – 5.4: Area Wise Customer of Non-Bulk Sector

Category	RSD – 1	RSD – 2	RSD – 3	MDSD	RSD – BR	Total
Ind.	560	605	84	1091	28	2368
Ind. (S)	-	40	108	4	-	152
Commercial	810	332	160	5327	129	6758
Domestic	80552	79294	16561	560325	23837	760569

CHAPTER – 6

CONTRIBUTING FACTORS OF SYSTEM LOSS FOR A TRANSMISSION SYSTEM

Contributing factors are those, which have a direct bearing on system loss. In a transmission system there may arise a number of contributing factors, which are related to system loss These factors arise from the design faults and imperfect operation. Improper selection of a flow meter can also cause system loss. Metering station configuration has a direct effect on system loss if these are not built as per the International standard. Meter run design is also an important factor. Improper meter or regulator and control valve selection can also cause pulsation, which can increase system loss. Improper operation of the transmission pipeline valve station and metering and regulating station also cause operational problem and measurement error. Safety and environmental issues are also important and these should be considered during designing period. A number of contributing factors related to system loss for a transmission system are listed and discussed in this chapter these are as follows:-

6.1 Contributing Factors Of A Transmission System

1) Pressure measurement.
2) Temperature measurement.
3) Density measurement/specific gravity measurement.
4) Determination or calculation procedure of compressibility or super compressibility.
5) Line pack and its calculation.
6) Metering station configuration.
7) Meter run design.
8) Selection of meter (Type, size and accuracy)..
9) Meter rangeability.

10) Meter repeatability.
11) Installation effect.
12) Un-metered usage due to meter damage.
13) Pulsation effect.
14) Condensation of natural gas.
15) Gas velocity or Reynolds number.
16) Gas quality.
17) Relief or venting.
18) Purges.
19) Leakage.
20) Calibration of meter.
21) Calibration of secondary instruments such as recorder, gauge, transmitter and transducer.
22) Isentropic exponent usage for calculation.
23) Elevation/Barometric effects.
24) Conversion process.
25) Accounting procedures.
26) Billing or accounting cycles.
27) Uninterrupted power supply for computerized metering system.
28) Swirl and cross current
29) Velocity profile.
30) Foreign materials.
31) Changes of gas composition.
32) Profile distortion.
33) Internal pipe roughness.
34) Primary flow element.
35) Metering run inlet header.
36) Chart recorder and chart reading.
37) Preheating of natural gas.

6.1.1 Pressure Measurement

Metering pressure measurement has an important effect on system loss. Incorrect pressure measurement directly affects system loss because of direct involvement of pressure in gas calculation procedure.

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'. An accuracy of about ± 1% should be available for at least the upper range value of a good 'Bourdon Tube' type pressure gauge. There are some master pressure gauge with an accuracy of ± 0.25%.

Pressure gauges also adopt bellows as the means of translating the pressure into a visual scale. By using the concept of Bellows, Bourdon tube and Thermo-well, Mechanical recorder are produced by the manufacturer with different ranges and sizes, which are used to measure the differential pressure, static pressure and temperature of gas with circular chart. The accuracy of this device is:-

a) Differential pressure element: ± 0.5% of full scale.
b) Static pressure element: ± 1% of full scale.
c) Temperature element: ± 1% of full scale.

Another pressure measuring device that is called pressure transmitter. Now a days for better accuracy this type of pressure measuring instruments are used. These are:-

1) Variable resistive pressure transmitter.
2) Variable inductive pressure transmitter.
3) Variable capacitive pressure transmitter.
4) Piezo-electric pressure transmitter.

The variable capacitive type pressure transmitter is now widely used for pressure measurement. Most electronic pressure transmitter has a 4-20 mA output signal, which corresponds to 0% and 100% of the given pressure measuring range. A wide range of pressure can be measured with this transmitter. Now a days-smart transmitter with

'HART' (High-Way Addressable Remote Transmitter) protocol is used for pressure measurement. Accuracy of this type of transmitter is 0.1% or less. Now it will be useful to discuss some of the potential error about pressure measurement:-

6.1.1.1 Incorrect Location Of Pressure Tap

The correct location of the pressure tap is important not only from the requirement to get a representative reading, but also to ensure that the gas flow past the tap does not create any undue turbulence which could be detrimental to the proper operation of the flow meter. Unfortunately it is not always possible or practical, to have the pressure tap at the ideal location. In situations such as this, corrections are to be given for pressure readings. For flange tap type Orifice Meter the location of pressure taping point are:–

1) Upstream tap: 1″ inch upstream of the nearest plate face.
2) Downstream tap: 1″ inch downstream of the nearest plate face.

For Turbine Meter in close vicinity of the wheel, a special reference pressure point P_r is provided. An error will be introduced in pressure measurement; if reference point pressures are not used. In Titas, system most of the tapping point are other then the special pressure point, P_r. So there may arise an error for pressure measurement.

6.1.1.2 Faulty Gauge Recorder Or Transmitter Used

Sometimes a faulty pressure gauge, recorder or transmitters are used on a custody pressure point, which accuracy is higher than ± 1%. This type of pressure measurement has a strong effect on system loss in transmission system.

6.1.1.3 Pressure Gauges, Recorders And Transmitters Are Not Calibrated At Regular Interval

Sometimes pressure gauges, recorders and transmitters are not calibrated as per manufacturer recommended interval. This may create error in gas measurement.

6.1.1.4 In correct Reading Of Gauge Or Pressure Recorders

When pressures are read manually from gauges or recorders then there may have chance to read pressure incorrectly which may increases error in gas measurement.

6.1.2 Temperature Measurement

Two scales tend to be more commonly used for temperature measurement these being the Celsius and the Fahrenheit scales. For the International System of units (SI), the Kelvin (^{0}K) and for F. P. S. system Rankine (^{0}R) are used as a temperature measurement scale. 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 like 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 requirement. Overall control requirements are also important. This can lead to the selection of a mechanical or pneumatically transmitted system, giving freedom from external power sources and simple maintenance requirement. 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. Some of the potential errors regarding temperature measurement are discussed below.-

a) Incorrect thermo well point or tapping point

Sometimes thermo well or temperature tapping points are not installed according to recommended standard. For orifice flow measurement this standard is AGA Report no. 3 or ISO – 5167. And for Turbine type gas metering this standard is AGA Report no. 7 or ISO – 9951. According to these standard the temperature tapping point will be in between five nominal pipe diameters from downstream of the meter.

b) Under or over size thermopile

The protrusion length of thermopile should be ¾ of the nominal pipe diameter or 150-mm whichever is less. Sometimes under or over size thermopiles are used for temperature measurement. Undersize thermopile cannot measure the correct temperature of the gas. On the other hand oversize thermopile (length) produces turbulence, which causes measurement error.

c) Incorrect temperature gauges, recorders of transmitters usage

Sometimes incorrect temperature gauges, recorders or transmitters are used to measure temperature. This creates error in temperature measurement.

d) Incorrect gauges, or recorders reading

Sometimes technician reads temperature manually from a gauges or recorders. These causes error in temperature reading, which may cause measurement error.

e) Gauges, recorders and transmitters are not calibrated at regular interval

Gauges recorders and transmitters, which are not calibrated at a regular or recommended interval may cause measurement error.

f) Thermo-wells are not filled with oil

For correct temperature sensing of the flowing gas the thermo-well should be filled with oil. This completes heat transfer from gas to oil. But in the existing system the thermo-well are not filled with oil. At present it is filled with air or water. So it is not possible to get the correct temperature of the flowing gas.

6 1 3 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-situ measurement device, the densitometer was developed.

Densitometer sometimes shows higher density value than the actual due to condensation of gas in the device. This may alter the actual density value of following gas and cause measurement errors.

6.1.4 CompressibilityOr Super Compressibility Determination

Compressibility is the ability of a material to reduce in volume when subjected to an increase in pressure. Super compressibility is reciprocal of compressibility. Compressibility and super compressibility determination are needed for calculating gas flow And this has a strong effect on system loss.

There are three more common methods for the calculation of compressibility these are:-

i) AGA NX – 19
ii) AGA – 8

iii) GERG.

Although NX – 19 has been universally used to determine the gas compressibility factor F_{PV}, field measurements in both the U.S.A. and Europe show major discrepancies between the actual measured compressibility and that derived through the application of NX – 19. This has led to independent research work by Group European des Recherché Gaziers (GERG) and the American Gas Association (AGA) into improved methods to determine gas compressibility which is discussed in Gas Flow Measurement, Quality and Control by GASCOR Consult International, Australia (Reference – 9). Although the two groups cooperated through the exchange of data, different results have been produced. Both studies have resulted in reports that give sets of equations to calculate the gas compressibility 'Z'.

The flow measurement quantity may vary subjecting to the method used for compressibility measurement. AGA – 8 is the best method for compressibility measurement.

6.1.5 Line Pack And Its Calculation

Line pack is the amount of gas that always remains in the pipeline from the purchase figure. With the build up line pressure the amount of gas packed increases in the pipeline. As pressure is always changing in the pipeline and pressure is higher in the lean hour than the peak hour. So line pack is higher in the lean hour. Line pack is always changing. Line Packs or change of line pack has a strong effect on system loss calculation procedures. Compressibility must be included with the line pack calculation due to compressible nature of natural gas. If this is not included in the line pack calculation then it will cause measurement error.

6.1.6 Metering Station Configuration

The overall design of a Regulating and Metering Station (RMS) should have regard to the particular conditions and duties that it is required to perform. As per International Gas

Engineer's recommendation IGE TD – 9, to install a RMS the following requirement are necessary:-

a) Range of flow rate required.
b) Range of inlet and outlet pressure related to flow rate.
c) The degree of security for supply required.
d) Cleanliness of the gas in respect of both solid particle and liquid entailment.
e) The need for preheating prior to pressure reduction.
f) The need for metering.
g) The need for noise control.
h) The requirements for telemeter information and remote control..
i) Any special characteristics of the load when the installation is supplying an industrial or commercial customer.
j) The requirements for maintenance.

6.1.6.1 Recommended Minimum Requirements

Having regard to the preceding clauses the design should include as a minimum as per IGE-TD – 9 (Reference – 2). These are:-

a) Two or more high-pressure inlet filters with suitable valving and connections to permit design with one unit out of action. Means to avoid the entailment 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.

b) Two or more streams of pressure regulators each stream to contain at least two regulators, so 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. These requirements for the provision of slam-shut valves are as a safety device. Small installations where the potential gas release via a relief valve can be allowed. A combination of slam shut and relief valve can be used for higher capacity RMS to ensure better safety.

c) Installations should be design 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 fail 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 exceed. 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.

d) 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.

In short a regulating and metering station should be included the following equipment:-

(i) Insulating joint.
(ii) Inlet emergency shut down valve.
(iii) Knock out separator/ scrubbers and filter separators.
(iv) Heaters or heat exchanger.
(v) Valves and valves actuators.
(vi) Slam-shut valves.

(vii) Regulators.

(viii) Silencers.

(ix) Relief valves.

(x) Meters.

(xi) Liquid separator.

If the metering stations are not installed as per the international recommendation then there may cause operational difficulties and measurement error.

6.1.7 Meter Run Design

To obtain a reliable and accurate metering it is just not a matter of selecting an appropriate flow meter. The choice of flow meter will affect the meter run, however the design of the meter run is paramount if the flow meter is to perform reliable and accurate. Therefore a strong interdependence exists between the meter and the meter run design. The meter run design requirements and limitations must be reviewed in conjunction with the flow meter characteristics. Taking this into account, together with meter manufacturers recommendations and those given in the recommended standards generates a list of items may include but not limited to (Reference – 9). These are: -

- Reynolds number sensitivity.
- Rangeability limits.
- Flow characteristics (intermittent, continuous, etc.).
- Maximum and average line pressure.
- Allowable pressure drop across meter.
- Space availability.
- Calibration/proving requirements (legal metrology requirements).
- Maximum and average operating temperature, cost expectations (capital, operating).
- Properties of measured fluid (corrosive, viscosity etc.).

6.1.8 Selecting A Gas Meter

In selecting a gas meter, one must first determine the type of meter that will be best suitable for the application. Meter choice will be made by the data that have been gathered for the overall station design. Following data are need for selecting a gas meter (Reference – 9):-

- Volume flow rate – Maximum, minimum and average hourly flow rate.
- Pressure – Maximum, minimum and average operating pressure.
- Type of load – steady, fluctuating, intermittent.
- Physical and chemical property of natural gas such as gas composition, water content, CO_2. N_2, heating valve, density, viscosity, corrosiveness, etc.
- Daily Range – Ratio of maximum to minimum hourly volumes in any one given 24-hour period.
- Space availability – Room that can be used or is available.
- Economic consequences – Accuracy, safety and service of primary importance.
- Legal metrology requirements – Approval of legal metrology (OIML – Organization International Metrology de Legal).
- Cost effectiveness
- Duration of operation of the meter.
- Consequences of the gas flow rate being stopped by meter malfunction.

There is no universal meter; each type has some limitations. Some meters may only be useful for specific applications, whereas others can be widely adopted. The correct meter selection is important not only from a measurement requirement, but also from economic, supply, security, safety and even customer confidence. The following types of meter may accomplish for gas flow measurement: -

(i) Differential pressure measurement – Orifice, venturi and nozzle flow meter.

(ii) Positive displacement – The diaphragm meter.

(iii) Rotary inferential – Rotary meter, turbine meter.

(iv) Fluid oscillatory – Vertex shedding, swirl meter.

(v) Electromagnetic – Magnetic flow meter.

(vi) Ultrasonic – Doppler.

(vii) Direct mass – Coriolis.

(viii) Thermal – Thermal profile.

In transmission system Orifice and Turbine type gas meter of various sizes are used for gas measurement. Faulty, under or over size meter selection can increase measurement error which interns increase system loss.

6.1.9 Flow Range Or Rangeability Of Meter

This is the ratio of maximum and minimum flows over which the meter will maintain the specified accuracy or linearity. Rangeability has a strong effect on system loss. Because meter with improper ranged can not measure truly. Accuracy is how close to true flow the meter can measure. This is usually stated as a percentage over a flow range. And linearity is the ability of a meter to maintain a constant calibration factor throughout its specified flow range.

The rangeability of a single orifice meter is about 3:1. By using a series of differential element read out device this can be raised to 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 ratio' which is a ratio of the maximum flow divided by the minimum flow, again over a given accuracy tolerance. On the other hand rangeability of turbine meter is very high. At lower or medium pressure it is 20:1 and it increases as pressure increases.

Rangeability is very important for meter selection. Where the gas consumption is stable or where there is no load variation then it will be wise to use an orifice meter. And for load variation turbine meter can be used efficiently. Selection of an improper range meter can increase measurement error, which in turns increases system loss.

6.1.10 Repeatability

Repeatability is the ability of a meter to replicate the same reading each time given that the same flow conditions exist. It is the closeness of the agreement between the results of successive measurements carried out under the same conditions.

Repeatability conditions include: -

- The same measurement procedure
- The same observer
- The same measuring instrument used under the same conditions
- The same location, and
- Repetition over a short period of time.

A meter with closest repeatability is desired. It is expressed in percentage. A repeatability value of 0.10% is a very good one. Repeatability has a strong effect on system loss. Meter with higher repeatability value can increase system loss and lower repeatability can decrease it.

6.1.11 Installation Effect

Installation has a strong effect on system loss. It may affect proper metering and operation For proper metering of natural gas it is very important to consider the installation factors. In this study a brief discussion of some of these factors are given below:-

1) Provision of adequate filtration.
2) Requirements of preheating the gas.
3) Elimination of liquid droplet and vapor presence with the gas.
4) Elimination of pulsation and flow surges.
5) Elimination of the possibility of reverse flow.
6) Access requirement for maintenance and operation.

7) Regulator, hazardous zone, safety requirement, secondary instrument and interface requirement.
8) Sources of interference and special requirement.

Installations those are not built as per the internationally accepted standard like ANSI, API. DIN, NIN, IGE, AGA, ASME, ISO ASTM etc. may cause improper operation and measurement error which intern's increases system loss.

6.1.12 Un-metered Usage

In a transmission system sometimes it is not possible to meter gas due to damage or absence of gas meter. Un-metered uses are not reflected in the system balance or system loss calculation process. Third party that which is not very easy to identify sometimes damages gas meters. Flow meters of CGS, TBS, DRS and RMSs are damaged by third party with a view to create a disturbance in calculating input gas of a sales area. So un-metered usage have a strong effect on system loss.

6.1.13 Pulsation Effect

Pulsation created by flow control valves, regulators and some piping configurations may cause significant errors in gas flow measurement. In recent years the Pipeline and Compressor Research Council (PCRC), a subsidiary of the Southern Gas Association, commissioned and funded various pulsation reacherch project at Southwest Research Institute (SWRI) in San Antonio Texas. This is discussed in "Appalachian Gas Measurement" short course – 1999, U.S.A. (Reference – 8). The PCRC sponsored research programs concluded that pulsation induced measurement errors fall into two broad categories.

a) Primary Element Error

   Which includes square root averaging error (SRE), inertial errors, and shifts in the orifice co-efficient.

a.1 Square Root Error

In our transmission system most of the natural gas measurement is performed with orifice plates. Gas volume (Q) is calculated using the basic formula $Q=C'\sqrt{\Delta P\times P}$. The fixed orifice coefficient (C') is desired from a formula found in the latest edition of AGA Report No. 3. Differential pressure (ΔP) and line pressure (P) are measured with mechanical chart recorders or electronic transmitters. Under steady – state flow conditions, gas volumes can be accurately measured with current state-of-the-art equipment. However, inaccurate measurement occurs when the ΔP modulates, or changes, at a frequency greater than the frequency that the measurement system extracts the square root of the ΔP. Pulsation from control valves, pressure regulators, and some piping configurations are one source of frequent ΔP modulation. The measurement error referred to above is called Square Root Error (SRE) – the calculation of unsteady flow using the square root of the average ΔP vs. the average of the square root values of the instantaneous ΔP. Because SRE is directly related to flow measurement error, it has become a very important topic to those who buy and sell natural gas. SRE is the largest component of primary element error caused by pulsation.

a.2 Other Primary Element Errors

Though SRE is the largest component of pulsation induced primary element error, under extreme pulsation conditions, inertial error and coefficient shifts will both increase in magnitude. A brief explanation of each follows:-

a.2.1 Inertial Error

Pulsating gas flow will tend to remain in motion due to its inertia. As a result, flow velocity changes lag behind ΔP changes. Inertial errors are insignificant unless pulsation amplitude and frequency are both relatively high.

a.2.2 Co-efficient Shift

Though difficult to quantify test data indicates that pulsation level above 1.5% SRE contribute to shift in the orifice co-efficient.

b) Secondary Element Errors

Which consist of gauge line distortion and gauge line shift, together commonly referred to as Gauge Line Error (GLE). Gauge line a error exists when Δp at the taps does not equal to the Δp at the end of gauge lines. It is caused by pulsation.

6.1.14. Condensation Of Natural Gas

Within natural gas environment the word condensate refers to the liquid those are formed by the condensation of a vapor or a gas; specifically, the hydrocarbon liquid separated from natural gas because of changes in temperature and pressure when the gas from the reservoir is delivered to the surface separators and inlet separators of a Regulating and Metering Station (RMS). The Condensate formed this way is essentially made up of pentanes and higher hydrocarbon. In a gas transmission and distribution system liquid condensates are separated through the knock out, filter and liquid separators and collected into the under or over ground storage tanks. Then the collected Condensate is delivered to Oil distribution Company through tank lory by carrying contractors.

For system balance or loss/gain calculation these collected condensate are converted to equivalent cubic meter of gas. Presently a conversion of one-litre condensate is equal to one-meter cube natural gas as per the recommendation of Chemical Engineering Department of Bangladesh University of Engineering and Technology (BUET). Condensate collection facility and efficiency has a great influence on system loss. Because this increases operational abnormalities and measurement error. Sometimes condensates are carried to the distribution network causes operational problem. Some quantities of condensate are losses by pilferage in collusion with the carrying contractor.

6.1.15 Reynolds Number

Reynolds number R_e is a dimensionless variable, which represents the nature of the flow in a pipe has strong influence on measurement.

$$R_e = \frac{\rho v d}{\mu}$$

where, R_e = Reynolds number

ρ = Density of gas

V = velocity of gas

D = Diameter of the pipe

μ = Dynamic viscosity.

Reynolds number has been found to be an acceptable correlating parameter that combines the effects of viscosity, density, and pipeline velocity. A high Reynolds number means that viscous forces are small, whereas a low value means that viscous forces dominate. When the value of Reynolds number is below 2000, the flow is termed laminar. Turbulent flow is said to exist when the value is above 40,000. Reynolds numbers, which falls between these two values, the flow may be laminar or turbulent – this being termed as transition area

$R_e < 2{,}000$	Laminar flow
$2000 < Re < 40{,}000$	transition zone
$R_e > 40{,}000$	turbulent flow.

For the measurement of Natural gas, the Reynolds number will be normally well above the transition zone. It is always advisable to check the Reynolds number sensitivity when considering a particular flow meter type for a given application.

6 1.16 Gas Quality

Gas quality has a strong effect on operation of the station and measurement system. The gas should be pipeline quality one. So gas must be filtered through KOD (Knock Out Drum: It is one kind of liquid separator) and two-stage filter separator. Dirt, dust, pipeline debris, waters and water vapor, higher hydrocarbon or condensate should be removed through these separating system. If these sorts of things are not separated then it will create a great impulse on meter vane showing measurement on higher side and consequently damages the meter.

6.1 17 Venting Through Relief Valve

Sometimes gas is vented through the relief valve of regulating runs, separators (KOD, filter and liquid separator), condensate line etc. when the gas pressure exceeds the set point. This situation arises in the off transmission CGS, TBS, DRS and bulk customer RMS at the lean hour say at 01 00 P.M. to 05.00 P.M. hour every day weekly holiday period and special holiday like Edul-Azaha and Edul-Fitor due to decreasing of gas use level. So there are chances of gas losses through vent during this period, which also can cause operational anomaly and system loss.

6.1.18 Purges

Purges are the amounts of gas that are release to the atmosphire during a pipeline operation or a regulator setting or other related RMS operation. Sometimes this amount of gas is not recorded in a pipeline operation. These increases system loss. The purges should be duly recorded.

6.1.19 Leakage

Loss through leakage from the transmission piping system is less important because there are less chances of this type of leakage. Transmission pipeline networks are less complicated and Cathotically it is protected.

6.1.20 Meter Calibration

Meter calibration and process of calibration has a strong effect on system loss. Meter that which is not calibrated at a regular interval recommended by the manufacturers may cause measurement error. This increases system loss.

6.1.21 Calibration Of Secondary Element Like Recorders Gauges And Transmitters

Calibration of the secondary element like chart recorders. gauges and transmitters has a strong effect on flow measurement. If these shorts of instruments are not calibrated at a regular interval the uncertainty of measurement process increases. This increases system loss.

6.1.22 Isentropic Exponent Usage For Calculation

The isentropic exponent (K) is a thermodynamic state property that establishes the relationship between an expanding fluid pressure and density as the gas flows through the orifice plate bore. The natural gas isentropic exponent value used for calculation process required an exact one. An erroneous isentropic exponent used for calculating gas flow by orifice meter has a strong effect on measurement uncertainty.

6.1.23 Elevation/Barometric Effect

Gas flow rate of the individual metering station are calculated on the basis of the barometric height or elevation of sea. And individual metering stations barometric height is not reflected in this regard. This causes measurement error.

6.1.24 Conversion Process

There may have chances of system loss or Unaccounted For Gas (UFG) with in the unit conversion process of the gas calculation procedure. If the conversion factors are not properly used then the calculated amount can vary from the actual.

6.1 25 Accounting Procedures

There may have chances of increase system loss if proper accounting procedures are not use in calculating gas bill preparation and payment.

6.1.26 Billing Cycle Effect

Billing cycle is the time between the consequent billing month. This is the first day to the last day of a month. The meter reading of all transmission installation should be collected at the same time. If these are not collected at the same time then total gas flow will higher or less than the actual gas flow. On the other hand billing cycle of sales system is 21st day of a month to the 22nd day of the next month, this in consistency in billing may cause system loss.

6 1.27 Interrupted Power Supply

If the power supply for the flow computer, gas chromatograph, pressure, differential pressure and temperature transmitters are interrupt for some time then the flow computer fail to compute the gas flow rate at that time. So the flow computer shows less gas flow than the actual flow. So interrupted power supply is a strong factor for system loss for the computerized gas computing system.

6.1 28 Swirl And Cross Current

One of the major design faults for a gas metering system is having a number of pipe bends close to each other. This results bulk swirl, which may persist for significant distances downstream in the pipeline. Observations of actual conditions have confirmed that this distance can be in excess of 1000 D. To put this in perspective, 100 D is up to 10 times greater than the upstream straight length provided by some metering system design (Reference – 9).

Swirl may occur alone within a pipeline system or together with velocity profile distortion. Generally swirl is the result of having adjacent bends in different planes within the pipe. The use of straight lengths of pipe can reduce or eliminate swirl, with the viscosity of the fluid influencing the length of straight pipe required. This means a liquid would require a much shorter pipe length than the natural gas. Of course, flow conditioner can also be used for reducing swirl within a pipe. The decay of swirl is also influenced by the pipe wall roughness. For a very smooth internal pipe wall, swirl may persist for well over 100 pipe diameters downstream of the source.

Swirl and crosscurrent has a very strong effect on flow measurement. In presence of swirl the flow measurement may be faulty. Swirl in the direction of flow can increase the flow rate than the actual and opposite to the flow direction decrease the flow rate than the actual value.

6.1.29 Velocity Profile

It can be seen that the Reynolds number is a guide to the profile and stability of the fluid flow pattern. For laminar flow (Re < 2000) the profile is parabolic and it is not influenced by the pipe wall roughness. At these conditions a particle at the center of the flow would be travelling at about twice the velocity of the average of the fluid particles. In the total turbulent region, the flow profile is nearly flat, with particles travelling at the same velocity. The exception being particles close to the pipe walls interface, which travel at a lower velocity. Velocity profile has a strong effect on gas measurement.

6.1.30 Foreign Material

Different meters will react differently to the presence of foreign material within the fluid being measured. The foreign material may result in abrasive, corrosive or pulsating action on the meter. This in turn will lead to inaccurate flow registration or even stop the meter completely.

6.1.31 Changes Of Gas Compositions

Knowing the composition of the fluid and its likely rate of change can be important for a number of reasons. For gas flow measurement it is desirable to free from dirt dust and decay. The composition and change of composition can also significantly alter the gas density. Some gases are unstable and may cause measurement problems by breaking compositions along the pipeline, which will initiate a change of state. With changes of gas composition the density of gas will change. Since gas composition is not analyzed in online or regular interval rather it assumes a constant value. So with changes of gas composition flow measurement can be changed.

6.1.32 Profile Distortion

Other variables, which can cause installation effects, include profile distortion, the condition of the internal pipe walls, the number of straight lengths available both upstream and downstream of the flow meter, and the location of valves, change of pipe diameter and proximity of reciprocating plant. Swirl and profile distortion is the two major types of disturbance within pipelines. Profile distortion is sometimes referred to as jetting. Both these elements may occur together or separately considerable work has been undertaken over the past decade to eliminate this conditions prior to the flow meter. The elimination or minimization is achieved through the use of flow conditioner. Some very novel and effective flow conditioner design are now available.

Profile distortion can be of a temporary nature, as it is caused by obstruction in the gas flow path. Items, which would constitute an obstruction, like a partially open valve, a blockage in the pipeline or other irregularities within the pipe can cause profile distortion. Incorrectly fitting or protrusion of gaskets is another common contributing factor to profile distortion.

The influence of swirl to the flow meter is closer the bends. Rotating plant such as compressors, generators; pump etc. can excite piping vibrations, which in turn result damage of the metering equipment. Profile distortion cause measurement error.

6.1.33 Internal Pipe Roughness

Internal pipe roughness has also recently received considerable research attention. The National Institute of Standards and Technology (NIST), Colorado, U.S.A. has found that flow measurement errors of around one percent can result from the use of pipe that has an internal surface finish that is too rough but complies with the given standard. A rough wall pipe will contribute to profile distortion because the velocity profile in a pipe with a smooth wall is such that the velocity near the wall is higher than at the same radius in a rough walled pipe. With respect to pipe wall roughness and application to orifice plate systems, it has been demonstrated the following results from research studies into orifice metering at the Nova Husky "Research Corporation in Canada and NIST in U.S.A." (Reference – 9).

a) Orifice meters are sensitive to pipe roughness for diameter ratio $\left(\beta = \frac{d}{D}\right)$ greater than 0.6 however no significant statistical effect could be found for beta ratios less than 0.5.

b) A relatively short piece of rougher pipe (about 2.5 pipe diameters) can have a major influence on reading accuracy.

c) For an orifice plate diameter ratio of 0.73 and a pipe wall surface roughness value approximately 7.6 μm, the roughness effect on the discharge co-efficient can exceed 1%.

d) For pipe wall surface roughness value less than 3.8 μm, the effect on the discharge co-efficient caused by roughness is less than 0.5% for any beta ratio less than 0.75.

6.1.34 Primary Flow Element

A problem that does exist with metering system design and is the choice of the primary flow element especially orifice plates, location and orientation of pressure tapping points and associated lines for instrumentation etc. For gas measurement, taps should come at the top or at least no more than 45^0 degrees from the vertical of the gas measuring line. This is to make sure that any liquids that get into the main pipe are not able to be drawn into or block the instrument lines. Improper design of primary flow element can cause measurement error.

6.1.35 Metering Run Inlet Header

Another design point worth consideration is the metering run inlet header. The size of this header can be used to control the velocities of the fluid to the meter runs. Naturally, the appropriate standards should be always referenced.

As can be seen, meter run design can influence the operation of the flow meter. Other points that should also be considered are that most meters will have their best accuracy at the upper range and at conditions where other measured variables would change little i.e. stable pressure, temperature and density.

6.1.36 Chart Recorder And Chart Reading

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 use charts as a permanent record for accounting purposes.

When uncertainties of measurement are considered, the billing or gas accounting process tends to be overlooked. The recording and calculation process is the final consideration for obtaining accurate flow measurement. This process can and does contribute to the overall uncertainty of measurement. This can be through the application of averaged data, if electronic recording means are used, or from incorrectly reading hard copy data, such as that derived from chart readings.

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. Understanding and training of the maintenance personnel. 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. Malfunction or erroneous reading of chart recorder can cause measurement error.

6.1.37 Requirements Of Pre-heating The Gas

When temperature of the gas falls below the dew point, hydrates can form and freezing occurs in and on the pipeline and regulation becomes cheese. This creates operational hazard and incorrect flow measurement. To prevent this, particularly at the stage when pressure reduction takes place, it is necessary to ensure that the temperature of the gas remains above that of the dew point at the exit to the pressure reduction section of the system. During pressure reduction the temperature is reduced by approximately one degree F, for every bar by which the pressure is reduced. Preheating of gas is necessary for smooth operation and correct flow measurement. Typically the system will provide two heating units one on active service, the other on stand by duty. The commonest form of heater used to raise the temperature of gas, is the water bath type of heater or exchanger.

The factors those are discussed above have strong effects on system loss, since a huge amount of gas are metered or transfer through the transmission system. A small percentage of loss will be a big amount of gas loss. So care should be taken to minimize all these factors, especially installation effects and measurement related factors.

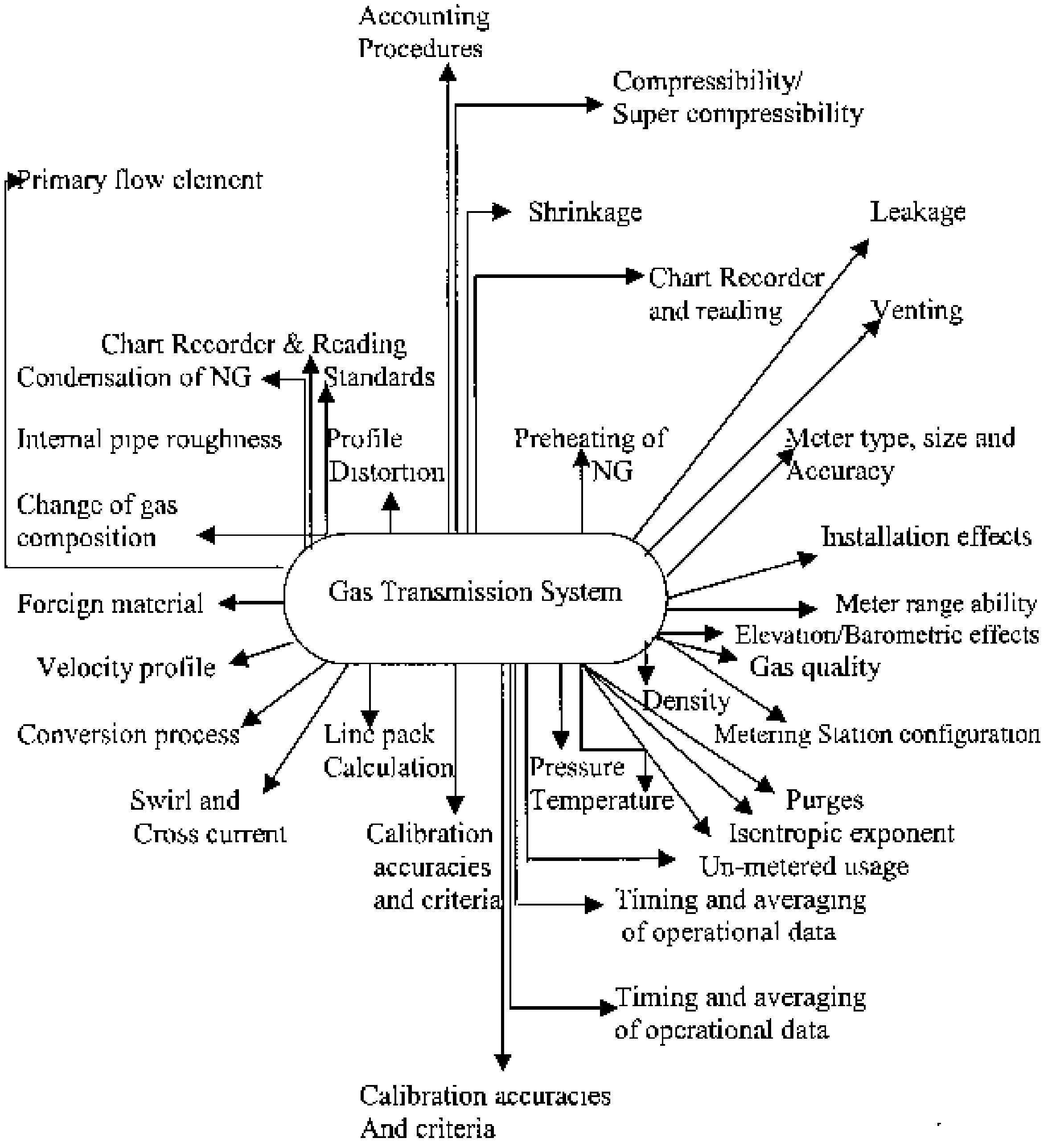


Figure 6.1: Contributing Factors – System loss for a Transmission system

CHAPTER – 7

CONTRIBUTING FACTORS OF SYSTEM LOSS FOR A DISTRIBUTION SYSTEM

In a gas distribution or sales system there may arise a number of contributing factors, which are related to system loss. These factors arise from the design faults and imperfect operation and gas pilferage. Improper or faulty selection of a flow meter can also cause system loss. Customer Metering Stations (CMS) configuration can also cause system loss if these are not built as per the internationally recommended standard. Improper selection of regulator, control valve or meter can also cause pulsation, which can increase system loss. Improper operation of distribution lines, valves, DRS and CMS also cause operational problem and measurement error. These are all technical errors.

The other types of losses are called non technical loss, which mainly causes from piracy or theft of gas through a number of indigenous ways and that is the major component of system loss. A number of contributing factors related to system loss for a distribution system are listed and discussed in this chapter, these are:-

7.1 Contributing Factors

1. Fixed pressure factor used in gas calculation.
2. Fixed temperature factor used in gas calculation.
3. Metering station configuration.
4. Meter sizing and selection.
5. Meter accuracy.
6. Meter rangeability.
7. Meter repeatability.
8. Meter reading errors.
9. Load approval.

10. Un-metered domestic flat rate tariff base.

11. Meter calibration and service.

12. Non registration of pressure and temperature.

13. Theft.

    a) Meter tampering.

    b) Regulator tampering.

    c) Meter index slowdown.

    d) Meter index changing.

    e) Rotation of meter index in reverse direction.

    f) Interference.

    g) By pass connection.

    h) Theft by other equipment of RMS.

    i) Registering lower meter reading.

    j) Imitation of seal.

14 Leakage.

15. Venting through relief valve.

16. Conversion process.

17. Accounting procedures.

18. Billing cycle effect.

19. Pilot loss.

20. Pulsation effect.

21. Third party damage.

22. Un-metered usage.

23. Incorrectly reported usage.

24. Pressure regulating and metering station performance.

25. Absence of regional blanching or accountability.

7.1.1 Fixed Pressure Factor For Billing

Gas consumptions of customers are calculated and billed in terms of standard or base condition in cubic meters. This is the volumetric flow rate that would occur if the pressure would be reduced to standard or base pressure and temperature (14 73 psia and 60°F). The base volume can be calculated with a formula that can be write as:-

$$Q_b = Q_f \cdot \frac{P_f}{P_b} \cdot \frac{T_b}{T_f} \cdot \frac{Z_b}{Z_f}$$

Where,

Q_b = Base volume flow rate in m^3/hr.

Q_f = Line condition volume flow rate in m^3/hr.

P_f = Static pressure at line condition PSIA.

P_b = Base pressure at base condition PSIA.

T_b = Base temperature °R.

T_f = Flowing temperature °R.

Z_b = Compressibility at base condition.

Z_f = Compressibility at flowing condition.

For lower pressure, temperature factor $\frac{T_b}{T_f}$ and

Compressibility ratio $\frac{Z_b}{Z_f}$ are taken to be unity.

So the above formula become

$$Q_b = Q_f \cdot \frac{P_f}{P_b} \cdot$$

Metering pressure of customers are the contractual pressures by the company with the customers. Since no permanent pressure recording devices are not installed in customer's RMS. So for gas metering fixed pressure factor is used. This fixed pressure factor has a strong effect on system loss. Generally the customers use gas at a higher pressure than the contractual pressure by unauthorized handling or tampering of regulator and pressure gauges, RMS pipes, fittings, stainers and other equipment by breaking the seals.

Sometimes it becomes very difficult to identify the seals that are actually broken by unauthorized way.

7.1.2 Fixed Temperature Factor

The formula for temperature factor can be written as $F_{ft} = \frac{520}{T_f + 460}$. In TGTDCL's distribution system the temperature factor used to calculate the gas flow rate is unity. This means that flowing temperature is always 60°F. It shows that $F_{ft} = 1$, only for T_f = 60°F. But in actual case this factor is not unity because customers use gas lower than the base temperature. So this fixed temperature factor has a strong effect on system loss. At present there are no temperature recording devices in customer RMSs premises.

7.1.3 Metering Station Configuration

Metering station configuration has a strong effect on system loss if it is not built and installed as per the internationally recommended standard with maintaining the entire requirements for filtering, regulating, metering and safety. At least minimum requirements should be meet. In this regard International Gas Engineers (IGE) recommendation IGE TD – 10 and American Petroleum Institute (API) recommendation should be used as a guideline. The pipe & fittings should be installed such that turbulence can be avoided or minimum.

7.1.4 Meter Sizing

Meter sizing has a strong effect on system loss. If meter sizing is not appropriate such as under or over size then it cannot measure properly. In this context turn down ratio is very important. It is the ratio of the maximum to minimum volume of gas that can be measured properly and safely with desired accuracy. Meter should be sized so that it can cater minimum flow rate and also maximum flow rate properly with out any damage.

Meter is generally sized and selected on the basis of hourly load. As per approved load Diaphragm meters are used for metering gas of domestic and commercial customers and Rotary and Turbine meters are used for industrial customers. Presently meters are selected on the basis of G size. International Organization of Legal Metrology (OIML), internationally approves G size. Flow rate in meter cube can be determined from G size by multiplying it with 1.6. For G – 1.6 to G – 10 with operating pressure 0.4 Bar, Diaphragm meters are used. For G – 25 to G – 65 Rotary type meters are used. And For G-size 100 to higher turbine meters are used to measure gas.

7.1.5 Meter Accuracy

Meter deviation from perfect measurement can be expressed in terms of % Error, % Accuracy and % Proof.

% Error is the relationship between measured and true volume, and expressed as:

$$\% \text{ Error} = 100 \times \frac{V_m - V_t}{V_t}$$

Where,

V_m = the volume measured by the meter.

V_t = the true volume, usually determined by a standard or master Meter.

$$\% \text{ Accuracy} = \% \text{ Error} + 100\%$$

$$\% \text{ Proof} = \frac{1}{\% \, Accuracy}$$

Negative values of % error represent lost volume or slow meters. Positive values of % error represent over-registration or fast meters. If % Accuracy, numbers less than 100% means slow meter. % Proof is the opposite of % Accuracy.

Meter accuracy has a strong effect on system loss. Meter accuracy higher than ± 1% might increase technical component of system loss and it is not internationally accepted. Accuracy less than 0.5% is good.

7.1.6 Meter Rangeability

This is the ratio of maximum and minimum flows over which the meter will maintain the specified accuracy or linearity. Some times it is called turn down ratio. Meter with high turn down ratio is desirable. The turn down ratio of orifice meter is very low and it is 3:1. By using a series of differential element read out device this can be rises to 9:1. So orifice meter is suitable for constant flow rate. The turndown ratio of rotary and turbine meter is very high it can be increase from 5:1 for lower pressure to 100:1 at higher pressure.

In our distribution metering system turbine and rotary meters are used as an input-metering device. Industrial customer uses rotary and turbine meter on the other hand commercial customer uses diaphragm displacement meter. Turn down ratio has a great influence on system loss The meter should be capable of measure the minimum and maximum flow with desirable accuracy. If the installed meter lower range is higher than the actual demand then the meter will register lower flow rate. On the other hand if the installed meter higher range is lower than the actual load demand then meter will damage with spin effect. So meter rangeability has a strong effect on system loss. If the meter is not choice according to the actual load then it will increase system loss.

7.1.7 Repeatability

This is the closeness of agreement between the results of successive measurement when the same measurements are carried out under the same measurement conditions.

It is important to understand that repeatability conditions are:-

- The same measurement procedure.
- The same observer.

- The same measuring instrument used under the same conditions.
- The same location.
- Repetition over a short period of time..

Meter with lower repeatability percentage says 0.1% is desirable. Repeatability has some effect on measurement uncertainity because accuracy and repeatability are closely related. Meter with higher repeatability percentage increases measurement uncertainty. This uncertainty increase system loss.

7.1.8 Error Or Suppressed Meter Reading

Meter reader may read meter reading erroneously for lack of his or her knowledge. Sometimes meter readers write meter reading less than the actual reading in collusion with the dishonest customer. This is a very important issue or factor for system loss. Error or suppressed meter reading can increase system loss. And this is an evil practice in TGTDCL.

7.1.9 Load Approval

During load approval of a customer 'Gas Sales Manuals' for TGTDCL are not followed properly. Generally the customer shows their gas uses lower than the actual demand by submitting false papers or documents. Sometimes they do this in collusion with the official related with the load approval or gas connection. So after approvals of this less amount gas, customer meet up their excess gas demand by gas pilferage through illegal handling of meter, regulator or any other equipment or an illegal by pass connection. This is a vital issue or factor for system loss.

7.1 10 Domestic Un-metered Flat Rate Tariff Base

TGTDCL introduced domestic gas metering system in FY 1985-86 and about 70% of domestic consumers existing at that time were brought under the system. But the system was practically discontinued within the next couple of years due to various technical and social reasons.

Domestic consumers eventually continued to pay their monthly gas bills on the existing flat rate tariff system revised year to year by the government. There were always two options available for domestic users in flat rate tariff system; single and double burner. The gas tariff set by government from time to time for flat rate billing system has always been based upon some estimated monthly gas consumption rate. Different studies show that this estimated gas is less than the actual uses. Due to this flat rate the customers do not close their burner after finishing their cooking. This practice increases system loss.

7.1.11 Meter Calibration And Service

If gas meters are not calibrated at regular interval in field or workshop as per the approval of the manufacture then it can create measurement error. In a meter calibration system the calibration facilities should be of primary standard. This should be very accurate, modern and less time consuming. This should be able to resist all types of interference and articulation. The calibration facilities in our existing system are very old, inaccurate and manual. In this calibration system there are chances for the calibrator to articulate the accuracy of the meter. Sometimes dishonest official in collusion with the customer shows inaccurate meter as an accurate one. So delinquent customers are not getting punishment for gas pilferage. This has a strong effect on system loss. Under third natural gas development project TGTDCL installed two computerized meter calibration bench in 2002. But at present, TGTDCL is using the old manual system though computerized modern meter calibration systems are available.

7.1.12 Non Registration Of Pressure And Temperature

In a TGTDCL customers RMSs pressure gauges are used to read the metering pressure and there are no temperature reading devices. With this pressure gauge it is not possible to record or store pressure permanently. So in TGTDCL system there are no facilities for registration of metering pressure and temperature. The customer always uses gas at a higher pressure than the contractual pressure. So there are chances of gas pilferage for the customer. This is a vital issue for system loss.

7.1.13 Gas Theft Or Pilferage

Gas theft or pilferage is the highest component of system loss. There are a number of indigenous ways that are applied to theft gas by the dishonest customers. The ways or methods used by the customer for gas pilferage can be written as:–

a) Direct handling the meter index or meter.

   (i) Slowing the meter index by unauthorized handling.
   (ii) Changing the gear train thus permanently slows the meter.
   (iii) Lowering the meter reading by reverse rotation.
   (iv) Changing the meter index.
   (v) Interference the meter index with any other ways.
   (vi) Changes the meter installation direction.

b) Tampering the regulator or pressure gauge or both of them to use gas at higher pressure.

c) To create an obstacle in recording the gas use by interference the RMS pipefittings etc.

d) Meter readers record lower meter reading than the actual uses in collusion with the customers without handling the meter or meter index.

e) Unauthorized by pass usage.

7.1.14 Leakage

Loss through leakage from the distribution piping system can increase system loss. Pipeline that has installed a long time ago have chance of leakage. If the cathodic protection systems are not checked at a regular interval then the chance of leakage enhance. This is also a strong component of system loss.

7.1.15 Venting Through Relief Valve

Sometimes gases are vented through the relief valve when the gas pressure increase and cross the set limit. This situation arises in the CGS, TBS, DRS and customer RMS at the lean hour. During the time of Edul Fitor and Edul Azha or any other festival day, friday and every day after 1:00 AM to 5.00 AM gas demand decreases. In this period there may have chance of gas losses through venting.

7.1.16 Conversion Process

In gas calculation process sometimes there need to convert the unit from metric system to British system. So, if proper conversion factors are not use then there may have chance to increase system loss.

7.1.17 Accounting Procedures

There may have chance of increase system loss if proper accounting procedures are not use in calculating gas uses, bill preparation and payment.

7.1.18 Billing Cycle Effect

Billing cycle is the time period between subsequent bills . Duration of this billing cycle is one month. The time frame of this billing cycle starts from 21^{st} day of a month to the 22nd day of the next month. At present in TGTDCL system there is no SCADA or tele-metering system for collection of meter reading for system input and customer billing. Meter readings are collected manually. So there may have chances of intentional error or unable to collect meter readings with in this time frame due to shortage of manpower. Because a huge number of customers readings are not possible to collect at a time with the existing manual meter reading collection system. As a result meter readings are collected at different time or days. So some of the reading are more than one month duration others become less than one month. This inconsistent meter reading collection increases system loss.

7.1.19 Pilot Loss

Sometimes gases are losses through the vent line of the regulator pilot or any other instruments.

7.1.20 Pulsation Effect

Pulsation created by flow control valves, regulators and some piping configuration may cause significant error in gas flow measurement. Pulsation towards the direction of flow increases flow where as pulsation to the opposite of the direction of flow decreases the flow. The effects of Pulsation in a transmission system are described in chapter – 6 of this study. The effect of pulsation in a distribution system are the same as transmission systems.

7.1.21 Third Party Damage

Sometimes third party damages meters of CGS, TBS, DRS or CMS. Third party damage is a great hardel for system loss calculation because true gas input is not possible to calculate during this time. Third party is a non identify person. So third party damage is a strong factor for system loss.

7.1.22 Un-Metered Usage

Sometimes customers use un-metered gas due to actual or intentional damage of flow meter. The domestic uses are also un-metered in our country. Sometimes meter of the CGS, TBS, DRS are also damage or under sized then the input gas can not be measured or accounted. So un-metered usage is a strong factor for system loss for a distribution system.

7.1.23 Regulating And Metering Station Performance

Performances of the Customers Metering Station (CMS) also have a strong effect on measurement and operation. If the regulators of the CMS are in faulty operational conditions then the customer can use more gas. At the time of regulator re-setting there may have chance to take gas at higher pressure by the dishonest customer in collusion with the officials of TGTDCL.

7.1.24 Absence Of Regional Wise Accountability

The input stream of TGTDCL are not isolated region or area wise as described in table – 9.b. So, it is not possible to calculate the area wise input of the metro Dhaka sales office and regional sales office. So there are chances to gas pilfer.

All the factors those are discussed above have a strong effect to increase system loss.

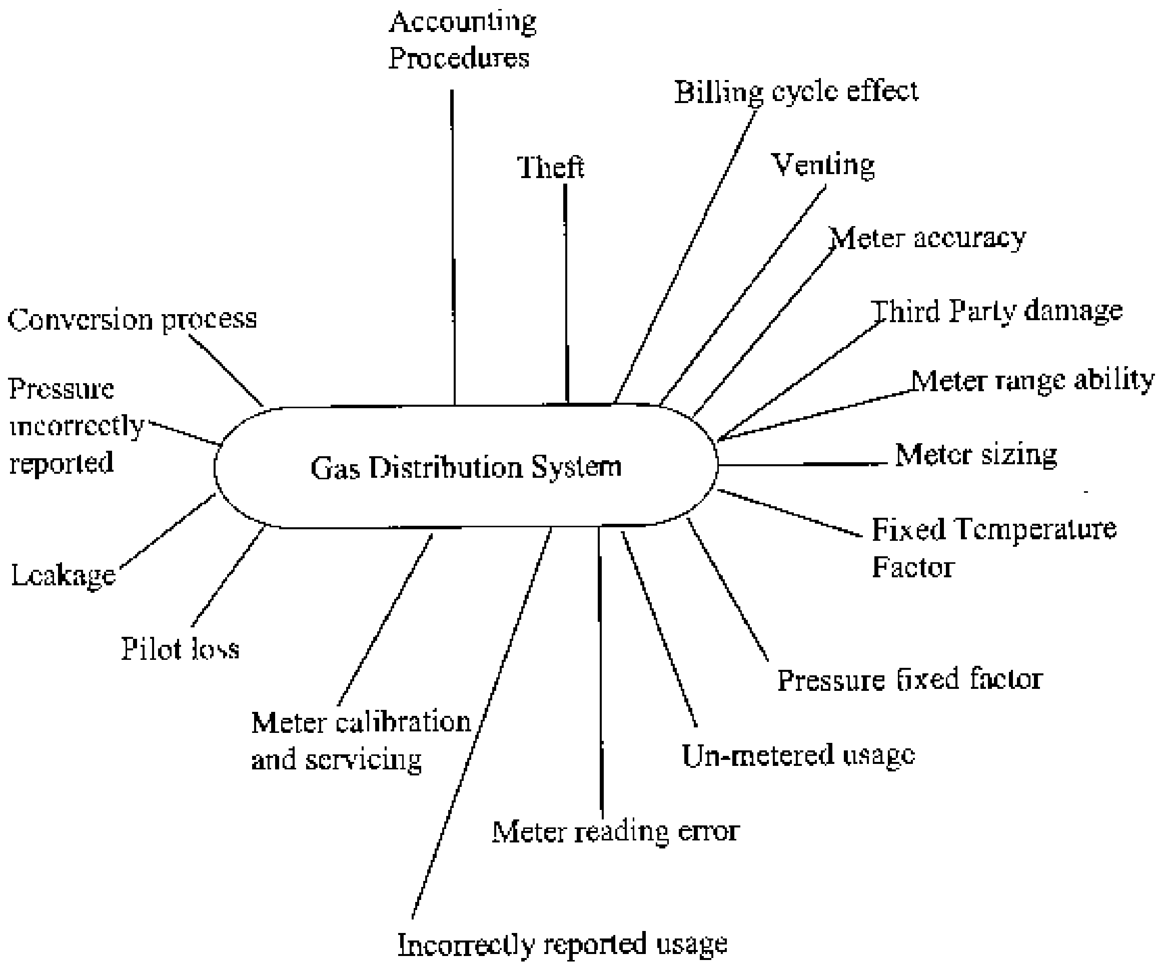


Figure 7.1: Contributing factors – System loss for a Distribution System

CHAPTER – 8

SYSTEM LOSS, MEASUREMENT UNCERTAINTY, CALIBRATION AND TRACEABILITY

In the design, calibration and operation of a gas metering station there are a number of very important criteria, which must be considered to keep the system readings to a meaningful stage. Minimal uncertainty of reading associated with the derived results is also desirable. Measurement uncertainty, methodology, and traceability of calibrations and reference standards are also very important to study system loss. The following terms are quoted from 'Gas Flow Measurement, Quality and Control' by GASCOR Consulting International, Australia (Reference – 9).

8.1 Measurement Uncertainty

In 1978, the lack of international consensus on the expression of uncertainty in measurement, the world highest authority in metrology; the Committee International des Poids et Measures (CIPM), request the Bureau International des Poids et Measure (BIPM) to address the problem in conjunction with the national standards laboratories and recommendation. From the resulting work, the following definitions were adopted (Reference – 9):-

8.1.1 Measurement Uncertainty Definition

Measurement Uncertainty is defined as a parameter, associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand. The measurand is the quantity to be measured. Measurement Uncertainty encountered within a gas measurement process can be summarized as follows:-

- From the above definition, it can be stated that the uncertainty is an estimate characterizing the range of values within which the true value of the measurand lies.

- Any uncertainty value quoted should give a statement as to the probability of the true value lying within that range.

- Uncertainty is made up of two types of error, namely
  - Random error, and
  - Systematic error.

  A random error is the result of a measurement minus the mean that would result from an infinite number of measurements of the same measurand carried out under repeatability conditions. It has to be appreciated that because only a finite number of measurements are normally made, the value of the random error determined must be taken as an estimate.

  A systematic error means that would result from an infinite number of measurements of the same measurand carried out under repeatability conditions minus a true value of the measurand. The systematic error can be regarded as the bias of a calibration. The variations in measurement uncertainty are shown in Figure 8.1 and 8.2.

- Errors from pressure, temperature, gas density, determination of composition, installation conditions etc. can also affect the overall uncertainty.

- Manufacturer data on a particular transducer cannot be directly related to the field result. This is because installation conditions have not been accounted for.

In the definition given previously for random and systematic error, repeatability conditions are referenced. There tends to be some confusion in flow measurement and in particular with respect to flow meters, with respect to the understanding and application of the term repeatability. In many cases it should be referred to be reproducibility. The following definitions will help explain this statement.

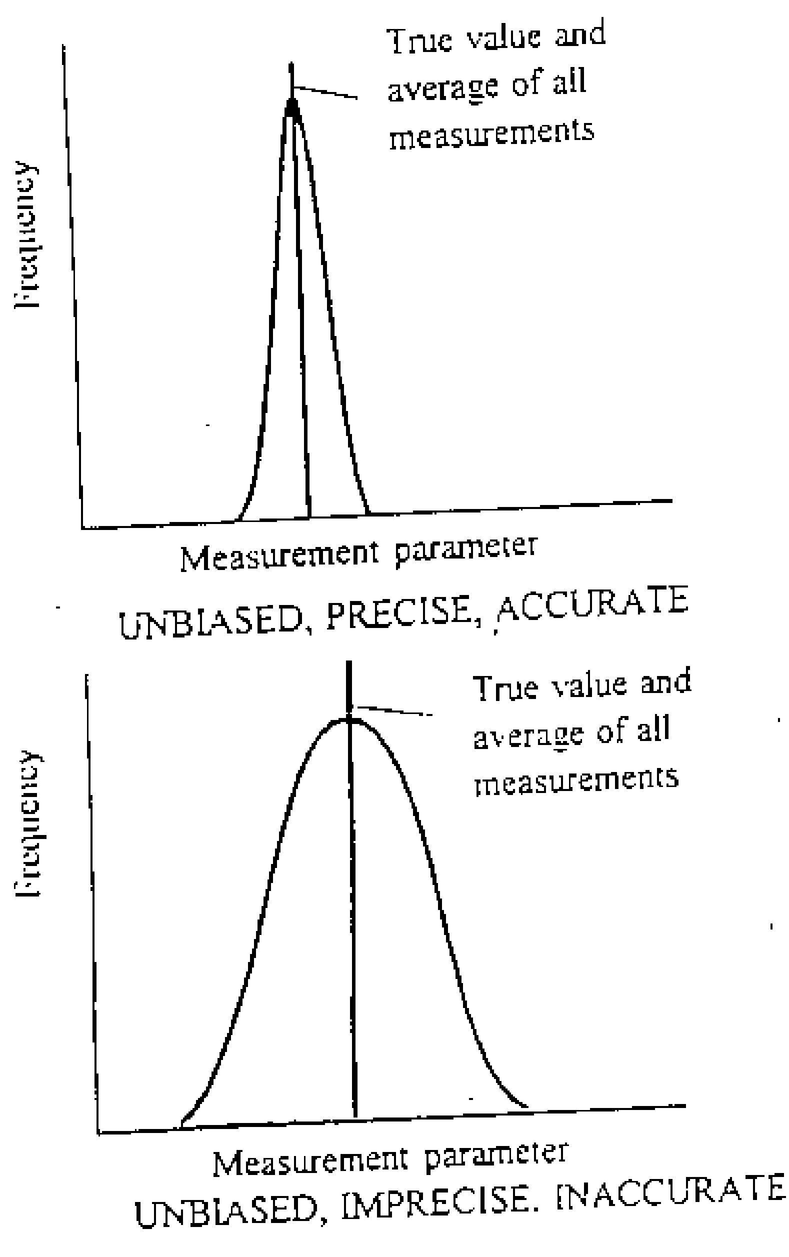


Figure 8.1: Variations in Measurement Uncertainty (Courtesy GASCOR Consulting International, Australia)

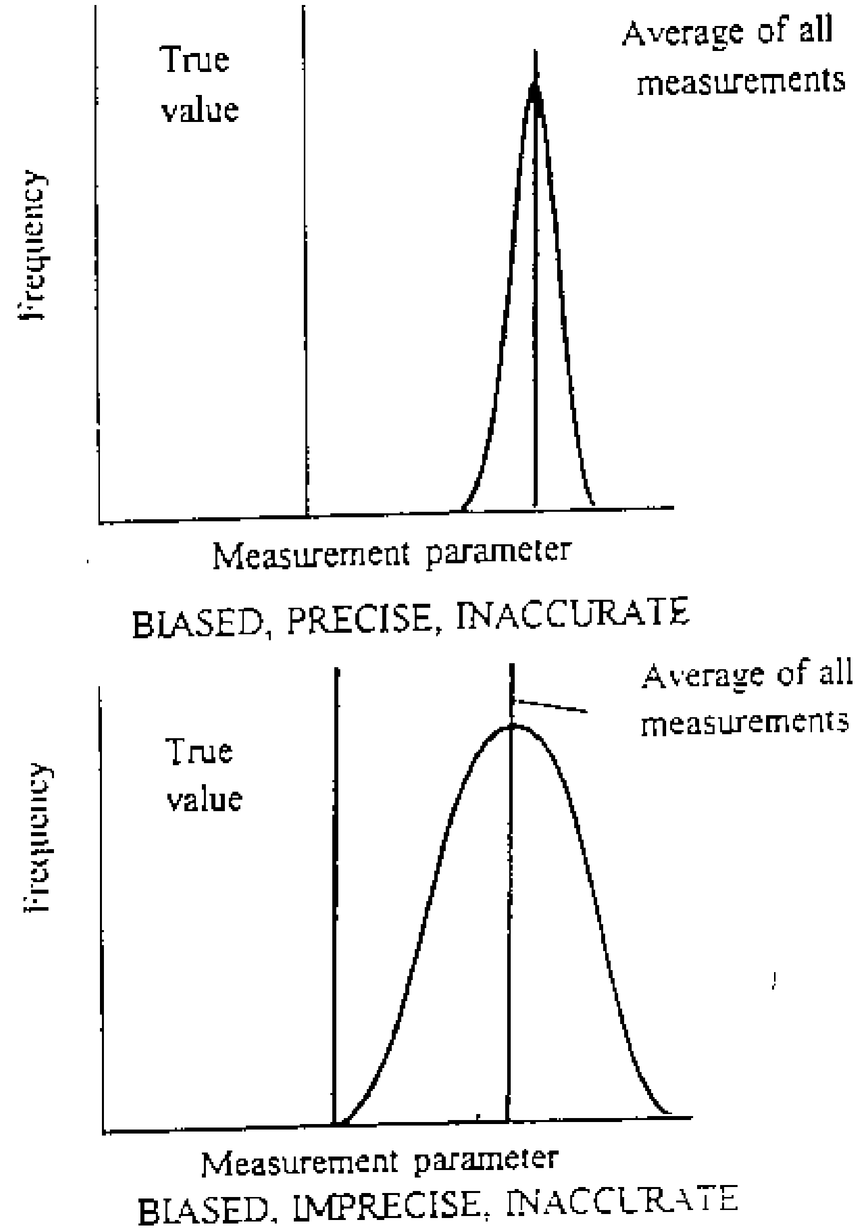


Figure 8.2: Variations in Measurement Uncertainty (Courtesy GASCOR Consulting International, Australia)

8.1.2 Repeatability

This is closeness of agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement.

It is important to understand that repeatability conditions are:-

- The same measurement procedure.
- The same observer.
- The same measuring instrument used under the same conditions.
- The same location.
- Repetition over a short period of time.

8.1.3 Reproducibility

Reproducibility is the closeness of the agreement between the results of measurements of the same measurand carried out under changed conditions of measurement.

The changed conditions of measurement may include:-

- Principle of measurement.
- Method of measurement.
- Observer.
- Measuring instrument.
- Reference standard.
- Location.
- Condition of use and
- Time.

The error of measurement is the result of a measurement minus a true value of the measurand. The random error is equal to error minus systematic error. The systematic error is equal to error minus random error.

As can be seen there are clear differences between repeatability and reproducibility. As an example of application; a meter manufacturer will supply a calibration certificate with a meter. This certificate will usually state a repeatability value for the given calibration. The end user of the meter then perform a calibration on that meter, there will be reasonable chance that we will not get a value within that the manufacturer has started. This because the calibration conditions are at a different location, different time, different operator and most likely a different principle of measurement will apply. There could also be number of other variations in actual fact that have to perform a calibration under reproducibility results.

8.1.4 Measurement Calibration

Calibration is defined as the comparison of a measuring instrument, with specified tolerances but an undetermined accuracy, to a measurement standard of known accuracy for the purpose of determining and/or eliminating by adjustment any out of tolerance conditions.

The use of an un-calibrated instrument creates the potential error in measurement and resultant erroneous conclusions and decisions. It is calibration that provides confidence in measurement and assurance that an instrument has the accuracy required maintaining and producing or processing within specifications.

For calibration to be meaningful there must be some prior understanding of the variables, which need to be measured, and the uncertainty of measurement, which has to be maintained. Of course it is of little use making a statement of the calibration conditions required if the device being calibrated cannot hold the required level of measurement uncertainty due to poor resolution, zero drift or range.

The standard or reference device used in any calibration must have a lower measurement uncertainty than the device being calibrated. The most common method for estimating overall system measurement uncertainty is to calculate the root mean square average using the uncertainty values for each identified parameter in the total measurement

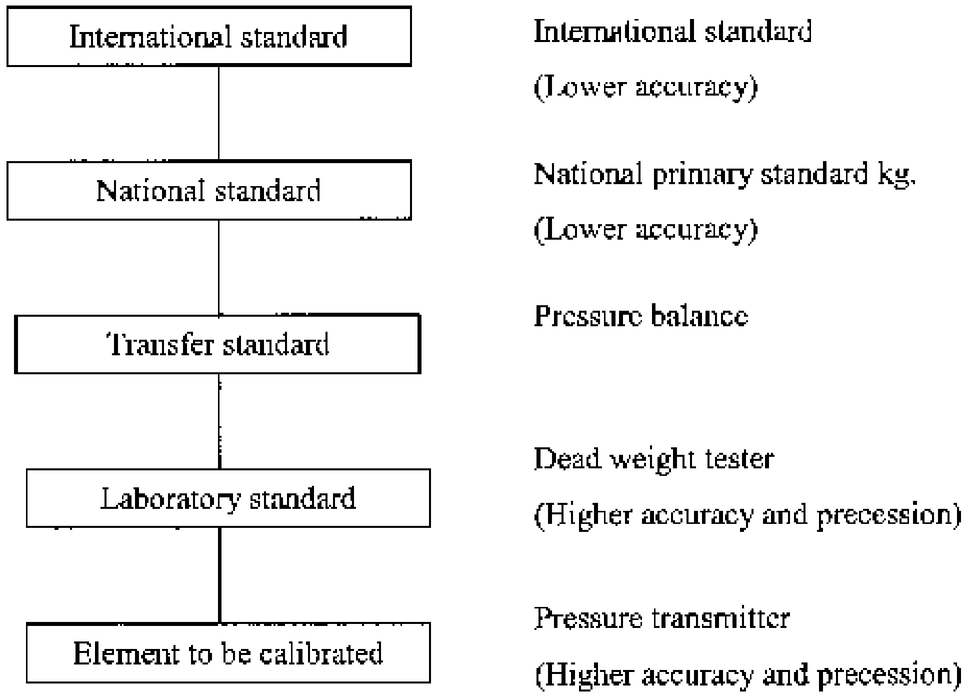


Figure 8.3: Example of a simple calibration chain.

system. For example let a measurement value, say W, be made up of three contributing variables X, Y and Z. Let the uncertainty of measurement for each of the variables be ± Δx, ± Δy and ± Δz. Then the uncertainty in Δw will be

$$\pm \Delta w = \left[(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2\right]^{0.5}$$

If we assign values to Δx, Δy, and Δz of say 0.5%, 0.1% and 0.2% the following result will apply to ΔW

$$\pm \Delta w = \left[(0.4)^2 + (0.1)^2 + (0.2)^2\right]^{0.5}$$

$$= (0.21)^{0.5}$$

$$= \pm\, 0.458\%$$

For orifice meter using three pen chart recorder

$$\pm \text{Accuracy} = \left[(1.00)^2 + (0.5)^2 + (1.00)^2 + (0.80)^2\right]^{0.5}$$

$$\pm \text{Accuracy} = \pm 1.7\%$$

8.1.5 Measurement Traceability

From the Figure 8.3. It can be seen that

I) For a transducer performance statement to have any real meaning, the calibration must be referred back to a standard.

II) Standards applied are usually National or International Standards

III) The traceability describes how the transducer/meter calibration can be related to the given standard.

IV) Each separate calibration or reference system in the calibration chain adds more uncertainty.

Generally, a testing laboratory will test to a reference standard, or transfer standard, that has a level of uncertainty of about 3 to 10 times less than that of the required uncertainty of the transducer being tested. Therefore, if we were calibrate a pressure transmitter to an excepted level of uncertainty of ± 0.3% then the dead weight tester would be expected to have an uncertainty of reading of about ± 0.05%.

The calibration chain for gas flow meters, including developments in reference standards, has undergone considerable development over the past few years. The levels of uncertainty of calibration at each stage of the calibration chain used by the Netherlands Measurement Institute are shown in Figure – 8.4. This is a more traditional calibration facility with the transfer metering system referenced to a bell prover. More recently commissioned flow calibration facilities are utilizing critical flow nozzles and gyroscopic weighing tanks. Other alternatives are the application of portable volume provers.

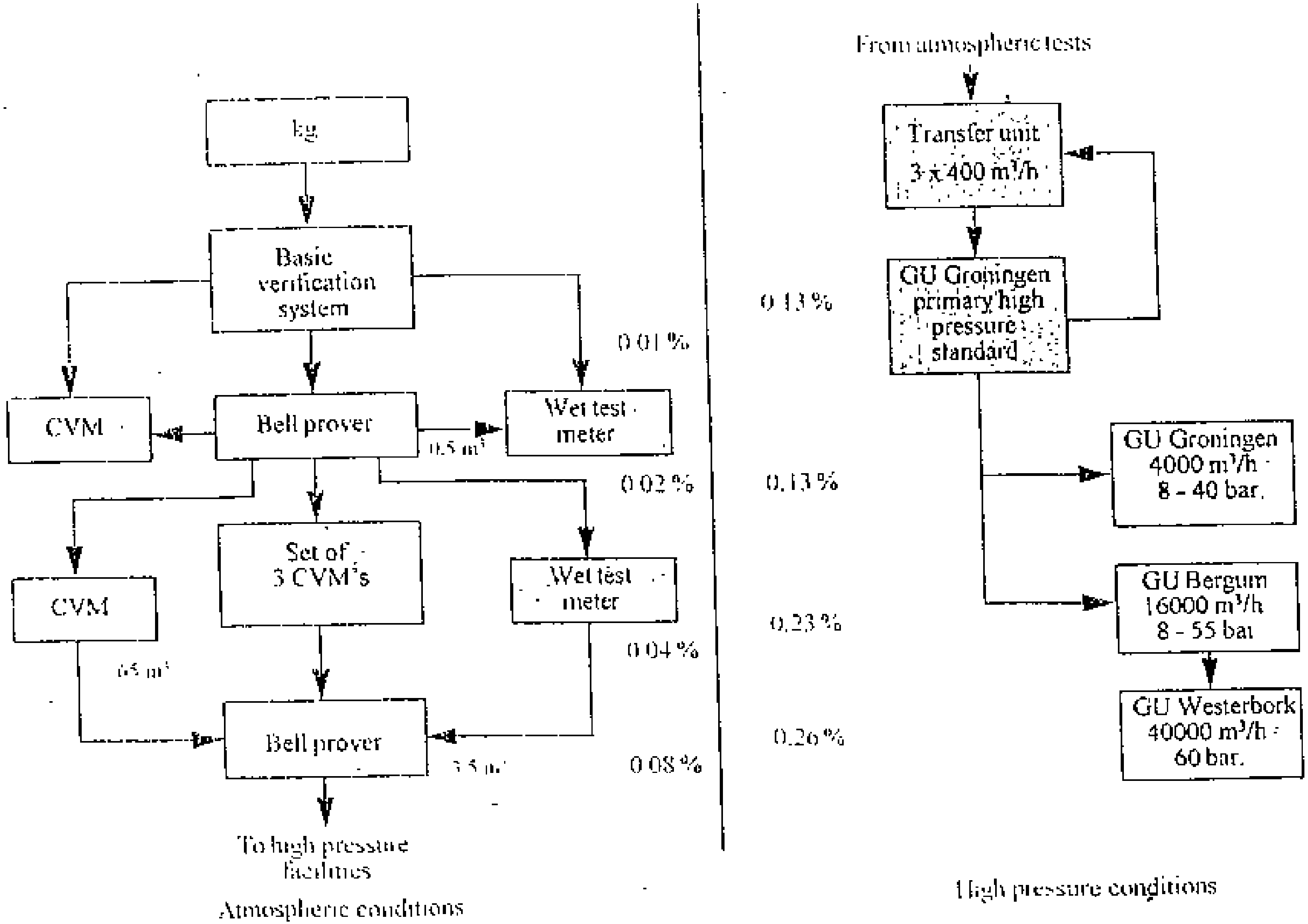


Figure 8.4: Trace ability Chain of the Gas Flow Standards in the Netherlands (Courtesy GASCOR Consulting International, Australia)

8.2 Case Study – I (System Loss)

The system loss is that portion of the gas purchased that is not accounted for by sales, transfer, and company own use or otherwise accounted for. System loss can be determine by two process

(I) From the operational figures

(II) From the sales figures

Finally a comparison can be made from these two figures.

8.2.1 System Loss Calculation Procedure

The Gas purchased by the company and sold to different sectors has been examined for the year 2002-03 for the purpose of this project. The net throughput of gas, which is equal to gross purchase minus company's own use for system operation in the company's transmission system for the twelve- (12) months of FY 2002-03, have been recorded. The sales to power and fertilizer sectors were deducted from the month wise net throughput amounts and the remainder obtained by this Netting Off Method (NOM) was considered one basis for the total input to the non-bulk sector comprising industrial, commercial and domestic customers. A Source Summation Method (SSM) adding together all flow through different CGS, TBS and DRS also calculated the input to the non-bulk sector. The sum of all sources under the SSM is found to tally with the figures derived from the NOM (Appendix – A). The overall annual difference between the two methods is found to be well within 2% of NOM figures.

8 2.2 Results

From Appendix – A

Gross system loss is 8.28% of net throughput and it is 24.08% of non-hulk input.
Estimated technical loss is 1.25%.

Deducting the inconsistent domestic tariff base and technical loss the net system loss become 6.69% of net throughput. And it is 19.47% of non-bulk input.

8.2.3 Discussion

1) Line packs and change of line packs are not included in the system loss calculation procedure.

2) Uncertainty of measuring instruments and meters are not included in the system loss calculation procedure.

3) Purges, leakage and vented gas are also not properly measured and included in the system loss calculation procedure.

4) Own uses of TGTDCL are not recorded properly due to absence of measuring instruments in some location.

System loss calculation is very important for the company to avoid loss of revenue and smooth operation of the system. Presently system loss is calculated on monthly and yearly basis. But to reduce system loss close monitoring is needed to collect all the meter reading and related data. And system loss can be calculated on daily basis or at least on weekly basis. Speed in data collection process is also necessary

8.3 Case Study – II (Measurement Uncertainty)

Measurement Uncertainty analysis is a numerical, objective; methods defining the potential error existing in all data. Knowledge of uncertainty in any measurement is crucial to understanding either the state or its performance.

In measurement Uncertainty analysis, errors are considered to be precision errors and bias errors. Precision or random error is that component of a measurement that is unknown, but with repeated measurements, it will change in a random fashion. Systematic errors or bias are constant in the sense that this affects every measurement.

As any measurement has some uncertainty associated with it, this level of uncertainty must be accounted for and fully appreciated if a meaningful study is to be made for the transmission and distribution system UFG value. The volumetric measurement of Natural Gas (NG) is complex due to the dependence on the accurate measurement of pressure, temperature and composition. With each measurement and calculation process required there will be associated random and systematic errors.

8.3.1 Application Of A Simplified Transmission System

To illustrate the random and systematic error, let us consider the simplified transmission system as shown in Figure – 8.5.

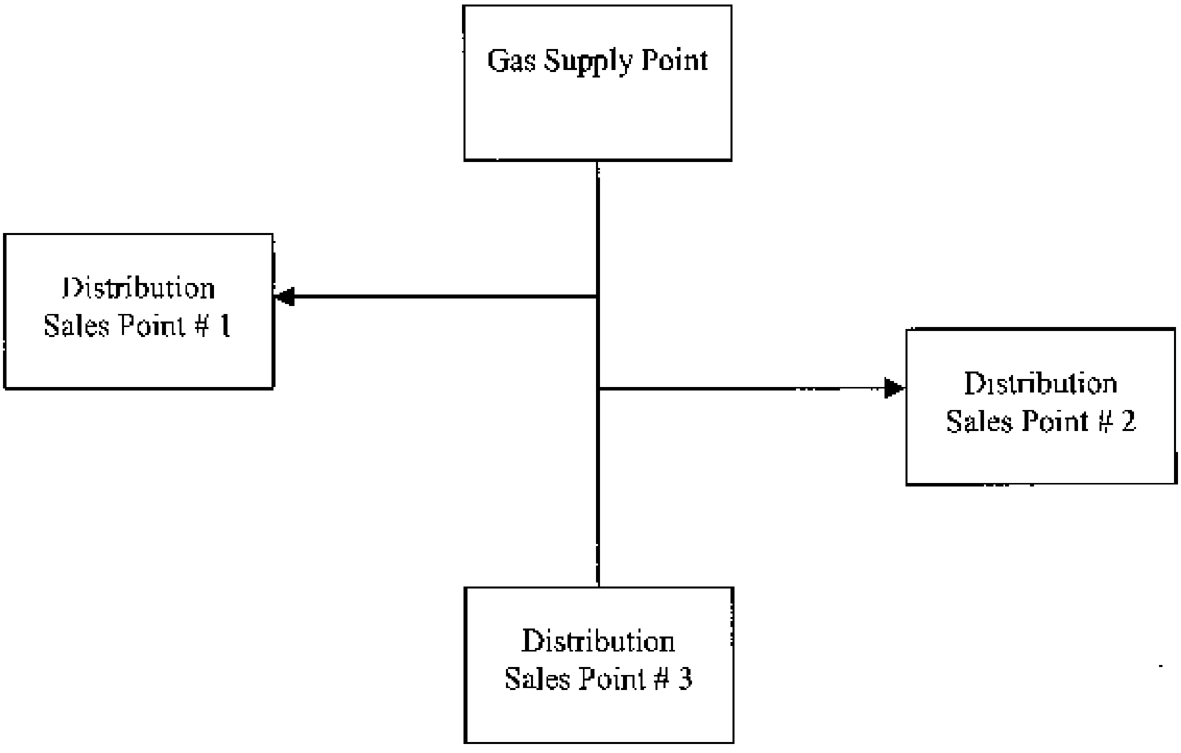


Figure 8.5: Simplified transmission system

With reference to Figure – 8.5, it will be noted that the given model has one single source of gas supply and three independent outlet points, which could be the supply to a distribution network. For simplicity, all four metering points are fitted with the same type of flow metering device; in this case orifice plates. It is assumed that all points also have compensation for flowing temperature and actual gas composition as well as differential pressure and static pressure measurement instruments with all calibrations having full traceability to a standard. Therefore, the measurement process has high accuracy.

The uncertainty of measurement associated with an orifice plate system is well documented and proven. with publications such as the International Standards Organization ISO 5168 "Measurement of fluid flow estimation of uncertainty of a flow rate measurement", giving very comprehensive details on how to compute the necessary uncertainty of measurement (Reference – 10).

It can be shown that the uncertainty of measurement associated with a correctly sized single orifice plate installed in accordance with international standards such as AGA – 3 or ISO 5167 would be the order of ± 0.8%. By placing a number of orifice plates in series operation, this uncertainty value can be reduced due to the influence of common uncertainties on each orifice plate.

For the transmission system shown in Figure – 8.5, let the gas supply point (Gas Field) has a metering facilities with three orifice plates operating in parallel. The uncertainty of volume flow measurement for the station is taken as ± 0.55%. For distribution sales points numbers 1 and 2, let the metering be a single orifice plate with associated uncertainty of volume measurement being ± 0.82%. Finally for the distribution sales point 3, let there be dual parallel orifice plates in service resulting in a measurement uncertainty of ± 0.63%.

From the above information, the system measurement uncertainty can be calculated and applied to the unaccounted for gas of a distribution system.

Assume the following nominal flow rates per day:

I) Inlet supply point – 100.000 SM^3/day

II) Distribution sales point # 1 – 20,000 SM^3/day

III) Distribution sales point # 2 – 25,000 SM^3/day

IV) Distribution sales point # 3 – 55,000 SM^3/day

The uncertainty of the inlet gas supply point is

$$= \left[(e_{qin})^2 \times \left(\frac{q_{in}}{\sum q_{in}} \right)^2 \right]^{0.5}$$

Where,

e_{qin} = Inlet measurement uncertainty

q_{in} = Flow at measurement point

$\sum q_{in}$ = Summation of all outlet flow.

Therefore, uncertainty of the gas supply point is

$$= \left[(0.55)^2 \times \left(\frac{100{,}000}{100{,}000} \right)^2 \right]^{0.5}$$

$= \pm\, 0.55\%$

Uncertainty for the distribution sales system will be

$$= \left[(0.82)^2 \times \left(\frac{20{,}000}{100{,}000} \right)^2 + (0.82)^2 \times \left(\frac{25{,}000}{100{,}000} \right)^2 + (0.63)^2 + \left(\frac{55{,}000}{100{,}000} \right)^2 \right]^{0.5}$$

$= [0.0269 + 0.0420 + 0.1201]^{0.5} = \pm\, 0.44\%$

System uncertainty for unaccounted gas will be

$$= \left[(e_{qin})^2 + (e_{qout})^2 \right]^{0.5}$$

$$= \left[0.55^2 + (0.44)^2\right]^{0.5}$$

$$= \pm 0.70\%$$

At present, measurement uncertainty is not accounted for in the system loss calculation process of TGTDCL. But for any measurement system there must have some uncertainty associated with it. So this should be included in the system loss calculation process.

CHAPTER – 9

GAS METERING

To study the system loss of TGTDCL it is very important to know the existing metering system of the company. Both administrative and technical activities are the view of this study. Identification of short- comings of the existing metering system is also important to diagnosis the problem. Appropriate measures can be undertaken from this diagnosis. The meter used by customers and the activity of the various department related to gas metering is also discussed in this respect.

9.1 Existing Metering System

Metering and Regulating Department and Transmission Department are related to meter selection, installation, calibration, maintenance, seal and new meter procurement. These two department works under operation division. The head of this division is Operation Director. The two department heads are designated as Deputy General Manager. Each department subdivided to section and each section is subdivided to sectors. These are shown in organogram (Figure – 9.1).

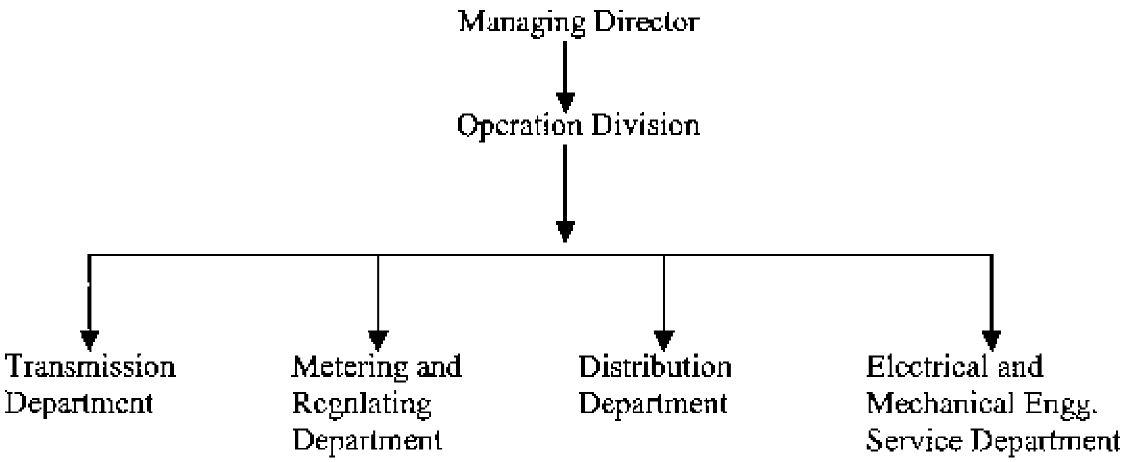


Figure – 9.1: Organogram of operation Division of TGTDCL

9.1.1 Activity Of Transmission Department

Transmission department works under operation division. This department purchases gas from various gas field and gas transmission company to sale it to bulk customer through Bulk customer RMS, and supplies the rest to distribution system through various CGS, TBS, DRS and RMS. This department is liable for operation and maintenance of various transmission lines, valve stations, bulk customer RMS, CGS, TBS, DRS and RMS. List of bulk RMS, CGS TBS, DRS and RMS are shown in Tables – 9.1, 9.2, 9.3 and 9.4 Since this department purchases gas from various gas fields and gas transmission company so they also monitor daily pressure, gas flow and maintain a log sheet regarding pressure and flow for daily system balance. Operation and maintenance of various type of RMS and procurement of the spare parts, equipment, meters and materials for the transmission system are also the activity of transmission department. Collection of condensate from various stations and transfer the same to Padma Oil Company through carrying contractor is also the activity of transmission department.

9.1.2 Administrative Reform Of Transmission Department

Transmission department works under operation division. The head of the operation division is designated as operation director. And head of the transmission department designated as deputy general manager. This department is subdivided into five sections. The head of each section designated as manager. Each section also subdivided into sectors. And head of each sectors designated as sector In-charge. The Organogram chart of transmission department (Figure – 9.2) is attached in this respect.

Table – 9.1: Gas Purchase Point

Sl. No.	Description	Meter Used
A.	BGFCL (Bangladesh Gas Field Company Ltd.)	
A.1	Habiganj Gas Field, Habiganj	Orifice Meter
A.2	Titas Gas Field, Loc – 1, B. Baria	Orifice Meter
A.3	Titas Gas Field, Loc – 3, B. Baria	Orifice Meter
A.4	Narsingdi Gas Field, Narsingdi	Orifice Meter
B.	GTCL (Gas Transmission Company Ltd.)	
B.1	Ashuganj Gas Gathering Station a) To VS – 3 to APS RMS b) To B. Basin region of greater Mymensingh area	 Orifice Meter Orifice Meter
B.2	GTCL Metering Station at BKB Gas Field, Bakhrabad	Orifice Meter

Table – 9.2: Transmission Sales Point To Power Development Board (PDB), IPP & Captive Power Producer

Sl. No. A	Description PDB	Meter used
A.1.	Ashuganj Power Station (APS) Unit no. 1 & 2, Ashuganj, B. – Baria	Turbine Meter, G – 1000
A.2	Ashuganj Power Station (APS) Unit no. 3, 4, 5, Ashuganj, B. – Baria	Turbine Meter, G – 4000
A.3.	Ashuganj Power Station (APS) Unit no. Acc [(90 + 60) MW] Ashuganj, B. – Baria	Turbine Meter, G – 1000
A.4.	Ghorasal Power Station (GPS) Unit no. 1 & 2, Ghorasal, Narsingdi	Turbine Meter, G – 1600
A.5.	Ghorasal Power Station (GPS) Unit no. 3, Ghorasal, Narsingdi	Turbine Meter, G – 2500
A.6.	Ghorasal Power Station (GPS) Unit no. 4, Ghorasal, Narsingdi	Turbine Meter, G – 2500
A.7.	Ghorasal Power Station (GPS) Unit no. 5, Ghorasal, Narsingdi	Turbine Meter, G – 2500
A.8.	Ghorasal Power Station (GPS) Unit no. 6, Ghorasal, Narsingdi	Turbine Meter, G – 2500
A.9.	Haripur Power Station (HPS), Haripur, Naryanganj	Turbine Meter, G – 2500
A.10.	Shiddirganj Power Station (SPS), Shiddirganj, Naryanganj	Turbine Meter, G – 1600

Contd.

Contd. (Table – 9.2)

	Description	Meter used
B	IPP	
B.1	RPCL Power Station, Mymensingh	Two Turbine Meter, G–1000
B.2	NEPC Power Station, Haripur, Narayanganj	Orifice Meter
B.3	AES 360 MW Power Station, Haripur, Narayanganj	Orifice Meter
B.4	AES 450 MW Power Station, Meghnaghat, Narayanganj	Orifice Meter
C.	CAPTIVE POWER	
C.1	Meghna Energy 10 MW, Power Plant	Turbine Meter, G – 400
C.2	Madhobdi REB 10 MW Power Plant	Two Turbine Meter, G–650
C.3	Ashulia REB 10 MW Power Plant	Two Turbine Meter, G–650
C.4	Rahim Steel 20 MW, Power Station	Two Turbine Meter, G–1000

Table – 9.3: Transmission Sales Point to Fertilizer Factory

Sl. No.	Description	Meter Used
1.	Zia Fertilizer Factory Ltd. (ZFCL), Ashuganj, B. Baria	Turbine Meter, G-650
2.	Urea Fertilizer Factory Limited (UFFL), Palash, Narsingdi	Turbine Meter, G-1600
3	Palash Urea Fertilizer Factory Ltd. (PUFFL), Palash, Narsingdi	Turbine Meter, G-650
4.	Jamuna Fertilizer Factory Ltd. (JFCL), Tarakandi, Jamalpur	Turbine Meter, G-2500

Table – 9.4: Off Transmission Custody Transfer Point

Sl. No.	Descriptions	Meter used for Gas Metering
01	B. Baria TBS cum DRS	Turbine Meter
02	Ashuganj TBS cum DRS at VS-3	Turbine Meter
03	1. APS Domestic 2. ZFCL Domestic 3. Ashuganj Local (from APS)	Turbine Meter Turbine Meter Turbine Meter
04	B. Bazar TBS cum DRS	Turbine Meter
05	Narsingdi DRS	Turbine Meter
06	Madhobdi TBS cum DRS	Turbine Meter
07	Madhobdi DRS R.M Steel Metering run	Turbine Meter
08	Ghorasal TBS cum DRS at GPS RMS	Turbine Meter
09	UFFL Domestic	Turbine Meter
10	c) Tarabo TBS cum DRS Local d) Tarabo TBS Lakhon Khola Line e) Tarabo TBS Kanchon Line	Turbine Meter Turbine Meter Turbine Meter
11	Haripur TBS cum DRS to Rahim Steel	Turbine Meter
12	Haripur Power Station Domestic	Rotary Meter
13	i. Shiddirganj TBS – 1 ii. Shiddirganj TBS – 2	Turbine Meter Orifice Meter
14	Shiddirganj Domestic (Power Station)	Rotary Meter

Contd.

Contd. (Table 9.4)

Sl. No.	Descriptions	Meter used for Gas Metering
15	Demra Run – 1 (Tejgaon) Demra Run – 2 (Postogala) Demra Run Dhania	Turbine Meter Turbine Meter Turbine Meter
16	Joydevpur CGS Complex a) Joydevpur DRS (Local supply) b) Joydevpur Tangail Line c) Joydevpur Tongi Line	 Turbine Meter Turbine Meter Turbine Meter
17	Dhanua TBS cum DRS	Turbine Meter
18	Bhaluka M&R Station	Turbine Meter
19	Trisal M&R Station	Turbine Meter
20	Mymensingh M&R Station	Turbine Meter
21	Netrokona M&R Station	Turbine Meter
22	Kishoregonj M&R Station	Turbine Meter
23	Elenga M&R Station	Turbine Meter
24	Jamalpur M&R Station	Turbine Meter
25	Sherpur M&R Station	Turbine Meter
26	Tarakandi Jamuna Fertilizer Factory Domestic	Rotary Meter
27	Ghatail M&R Station	Turbine Meter
28	Gafforgaon M&R Station	Rotary Meter
29	Elenga TBS to Parchim Anchal Gas Co.	Turbine Meter

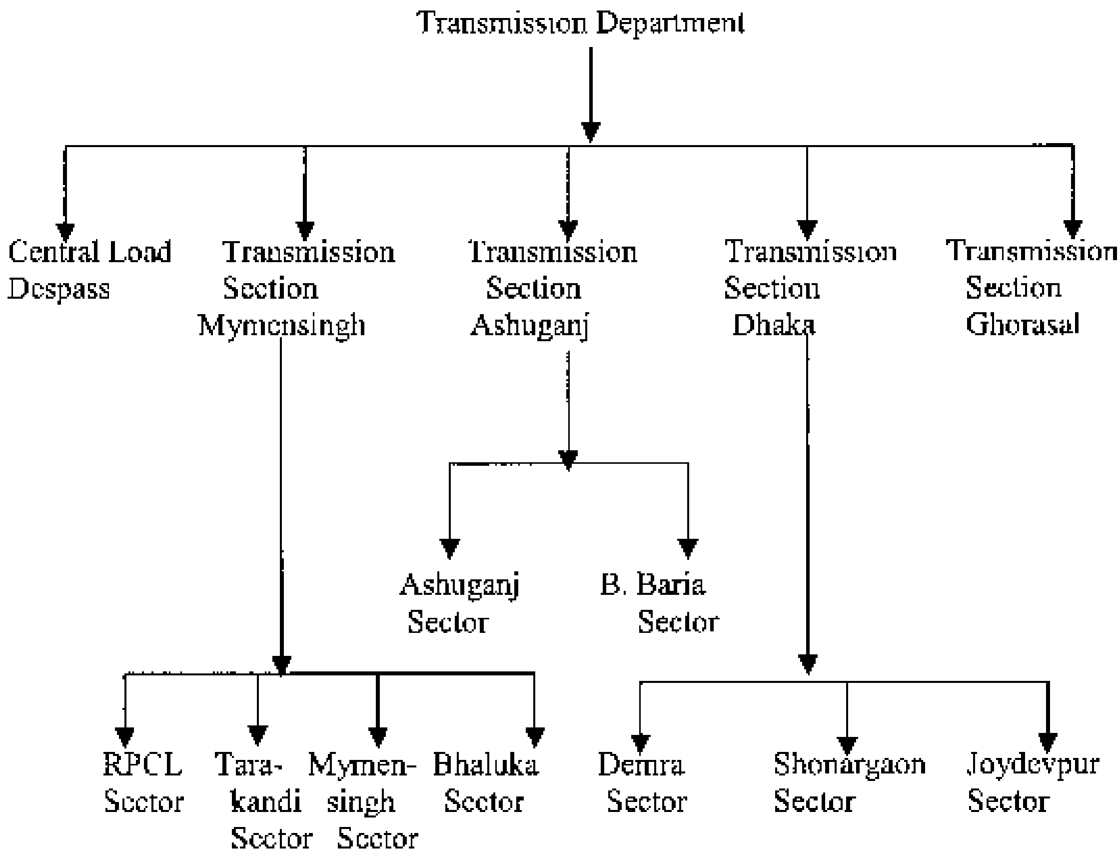


Figure – 9.2: Organogram Chart of Transmission Department

9.1 3 Meter Used In Transmission Department

In TGTDCL transmission system at present orifice and turbine meters are used for gas measurement. The purchase point and counter check meters are orifice meter with three-pen recorder as a secondary device for gas calculation. Now a days flow computers are installed for cross checking. For bulk customers like power and fertilizer, captive power producer, CGS, TBS, and TBS cum DRS turbine meters are used for gas metering. For IPP customers orifice meters are used as a billing meter with three pen chart recording and bills are produced manual calculation. Also flow computer, are used for cross checking A table regarding meters used in transmission department is attached there with (Table – 9.3).

Table – 9.3: Meter used in Transmission Department for purchasing and saling gas

Sl. No.	Locations	Meter Type	Remarks
01.	Purchase point of Gas Field	Orifice Meter with mechanical chart recorder	Manual gas calculation method is adopted also computerized facilities in some locations
02.	Counter metering Stations of purchase point	Orifice Meter with mechanical chart recorder	Manual gas calculation method is adopted also computerized facilities in some locations
03	Custody transfer Point of gas Transmission Company Ltd. (GTCL)	Orifice and turbine type gas meter with flow computer	Computerized gas calculation method. Manual check can also be provided
04.	Bulk customer RMS like power and fertilize Regulating and Metering Station	Turbine Type Gas Meter with Flow Computer	Computerized gas calculation also manual check also can be provided
05.	Individual Power Producer	Orifice Meter	Manual gas calculation method is adopted. Computerized facilities also available
06.	Small Scale Power Producer	Turbine Type Gas Meter	Manual Gas calculation method is adopted.
07.	City Gate Stations	Turbine Type Gas Meter	Manual gas calculation method is adopted computerized also available
08.	Town Border Stations (TBS)	Turbine Type Gas Meter	Manual gas calculation method is adopted
09.	TBS cum DRS	Turbine Type Gas Meter	Manual gas calculation method is adopted
10.	Metering and Regulating Stations	Turbine Type Gas Meter	Manual gas calculation method is adopted

9.1.4 Activity Of Metering And Regulating Department

Metering and Regulating Department works under Operation Division. This department supplies gas to domestic, commercial and industrial customers through DRS and CMS from the gas inputted to the distribution network through various CGS, TBS, TBS cum DRS and RMS of Transmission Department. This Department is liable to operation of various off-distribution DRS and CMS. Five sections works under this department. The activity of each sections is shown in Table – 9.4, in this respect. A orgranogram chart (Figure – 9.3), also attached herewith to show the administrative activity of each section.

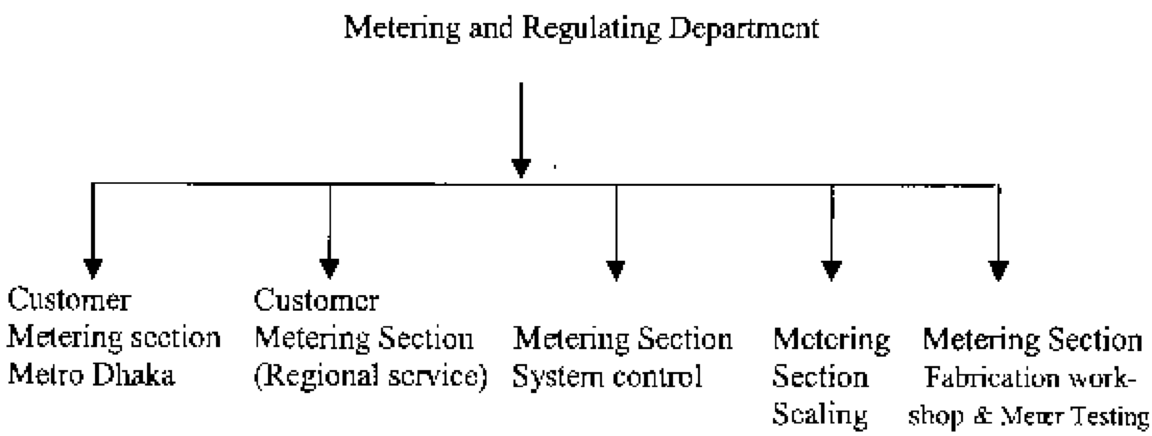


Figure – 9.3: Organogram chart of Metering and Regulating Department

Table – 9.4: Activity of Metering and Regulating Department

Sl. No.	Name of the Section	Activity
01.	System Control	Operation and maintenance of various off distribution DRS. Design new DRS or Customer and Metering Station (CMS). Material procurement for off distribution DRS and CMSs.
2.	Sealing	This section is liable for sealing the new meter. Checking or testing the previous seal and resealing.
3	Fabrication work Shop and Meter Testing	The fabrication of off distribution DRS and Customer Metering Stations (CMS) are the activity of this section. This section also test industrial and commercial meter.
4.	Metering Section Metro Dhaka	The activity of this section is to regulate and meter Customer Metering Station (CMS) of Metro Dhaka area. Installation of a new CMS. Regulator settling, Installation or meter change
5.	Metering Section Regional Scale	The activity of this section is to regulate and meter Customer Metering Station (CMS) of other than Metro Dhaka area. Installation of a new CMS. Regulator settling. Installation or meter change

9.1.5 Meter Selection

In Titas Gas transmission and distribution system gas meters are used on the basis of G-rating. G rating is a standard established by Organization International de Metrology Legal (OIML). Flow rate in cubic meter at line condition can be get if we multiply the G-rating with 1.6. A table (Table –9.5) regarding meters selection is attached herewith for simplicity of this study.

Generally meters are selected on the basis of hourly load. As per approved load Diaphragm Displacement type meters are used for metered domestic and commercial type customers. Rotary and Turbine meters are used for metering gas of industrial customer. Presently Rotary Meter is produced with G-rating from G-10 to higher rating. Due to compact size rotary meter is easy to installed in the customer yard. All most all the domestic customer has no meter. They use gas on the basis of flat rate billing system imposed by the government. Purchase point meters are orifice meter. Bulk users meters are Turbine Meter. Some of the individual power producers (IPP) customers used Orifice meter for gas billing as these type of metering is establish by their gas supply contact with the TGTDCL.

9.1.6 Technical Inadequacy Of The Existing Metering System

1. Meter is not protected and confined in the customer premises. So there are chance to change the meter reading by direct handling of meter or meter index

2. Meters are not installed correctly according to G-rating or customer load. Sometimes customer uses more gas than the approved quantity.

3. There are some old meters that are more than ten years old. The accuracy of these meters is not with in internationally accepted accuracy (± 1%) range now.

Table – 9.5: Meter Selection of TGTDCL

SL. No.	G-Rating of Meter	Meter Type	Where Used
1.	G-1.6 to G-16	Diaphragm Displacement type meter	Domestic and commercial customers RMS
2.	G-25 to G-65	Rotary type meter	Industrial customers
3.	G-100 to G-4000	Turbine type meter	Industrial, bulk customer RMSs (power and fertilizer produced), Town Border Station (TBS), District Regulating Station (DRS)
4.	-	Orifice meter	Sales and intake metering station of Power and fertilizer producer where orifice metering is established by contract
5.	Un-metered	Flat rate	Domestic customer

4. There is no customer data- base about their used meter specifications or identity with security system. And no secured data- base is used for collecting the meter reading.

5. Since the RMS are not protected and confined in the customer premises, there are a number of sensitive points from where there may have chance for gas pilferage.

6. The existing meter have no data storage facility for hourly, daily and monthly real gas uses with pressure, temperature with maximum and minimum value.

7. Regional basis the gas input-output is not isolated. So it is not possible to system balance for a region with respect to that regional CGS/TBS/DRS or RMS.

8. Inadequate sealing system with respect to present socio-economic condition. So sometimes it is not easy to identify gas pilferage though the customer has pilfered gas by broken the seal.

9. Sometimes meter are not installed as per the internationally accepted standard like AGA, ISO, ANSI, OIML etc. So there may chance to commit a measurement error.

10. Meters are not installed correctly according to G-rating or customer load. Sometimes customers in collusion with the dishonest officials reduce contractual quantity of gas but uses more than the contractual quantity.

11. Sometimes seals are broken in collusion with the sealing officials.

12. Existing old system of meter testing system is inadequate. In this system there may have chance of biasing the meter accuracy.

9.1.7 Problem Of Existing Metering System To Resist Gas Pilferage

1. Almost all the commercial and metered domestic customer has got a chance to pilfer gas from the unsealed meter. Mainly this type of customer use Diaphragm meter. So they can easily make a hole in the outlet manifold and create a disturbance to registered true gas flow. Beside this they adapt a number of method to pilfer gas like meter tampering, interchanging the inlet-outlet of the meter by pass etc. Since this type of RMS has no shade so installations of security seals are not effective.

2. Before installing a new meter or to change an existing meter security seals are put on varions sensitive points. After completion of sealing if the meters are not

preserve at least one day to solidify the cold metal (Turbo-metal, Dur-metal) then it become vary easy to remove the seals.

3. Though meters are preserve in the workshop for solidification of cold weld metal sometimes customer spent a long time to remove the thick paper seal and cold weld metal vary articulately, and after pilferage of gas they repute the seal with a gum like substance.

4. Sometimes sealing resealing of various points of a customer RMS are to be needed after replacement, maintenance of a new or existing equipment like meter replacement, regulator resetting, strainer changing etc. During this infield sealing the dishonest customer incollution with TGTDCL officials changes the meter index or crate a permanent system for gas pilfer.

9.1.8 Meter Calibration

The meters of industrial commercial, TBS cum DRS are still calibrated with the old transfer prover meter testing system installed long ago-though under Third Natural Gas Development Project a computerized calibration system has already been installed in the company at Demra office premises.

9.1.9 Collective Bargaining Agent

Collective bargaining agent plays a strong role in the activity of Metering and Regulating Department. Sometimes they biased the meter testing result. In collusion with the dishonest customer they create a gas pilferage atmosphere and from there they income much money.

9.2 Improvement Of Existing Metering System

The existing metering system administrative reforms of various department relating to gas metering and activity of it are discussed in this chapter previously. The inadequacy of the existing metering system and problem to resist gas pilferage are also discussed. Now a discussion will be held on the improvement of the existing metering system.

9.2.1 Actions For Improvement

The existing metering system can be improved by:-

1) Installing an electronic device such as electronic volume corrector, data logger or an electronic flow computer.

2) Installing a Cabinet type RMS.
3) Using a flow restrictor or sonic nozzle in metering runs.
4) Decreasing the possible pilferage point as minimum as possible.
5) Installing a dual chamber strainer.
6) Installing custody transfer meter with high accuracy repeatability, rangeability and reliability.
7) Killing the purging and pressure tapping point of service line.
8) Permanently killing the abandoned riser.
9) Installing customer internal service line above the ground.
10) Using the newly installed calibration facilities under TNGDP.
11) Application of information technology
12) Installing Tele-metering or SCADA system.

9.2.1.1 Installing An Electronic Device Such As Electronic Volume Corrector, Data Logger Or A Electronic Flow Computer

Prior experience says that a good number of customers are involved in gas pilferage with different ways. In doing this they use so many indigenous ways that it is difficult to identify. If it is possible to install a electronic metering device with the existing and new customer meters then the dishonest customer will not be encouraged because of the double registration system by mechanical and electronic index. Besides these with this electronic devices it is possible to log, store and analyze the gas usage. So it become very easy to identify gas pilferage from the actual usage and gas bill can be prepared from this actual usage.

This device can record or stored a good number of data such as pressure, temperature compressibility, uncorrected and corrected volume flow rate, total volume at flowing and base condition and the maximum pressure, temperature and flowing rate with time registration. So it will be very helpful to avoid the customers bill reduction application regarding minimum pressure usage. But this system will not be fruitful if the whole device is not installed with in a cabinet. The EVC can be secured by a two level security code, of which level – 2, operator level and level – 1, Engineer level. The memory of EVC should be nonvolatile and non-erasable one and it is able to recognize unauthorized handling.

9.2.1.2 Cabinet Type Regulating And Metering Station

Cabinet type regulating and metering station can be installed in the industrial customer premises. All the equipment of the RMS can be arranged with in a cabinet or box. The box can be closed with a lock and key and electronically with a two level security code. Proper sealing system should be applied to avoid unauthorized handling. If unauthorized entrance with in the cabinet can stopped then unauthorized handling of regulator, pressure gauge, meter index and meter can be eliminated.

Standard RMS can be designed on the basis of hourly load and outlet pressure of the commercial and industrial customer. And accordingly cabinet can be prepare with the following:-

- Cabinet/Box should be compact and less weighted.
- Material should be cheep and available.

- Easily identification number of each cabinet.
- Meter, pressure gauge and others devices reading should be visible from out side the cabinet.
- Facility for easy removing of gas originated from leakage or in side the cabinet.
- Ability of collecting information from the outside of the cabinet without opening the cabinet or remote facility.
- It will not hamper the maintenance of the RMS.

More than one number of locking arrangement or system should be included with in an industrial and commercial customer cabinet type RMS. One of them should be lock on time useable and not be able to unlock it without destruction itself. Beside this electronic locking system with two level passwords can be obligatory. Off these two level one is operator and another is supervisory. To open these cabinet both the two level code are needed without any off them the door will not unlock. For additional safely magnetic card or sealing system can be used.

9.2.1.3 Installation Of A Flow Restrictor/Sonic Nozzle In The Meter Line

Most of the customers use gas higher capacity than the approved load. In doing this they disorder the gas meter and shows low gas consumption by tampering the gas meter. It is very hard to convict the customer for meter damage. If we can install a restrictor or sonic nozzle down stream of the meter then this tendency of meter damage will entirely diminish because it will not allow excess gas through the meter run. This will also diminishes the tendency of the customer to approved lower gas load than the actual consumption. So it will be easy to control gas pilferage with more than the approved load or at higher pressure. This can be obligatory for the customers using rotary/turbine meter with G-rating G-40 or more.

9.2.1.4 Decreasing The Possible Pilferage Point As Minimum As Possible

If there are some plug point in the inlet and outlet portion of a customer RMS. Then it become very easy to pilfer gas through a by pass connection between these plug point. So the customer RMS should be design with no plug point and vent or opening or plug point as minimum as possible. And an authorized person should seal every plug point.

9.2.1.5 Installation Of A Dual Chamber Stainer

During the time of cleaning the strainer the customer pilfer gas in collusion with the officer and staff related to this work. If a single chamber strainer is used then the frequency of this cleaning will be more. So it will be wise to install a dual chamber Stainer in the customer RMS. At the same time cleaning class of the gas in the TBS, DRS will increase to minimize this offence.

9.2.1.6 Installation Of Custody Transfer Meter

To minimize system loss it is very much essential to install custody transfer meter with high accuracy, low repeatability percentage high rangeability, and reliability. Meter should have custody transfer certificate from OIML at the time of purchase.

9 2.1.7 Killing Of Purging And Pressure Tapping Point Of Service Line

It is very important to remove the service line which has a purging or pressure tapping point or if it is not possible to remove the pipe spool then it will be wise to kill the point permanently by welding. In construction a new service line it will be wise to keep no purging point.

9.2.1.8 Permanently Disconnect The Abandoned Riser

Sometimes dishonest customers pilfer gas from a abandoned riser by illegal connection. Disconnected customers uses gas illegally and continue their activities because it is not known to the company. So the abandoned riser should be disconnected permanently to reduce system loss.

9.2.1.9 Customer Internal Service Line

Customer internal service line should be installed above the ground. If the service line are installed under the ground there may have chance to by pass connection.

9.2.1.10 Using newly Installed Calibration Facilities for Meter Calibration

Under Third Natural Development Project the company has installed two computerized low pressure and a high-pressure meter calibration bench. These three benches are equipped with very sophisticated instruments. And in this calibration system there are no chances of biasing the meter calibration procedure or accuracy. But our Meter test section is now still using the old manual calculation transfer proving system. In this system there are chances to bias the meter accuracy. So it will be wise to test the meter with the newly installed meter-testing benches.

9.2.1.11 Application Of Gas Sales Manual

To bring the congruity of connected load among the same classes of different customers and keeping the dishonest customer aloof from gas pilferage the load approval or reapproval should be made according to the gas sales manual of TGTDCL. All the formalities and section of this manual should be properly apply for a gas connection.

9.2.1.12 Information Technology

Today is the age of computer and information technology. The world is very advance in this field but TGTDCL is not still in this stage. Most of the department of TGTDCL has no computer. The metering, sales and regional sales department have no soft wire related to customer data and information.

Application of information technology to prepare a customer data is very important to speed up the communication.

9.2.1.13 Tele-Metering

The existing metering system can improve by using remote metering or tele metering. The main component of the remote metering are as follows:-

a) Flow corrector or computer (EVC/FC)
b) Telecommunication system (Mobile phone unit).
c) Central computer system.

The advantage of this type of metering are:-

a) Prevent misuse of equipment.
   1) Check on over speed of turbine.
   2) Provide evidence when such occurred.
b) Verify contract execution.
c) Automatically create customer bills.
d) Collect management information.
e) Create tamper proof automatic checks by:-
   1. Burglar alarm on door at the time of unauthorized handling.
f) Flow checks against customer profile.
g) Pressure check to protect against by-pass.
h) Flow balance of all meters.

CHAPTER – 10

SYSTEM LOSS SPECIAL PROBLEM OF BANGLADESH

To find out the contributing factors in a distribution or sales system, there found a number of factors those are very special only for Bangladesh. These contributing factors are increasing system loss and, which are the biggest component of system loss. The main parts of these are pilferage loss caused by so many indigenous ways like meter tampering, by pass connection etc. and the other is inconsistent domestic tariff base. There are others technical and social factors for system loss are also discussed in this chapter.

10.1 Transmission System

TGTDCL has already undertaken a number of measures for proper identification and concurrent reduction of UFG in its transmission system. The major steps undertaken are stated below and these are at various stages of implementation. The actions are implemented according to internal work plan. The progress of implementation is regularly monitored and success of the same is soon expected to be in sight.

10.1.1 Checking Of Purchase Point Metering Arrangement

TGTDCL purchases gas from Bangladesh Gas Field Company Ltd. and Sylhet Gas Field Company Ltd. Purchase point meters are orifice meters and the secondary elements of these meters are mechanical three pens chart recorders. Gas bills are produced from the chart reading by manual calculation. To calculate the gas flow with the orifice meter, the following flow equations are used:-

$$Q = c'\sqrt{h_w \, P_f}$$

Where,

- Q = flow rate of gas in cubic ft/hr at base pressure and temperature condition.
- h_w= differential pressure in inches of water column which are measured from Chart Recorder.
- P_f = Static pressure in psia which are measured from chart recorder.
- C' = Orifice constant which are calculated according to the presented formula of AGA – 3.

According to AGA Report no. 3, the orifice plate is subjectively 'checked' for concentricity, flatness, diameter, edge sharpness and orifice plate thickness. Deviation in any of these factors can cause measurement error. Checking the meter's secondary element requires the meter inspection to transport numerous gauges, special test instrument, hand tools, reference books and volume calculation.

The Orifice Meter requires constant checking and calibration of its differential pressure device. Despite regular checking by qualified personnel, if orifice meters are not operating at near perfect conditions, measuring errors of monumental proportions do occur, as was shown during a special orifice meters evaluation program conducted by Columbia Gas Transmission Corporation (Reference – 7).

Columbia Gas Transmission Corporation under an extension investigation of orifice metering, the company found that the small deviation from perfect metering conditions result inaccurate measurement from these meters. Combinations of these deviations possibly create an additive or compensating error.

Columbia Gas Transmission Corporation found the following measurement errors:-

10.1.1.1 A Beveled Orifice Plate Installed Backwards

This creates a larger throat at the vena contracta and a lower differential across the tap holes. In the test, the differences between the calculated and actual flow resulting (–) 13.82% measurement error.

10.1.1.2 Dirt Accumulated Upstream Of The Orifice Plate

Dirt usually accumulated upstream against the bottom part of the orifice, which reduces flow velocity causing a (–) 6.2% measurement errors.

10.1.1.3 Dirt Accumulated Downstream Of The Orifice Plate

This reduces turbulence at the orifice plate and causes flow streamlining downstream of the plate. This increases the throat of the vena contracta lowers the differential pressure and causes a low registration of (–) 2.3%.

10.1.1.4 Dirt Accumulated On Block Sides Of The Orifice Plate

This reduces the area of the orifice opening and creates a higher differential across the orifice plate resulting in over registration of (+) 3.0%.

10.1.1.5 Dirt Accumulated On The Upstream Face Of The Orifice Plate

Usually wet or oily, the dirr covers the upstream face of the plate. It streamlines the gas and can cause a measurement error of (–) 23.12%.

10.1.1.6 Dirt Accumulated On The Face Of The Orifice Plate

This type deposit usually forms in the shape of a donut or a flat ring, streamlining the flow and causing a lower differential pressure, as well as a potential measurement error of (–) 27.7%.

10.1.1.7 Round And Nicked Upstream Edge Of The Orifice Plate

This damaged edge streamlines the flow, making the vena contracta larger, resulting in a lower differential pressure and a measurement error (–) 11.25%.

These are the seven most common and most easily duplicated conditions. Columbia Gas Transmission Corporation concluded that near perfect conditions must be attained and retained when constructing, operating and maintaining orifice meters.

These represent just a few of the conditions that exist which affect measurement of gas using orifice meters. Columbia suggests that more than one of the seven undesirable conditions may exist simultaneously in a meter tube. If conditions 6 and 7 existed at the same time, for example, the potential measurement error would be (–) 38.95%.

Some of the others potential sources of error associated with a square edged orifice plate with flange tapings are given below:-

1) Expansion factor referenced to incorrect tapping point.
2) Pressure taping hole too large.
3) Scale foreign material, burs etc. around pressure tapping point.
4) Incorrectly sized orifice plate.
5) Orifice plate too thick.
6) Buckling of orifice plate.
7) Upstream edge of plate not sharp-e.g. rounding of edge.
8) Orifice plate not concentric in holder.
9) Faulty gasket between carrier ring and flange.
10) Scratches, nicks, damage to orifice plate face and/or bore.
11) Abnormal roughness of pipe bore.
12) Pounding of liquid upstream of orifice plate.
13) Significant change in pipe diameter with in 8D upstream of orifice plate.
14) Protrusion in pipe, such as thermo-well, within 5D upstream of orifice plate.
15) Error in measurement of orifice bore and/or pipe bore.
16) Pulsating flow-can have significant influence.

17) Incorrect orifice plate in service.

18) Incorrect application/calculation of gas thermodynamic properties.

19) Incorrect base condition applied.

20) Incorrect calibration of secondary instruments.

21) Incorrect scaling of secondary instruments.

22) Condition of flow profile of fluid being measured.

23) Temperature at which orifice bore and/or pipe diameter measured incorrect or not applied.

24) Input pressure incorrectly stated – i.e. absolute/gauge.

25) Damaged or partially blocked instrument pressure lines.

26) Error in flow calculation process.

27) Partially open valve with in close proximity upstream of orifice plate.

From a review of the above list it will be noted that the majority of potential sources of error can be categorized as being that of installation effects. Many of these conditions will also apply to other types of meters such as Turbine Meters.

So measurement of gas with an Orifice Meter we have to maintain near perfect condition. And the meter should be installed as per AGA Report no.–3.

10.1.2 Bulk Customer Metering Facility Examination

Bulk customer means big user of gas. In TGTDCL system power and fertilizer producers are within this class (Tables – 9.2 and 9.3). Most of the bulk customers use Turbine Meter as billing meter. But in Individual Power Producer (IPP) RMS Orifice Meter is the billing meter. (Detail list in Table – 9.2).

The features of Orifice Meter related to accuracy have described earlier. Now a discussion about Turbine Meter and its accuracy are held in this chapter. Turbine Meter is a rotary inferential meter. Turbine Meter measurement systems are much easier to maintain than orifice systems. The only routine field maintenance recommended is to periodically lubricate the rotor bearings using the external lubrication system fitting with lubrication pump. This task can be performed while the Turbine Meter is operating, without service interruption. Turbine Meters can be expected to operate at an accuracy level with in (±) 1.0% over their entire rated operating pressure and flow range. If these meters have been calibrated at or near operating pressure, they are capable of a calibration accuracy of (±) 0.25%.

From the above discussion it is clear that there are no substantial error in bulk customer's gas measurement. There may have source of potential error in IPP sectors but at present these meters are checked and calibrated at regular interval.

10.1.3 Calculation And Recording Of Line Pack

Line pack is the amount of gas gathered in a piping system or network during a certain operation period. In calculating system loss or UFG, calculation of line pack is necessary because it can influence system loss. Now a days traditional method of system loss calculation is used in TGTDCL and change of line pack is not anticipated in system loss calculation process. But this should be included.

To calculate line pack truly, first the sketch of the network is necessary and from the network drawing it is possible to calculate equivalent pipe diameter. Then line pack can be calculated from the formula.

$$Q_{pack} = 0.372 \times F_{pv}^{\;2} \left(\frac{\pi d^2 L}{4}\right)\left(\frac{P_{av}}{14.73}\right)\left(\frac{520}{T_f + 460}\right) SCF$$

where,

L = Line in feet,

P_{av} = average pressure psia

d = internal diameter of pipe (equivalent)

T_f = average flowing temperature

F_{m}^{2} = super compressibility

$$P_{av} = \frac{2}{3}\left(P_u + P_d - \frac{P_u P_d}{P_u + P_d} \right)$$

where, P_u = upstream pressure pisa

P_d = down stream pressure

$$T_f = \frac{2}{3}\left(T_u + T_d - \frac{T_u T_d}{T_u + T_d} \right)$$

where, T_u = upstream temperature °F

P_d = down stream temperature °F

Compressibility must be included with the line pack calculation procedure due to compressible nature of natural gas. A soft wire can be produce for this purpose, which can help to shorten the long calculation time.

10.1.4 Calculation And Recording Of Purging/Testing Losses

For system loss calculation, recording of purging and testing loss are not include. In TGTDCL purging and testing are not properly recorded. Purging or testing loss can be calculate according to the standard formula.

10.1.5 Obsolete Measurement Basis

At present the gas measurement basis in our country is volumetric i.e. gas are being sold on the basis of volume delivered in cubic feet or meter. This is the oldest basis of the measurement system. Now a days developed countries uses mass or energy basis. In our country three IPP customers uses volumetric basis but this volumetric measurement is for 940 But/cubic feet and for the higher calorific value they pay the bill with a ratio of the actual caloric value by 940 But/cubic feet.

To improve the measurement basis, gas analysis and recording is necessary. Electronic Instruments and measuring device such as Flow Computers, Transmitters and

Densitometer can be installed to improved measurement system. A mass meter can also be installed in this purpose.

10.1.6 Condensate Volume Calculation For Equivalent Gas Loss

The volumetric balance affected by the condensation of higher hydrocarbons present in the gas due to reduction in following pressure and resultant temperature drop is another component of system loss. To calculate system loss, this condensate is to be convert to an equivalent amount of gas. This effect has not been taken into account before and the practical approximation for the same is also very complicated. At present an approximation determined by Chemical Engineering Department of Bangladesh University of Engineering and Technology (BUET). This is 1 litre = 0.971578 M^3 of gas at standard condition This approximation can be rechecked. Also a substantial amount of condensate are pilfered by the dishonest officials and technician related to the collection, carry and transfer process to Padma Oil Company. Condensate is also loss due to insufficient and manual collection system. So condensation increases system loss.

10.1 7 Off-Transmission Market Area Isolation

Now a days region wise input to the off-transmission system are not properly recorded. Region wise input to the off transmission area are not also isolated. So inputs to the distribution system are not easy to calculate. Due to this non-isolation of regional and metro sales, input are not calculated properly rather an estimation is made. So it is not possible to impose the clear responsibility of the regional or zonal manager for their system loss.

10.2 System Loss Special Problem Of Bangladesh In Non-Bulk Sector

Some special problems of Bangladesh in non-bulk sector regarding system loss are discussed in this chapter. These are:-

10.2 1 Domestic Flat Rate Tariff Base

a) TGTDCL introduced domestic gas metering system in FY 1985-86 and about 70% of domestic consumers existing at that time were brought under this system. But the system was practically discontinued due to various technical and social reasons with in the next couple of years. These are:-

1) To purchase gas meters for domestic customers a huge amount of money are required.

2) Meter procurement, preservation, calibration & maintenance works needs extra manpower and others logistics supports.

3) A great number of meter readers and manpower are required to collect meter-reading, gas bill preparation and correction and posting in ledger.

4) Opportunity of gas pilferage will increase and the Government will loss huge amount of revenue.

5) Crimenalization increase regarding gas pilferage like bypass connection, meter-tampering etc.

6) To control gas pilferage, excess manpower will be needed to examine the gas usage.

7) If it is not possible to sent the gas bill in due time then account receivable will increase.

b) Domestic consumers eventually continued to pay their monthly gas bills on the existing flat rate tariff system revised year to year by the Government. There are always two options available for domestic users in flat rate tariff system: single and double burner. The problem of flat rate are as follows:-

1) The present flat rate is lower than the actual gas uses of the customer.

2) Customers do not close their burner after finishing of their cooking. Even they open their burner all day long to save a match- stick. This type of usage will finish our valuable natural resources within a very short time and the country is not getting any benefit from the burned gas but environmental pollution.

3) Leakage in the service line of the customer may cause accident.

c) The gas tariff set by Government from time to time for that flat rate billing system has always been based upon some estimated monthly gas consumption rate. As per latest tariff the domestic gas flat rate is based on the following estimated consumption.

Single burner: 43.44 SCM/month
Double burner: 74.13 SCM/month.

d) Three different studies conduced by Petrobangla and TGTDCL over the last 10 years suggest that the real use of average domestic customer is higher than the above and are found to be as follows:

Single burner: 59.32 SCM/month
Double burner: 86.56 SCM/month.

e) Applying the above difference over a total of 419165 Single burner domestic customers and 491914 double burner domestic customers on 30th June 2003 it is seen that TGTDCL has lost about 153.243 MMSCM of gas over the 2002 – 2003, which is about 2.13% of total net throughput.

f) TGTDCL is further anticipating that the real number of domestic customers may be substantially in excess of recorded number and the customers would be largely double burner type whereas the record indicates the severs. This added with the apprehension that though connected as single burner for obvious advantages, a section of such customers have been using double burner, is contributing to the gas loss for TGDCL more.

g) It may be further noted from the above that although tariff provides about 60% of a double burner consumption by a single burner, the study reveals that the same would be about 70% which is more realistic because of the fact that regardless of the type of burner. the average domestic customers would use about the same amount of gas for cooking

10.2.2 Base Condition Variation

The whole situation relating to gas metering at gas custody transfer locations is dependent upon uniform base pressure and temperature conditions as well as on the metering facilities and calculation procedures. Base condition variation can cause measurement error. Purchase bulk sales and non-bulk sales should use same base pressure and for Bangladesh it is 14.73 psia.

10.2.3 Set Pressure Variation

The pressure set points of industrial consumers those who are using a simple type CMS cannot often be maintained at the set level. The set points generally change with the passage of time in normal operation and needs frequent manual intervention for re-setting. This is done as and when necessary but monitor often not possible on regular basis because of large number of customers and due to logistic problem. There are possibilities of gas loss on this account too. The dishonest customer intentionally changes the set pressure or point for suppressing real use.

10.2.4 Pilferage

Pilferage of gas by customers is reportedly rampant in the industrial and commercial sectors. TGTDCL is aware of the situation and as per the estimate furnished in this report the UFG on this account stands over 70% of total system loss (Table – 4.2).

There are reports of pilferage by the domestic customers also the magnitude of which requires investigation for assessment.

10.2.4 1 Mode Of Customer Gas Pilferage

The way or method used by the customer for gas pilferage can be written as:–

1) Direct handling meter index or meter.

    a) Slowing the meter index by handling it.
    b) Changing the gear train.
    c) Lowering the meter reading by reverse rotation of the meter.
    d) Changing the meter index.
    e) Interfering the meter index with any other way by the dishonest customer.

2) Tampering the regulator or pressure gauge or both of them to use gas at higher pressure.

3) To create an obstacle in recording the gas uses by interference the RMS pipes, fittings etc.

4) To show or record lower meter reading in collusion with the meter reader with out handling the meter or meter index.

5) Customers use gas with an unauthorized, hidden underground line.

6) Customers use gas unauthorized way from abandon and disconnected service line or a disconnected riser.

10.2.5 Account Receivable

Accounts Receivable regarding gas bills by the customers is an indirect component of system loss. This does not reflect during calculation of system loss but ultimately it goes upon the company's accounting system as a bad debit. So we can say that account receivable is an intangible component of system loss.

It could be seen from the statement Table – 10.1 given below that the accounts receivables as of 30th June 2003 is Tk. 862.53 crores which is equivalent to 5.11 months of gas sales on three months average billing basis. Considering the accumulated provision for bad and doubtful debts as per ADB requirements in terms of accepted accounting practice the amounts come down to Tk. 758.o2 crores which is equivalent to 4.49 months. Further considering some of the receivable which are beyond company's control at this stage then the position of account receivables would be Tk. 579.61 crores that is 3.43 months of gas sales on three months average billing basis.

Sector wise outstanding are shown in Table – 10.2. From this statement it can be seen that the outstanding dues of Tk. 382.93 crores against Government and semi-Government agency includes Tk. 84.37 crores against some of the receivable in respect of BTMC /BJMC, Government colonies which are beyond company control to realize at this stage. If these could be realize the accounts receivable in respect of Government sector will come down to Tk.. 298.56 crores, which are equivalent to 2.93 months average sales. On the other hand, the outstanding dues amounting to Tk. 479.60 crores against private sector customers includes Tk. 178.41 crores in respect of dues from customers against disconnection, money suits and injunction suits which are also beyond company's control at this stage. Considering the net outstanding in respect to private sector customers would come down to Tk.. 301.19 crore which is equivalent to 4.50 months of average sales as against 7.17 months as shown in the Table – 10.2.

Table – 10.1: Account receivable

Sl No.	Particulars	Amount (crore)	Average Monthly Bill (crore)	Equivalent Months Bill
⇒	Total Outstanding	862.53	168.93	5.11
⇒	Less Provision for Doubtful Debts	104.51	-	-
⇒	Total	758.02	168.93	4.49
⇒	Less Uncontrollable customers Dues: injunction suits – 50.93 Disconnected & Money Suits 127.48 Total = 178.41	178.41	-	-
	Total Adjustment	178.41	-	-
	Net Outstanding	579.61	168.93	3.43

Table – 10.2: Account receivable

Sl. No.	Sector	Outstanding (crore)	Percentage	Average Monthly Bill (crore)	Equipment Months
1	Govt. and Semi Govt.	382.93	44.40%	102.04	3.75
2	Private	479.60	55.60%	66.89	7.17
Total =		862.53	100%	168.93	5.11

The company is nevertheless putting serious effort to realize it's outstanding. As a result account receivable is huge in every sector like power, fertilizer, private and Semi-Government Organization.

Unsettlement of long pending money suits of the company and injunction suits of defaulting customers account receivable amounting to Tk. 862.53 crores as on 30-06-2003 includes Tk. 127.48 crores due to customers under money suit and Tk. 50.93 crores due from customers abstaining from paying under the shelter of courts injunction. The said amount of account receivable under dispute will remain unpaid as long as the suits are in question remaining unpaid or unsettled.

10.2.5.1 Bangladesh Power Development Board

PDB pays the gas bills of eight (08) power stations. In bill payment procedure they imposed some objections, as the billing amount is excess than the actual use. This situation arises in 1993 at APS, RMS gas bill and still the dispute is unsettled. Sometimes PDB could not collect required amount of money from its bulk customers like Dhaka Electric Supply Authority (DESA) & Rural Electrification Board (REB) to pay gas bill as per schedule which resulted in the increase of company's receivable due to PDB's inability to pay. The problem become acute when Individual Power Producer (IPP) company like AES, NEPC etc starts to produce electricity. From these IPP Power Producer, PDB Purchases power at a higher price and sale it to the customer at a lower price.

10.2.5.2 Fertilizer Factory

The authorities of 4 (four) fertilizer factories using gas, supplied by the company are not paying bills regularly. The account receivables of Tk. 39.78 crores are in this sector.

10.2.5.3 Gas Bills Of Government Colonies

As per Government order of Ministry of Finance dated 14-01-96 and 05.05.97, gas bills of the Government Colonies under respective Ministries are being recovered from the monthly pay bills of the official residing in those Government Colonies and the amounts are supposed to have been disbursed to the respective gas companies through Public Works Directorate (PWD) under Ministry of Public Works. Although, gas bills are being recovered regularly by the respective Account General's (AG) office but infact full payment has not been received by the Gas Marketing Companies due to some problems associated with this disbursement procedures. An amount of about Tk. 20.80 crores has been accumulated as outstanding bills to pay to TGTDCL by PWD since November 1995 to till June 2003.

10.2.5.4 Different Textile Mills Under BTMC

It may be mentioned here for information that in the meantime, 10 mills under Bangladesh Textiles Mills Corporation (BTMC) out of 17 mills under it have been placed under Privatization Board and the liabilities of those mills have been taken by the Government. The outstanding dues of those mills against gas bills are Tk. 12.03 crores.

10.2.5.5 Different Jute Mills Under BJMC

The payment of monthly gas bills of different Jute mills under BJMC are not being paid by the respective mill's authority because of their inability to pay. The outstanding of gas bills in this sector is Tk. 47.05 crores.

10.2.6 Technological Backwardness

Technological backwardness is a strong factor for system loss in Bangladesh. Technological backwardness means shortcoming of the gas utilization process or system. Glass, silicate, lime, re-rolling mills, batch type ceramic, brick/refractory, salt, dying and printing industries are called load intensive customers in TGTDCL system. Because these type of customer use more gas than their actual needs due to technological backwardness of the gas utilization process or system. Gas pilferage rate is also very high in this type of customer. The reason of gas pilferage is their technological shortcoming as well as lowering of moral and ethical value of the customers. All the above type of customers used a furnace that is locally fabricated called vatty. Air fuel mixing is not economically maintained in this type of furnace. So there creates a smokey atmosphere in sides the fractories. The gas is not burn fully in this type of furnace so the customer get a lower heat value from gas due to improper air-fuel mixing. The colour of the flame of this type of furnace is radish in stade of blue yellowlish. The furnace wall of this type of vatty are made of normal brick in stade of heat resistant firebricks. The ideas of critical insulation thickness are not applied in making the furnace wall of the vatty. Internationally accepted technology regarding this are not used in this area. The customers are not interested to make the furnace wall as per international standard to reduce heat loss in stead they are more interested to lower the production cost by pilfering gas.

Due to this process inadequacy almost all the heat near about 60 to 70% are losing through the furnace wall of this type of customers. This heat loss increases the amount of gas consumption to a greater extent that in turns increases the cost of production. At present TGTDCL has no supporting department regarding lowering of this excess requirement of gas. So to lower the production cost of the product the customers pilfer gas with a number of indigenous ways like meter tampering; bypass use and many other ways. A separate study can be conducted in designing a heat saving furnace to save gas loss.

10.2.7 Customer Load Approval

Customer connected loads are not approved as per the 'Gas Sales Manual' imposed by Petrobangla. At the time of load approval the customer shows their gas demand by submitting false papers or documents. Sometimes they do this in collusion with the official related with the load approval or gas connection. So after approval of this less demanded gas, customers meet up their excess demand by gas pilferage through a number of indigenous ways like meter and regulator tampering, illegal bypass connection etc. This is a vital issue or factor for system loss in TGTDCL.

10.2.8 Meter Calibration And Service Facilities

The calibration facilities in our existing system are very old, inaccurate and manual. In this type of calibration system there are chances for the calibrator to articulate the accuracy of the meter. Sometimes some dishonest official in collusion with the customer approved inaccurate meter as an accurate meter. So delinquent customer is not getting punishment for gas pilferage. This practice has a strong effect on system loss. Under third natural gas development project TGTDCL installed one high pressure and two low pressure computerized calibration benches in the year 2002. It is not possible to articulate the accuracy of meter calibrated with this bench. But TGTDCL is still using the old manual calibration system.

10.2.9 Absence Of Permanently Pressure And Temperature Recording Device

In TGTDCL system at present there are no permanently pressure and temperature recording devices. Now pressure gauges are used to record the setting pressure and no temperature measuring devices are used to record temperature. As pressure Gauge cannot record or store temperature permanently the customers always use gas at a higher pressure than the contructual pressure. In this way customer become able to pilfer gas. If there were some electronic volume correction device installed in the customer RMSs then it would be very easy the record the pressure and temperature and that may eliminate system loss to some extent. This is a vital issue for system loss.

10.2.10 Un-Metered Usage

Sometimes customers uses gas un-metered due to actual or intentional damage of flow meter. The domestic users are also un-metered in our country. Sometimes under size meters of CGS, TBS cum DRS, TBS, DRS and CMS are damaged due to over spinning. Intentional damages are also happened in these respect. Then the input of the network or a region cannot be calculate. In this way the customer in collusion with the TGTDCL makes a ways and means for gas pilferage.

10.2.11 Excess 20 MMSCFD Gas Demand During Winter Season

In the winter season the domestic gas demand increases 20 MMSCF gas per day with the same customer size than the summer or hot season. The company does not get any revenue for these excess 20 MMSCF demanded gas because all this gas are uses for domestic purpose Maximum amount of this gas are used to heat the room or to dry clothes.

10.2.12 Non-Isolation Of Regional Wise Input And Output

Gas input output of a area or region of TGTDCL are not isolated specially the Metro Dhaka's supply cannot be isolate due to complexity of the distribution network supply. So there are no region wise accountability of the metro Dhaka and some others regional sales office. Absence of these region wise non-isolation increases system loss.

10.2.13 Fixed Pressure Factor

In TGTDCL the gas bills of industrial, commercial and metered domestic customer are prepared on the basis of fixed pressure factor. And temperature and super compressibility factor assumes as unity. As metering pressure are the contractual pressures of customers with the company. So gas bills are prepared on this pressure factor. But the customer usage gas at a higher pressure than the approved pressure.

10.2.14 Billing Cycle Effect

Billing cycle is the time period between the subsequent bills, duration of this billing cycle is one month. The time frame of this billing cycle starts from 21^{st} day of a month to the 22^{nd} day of the next month. At present in TGTDCL system no SCADA or Tele-Metering system for collection of meter reading for system input or customer billing and meter readings are collected manually. But a huge number of customer meter readings are not possible to collect at a time with the existing manual meter reading collection system. As a result meter readings are collected at different interval. This inconsistent meter readings collection increases system loss.

10.2.15 Political Factors

Sometimes dishonest customers get a gas connection by exercising political power. The delinquent customers do not pay bill in the shade of political party. It is not possible to disconnect the gas connection of a politically shaded customer because they shows muscles power. Disconnected customers reconnected the gas line by using political power. This evil practice increases system loss.

10.2.16 Collective Bargaining Agent (CBA) Activity

In TGTDCL there is no elected CBA. illegally the present Government party's related labour organization is the legal CBA. The CBA changes with the changes of Government power. This CBA strongly handle the meter test and calibration facilities and the metering section and the sales and regional sales office. They transfer the existing manpower working in those office and posted there new officials those who will work according to their order or consent. They get a big amount cash or kind by transfer and a monthly allowance from these officials.

10.2.17 Degradation Of Moral And Ethical Value

At present the gas users and the official related to the sales and metering office want to be a rich man within a very short time. This objective has lowered their moral and ethical value. So now they can do an illegal task very easily. They always earn money illegally in collusion with the dishonest customers. This is a great hurdle to reduce system loss.

10.2.18 Criminalization

Some criminal cycles are now active in TGTDCL. They have sufficient technical knowledge about gas pilferage. So they are hired by the customers to do the ill activity related to system loss like meter tampering or bypass connection.

10.2.19 Company's Own Use

Company's own use is the amount of gas used for system operation required for heating, instrumentation etc. This amount of gas is not clearly quantified and reflected in system loss calculation. Mainly gases are uses to preheat the natural gas and as a fuel of stand by gas generator. Some of these generators have no meters for gas measurement or record.

CHAPTER – 11

ACTION PROGRAMME

11.1 Measures Taken To Reduce System Loss

TGTDCL launched a time bound action Program in August 1993 to bring down the then level of 7 to 8% overall system loss of gas sales against the net throughput in the pipeline to a level of 2.8% with in the FY 1994-95. The program, as partially revised over the initial draft (March 1993) came to be known as "Revised Time Bound Action Program (RTAP)" and it delineated the time frame for reduction of system loss on a gradual basis are shown in Table – 11.1.

Table – 11.1: System Loss Reduction Program Of TGTDCL In FY 1992 - 93

SL. No	Item of UFG	UFG as estimated percent of net through put	Time frame for reduction							
			FY – 1993-94				FY 1994-95			
			I	II	III	IV	I	II	III	IV
1	Technical system loss	1 25%	1.25%	1.25%	1.18%	1.10%	1.20	0 94	0 87	0.80
1.1	Transmission loss	0 49%	0 43%	0.49%	0.45%	0.40%	0 37	0 34	0 32	0.30
1.2	Distribution loss	0.76%	0 76%	0 76%	0.73%	0.70%	0 65	0.60	0.55	0.50
2.	Non-technical loss	8.11%	7.44%	6.74%	5.94%	5.14%	3.20	2.80	2.40	2.00
2.1	Pilferage loss	6.67%	6.00%	5.30%	4.50%	3.70%	3.20	2.80	2.40	2.00
2.2	Loss due to inconsistent domestic to bill	1.44%	1 44%	1 44%	1.44%	1 44%	-	-	-	-
	Total	9.36%	8 69%	7 99%	7.12%	6.24%	4 22	3.74	3.27	2.80

The RTAP (August 1993) was taken up in the backdrop of loan negotiations with Asian Development Bank (ADB) for Third Natural Gas Development Project (TNGDP). The RTAP was drawn in consultation with ADB and with due approval of the competent authority.

The system loss or Unaccounted For Gas (UFG), as defined in the RTAP and as still considered valid is that portion of the gas purchased that is not accounted by sales, transfer, company use or other wise accounted for. The factors affecting system loss were all grouped under two broad heads: technical and non-technical. Based on operational experience and available operational data, component wise contributions of each of the technical factors were estimated at that time about 1.25% and the non-technical factors to account for about 8.11% the total system loss being 9.36% of net throughput in the reporting year (FY 1992-93), which is shown in table – 1.1.

11.1.1 Action Program

Soon after the launching of the RTAP elaborate activities were initiated in all areas of system operation as well as customers level. The activities included inspection and improvement of region wise input metering, customers meter inspection, meter testing, and meter replacement, customer RMSs sealing, disconnection, load increase. Some of the activities are quoted from the Revised Time Band Action Programme. These are:-

Actions for proper identification and reduction of System loss.

1. Checking of purchase point metering arrangement.
2. Bulk Customer metering facility examination.
3. Calculation and recording of line pack.
4. Calculation and recording of purging and testing losses.
5. Examination of gas specifications and measurement procedures at various locations.
6. Condensate volume calculation for equivalent gas loss.
7. Market area isolation for off. transmission and off. distribution networks.

8. Survey of actual number of different categories of live customers to ascertain the extent of unauthorized use of gas.
9. Identification of load intensive customer and analysis of their load or operational behaviour.
10. Assessment of the actual gas use pattern by domestic customers through consumption survey by installation of meters at selected locations.
11. Regular joint calibration at purchase points.
12. Regular customer RMS inspection/ maintenance.
13. Defaulting and disconnected customer RMSs removal and riser killing.
14. Sealing of all industrial and commercial customer RMSs under special program.
15. Regular network maintenance operation to minimize leakage.

These activities yielded initially positive results, which was caused by a fall in the monthly UFG levels to about 6%. The improvement could not be sustained. The UFG level shot up over the next 2-3 years a raising concern for the company. As such fresh drive has become necessary to arrest UFG level, if not to the 2.8% on net throughput as covenanted in the loan agreement, hut to a reasonable low and tolerable limit.

11.2 Extended Measures Taken To Reduce System Loss

The company has been implementing action plans to reduce overall system loss/Unaccounted For Gas (UFG) by zonal isolation, meter sealing, calibration and replacement of old meters; intensive vigilance, disconnection of unauthorized gas connection by task force, speedy disposal of court cases, electronic metering, flow/pressure logging system etc. Necessary measures are taken to reduce the system loss to an extent of 50% at Narayangonj, Tongi, Narsingdi, Ashugonj, Brahmanbaria, Sherpur, Netrokona, Goffargoan areas. A target oriented programme known as Second Time bound Action Programme (STAP) are implemented by the officers to collect meter reading and frequent visit of the customer premises. Meter sealing and testing programme. It is mentioned that if the existing system loss can be reduced to an extent of

1%, yearly revenue loss of Tk. 24.00 crores and a monthly rate of Tk. 2.00 crores may be arrested.

11.2 1 System Loss Reduction Programme

In terms of reduction of system loss to a realistic level over a period up to FY 2004-05, subject to concurrence of all concerned, the company proposes a system loss reduction plan, which is shown in Table – 11.2.

It can be seen from the above mentioned table that the system loss percentage due to non-technical factors those are happening in the non-bulk sector are proposed to be reduced to a level of 2.0% within FY 2004-2005. Thus it is proposed, in other words, to reduce the non-bulk system loss to around 7% of the relevant input as against the current level of more than 20%. The company takes a extended action program to reduce the system loss, which is attached in Appendix – B. The main action programme are to improve area wise input metering, improvement of the customer metering, minimization of operational loss, strengthening customer management, development and implementation of system loss accounting procedure, identification of factors responsible for system loss in sales area against input, vigilance of load intensive customers, disconnection of delinquent customers and riser killing. The estimated cost of the programme is 41.29 crores.

The proposed system loss reduction targets delineated in Table – 11.2 would be forthcoming depending upon initiation and accomplishment of certain steps both within and outside the purview of company's own authority. The steps to be taken up will be separately drawn up with specific time frames up to FY 2004-2005 and placed before the authority for consideration. Major activities of Second Time Bound Action Programme (STAP) are as follows:-

1) Installation of 60,000 domestic gas meters.

    a) Issuance of IFB: with in 15 Oct, 2001.
    b) Award of purchase order: within 31 Jan, 2002.

Table – 11.2: Recommended Extended Action Program for System Loss Reduction

Year & Qtr.	Tech./system loss % of NT	Non-tech. Loss (% of NT)	Total UFG (% of NT)
FY 2001 – 2002			
I	1.25	6.75	8.00
II	1.25	6.25	7.50
III	1.25	5.75	7.00
IV	1.20	5.30	6.50
FY – 2002 – 2003			
I	1.15	4.85	6.00
II	1.10	4.40	5.50
III	1.00	4.00	5.00
IV	0.90	3.60	4.50
FY – 2003 – 2004			
I	0.85	3.40	4.25
II	0.80	3.20	4.00
III	0.75	3.00	3.75
IV	0.70	2.80	3.50
FY – 2004 – 2005			
I	0.65	2.60	3.25
II	0.60	2.40	3.00
III	0.55	2.20	2.75
IV	0.50	2.00	2.50

c) Delivery of meters at company store: with in 30 June, 2002.

d) Engagement of contractors for installation: with in 15 July, 2002.

e) Installation begin: 1 Aug, 2002.

f) Installation to be complete: 31 March 2003.

The procurement of the meter has been completed in 2003 June but the installation is not still started

2) Privatization of meter reading, billing and collection of Bills to qualified private parties:

   a) This activity is planned to be implemented in four (4) areas, two (2) inside metropolitan Dhaka and two (2) outside metropolitan Dhaka. The two areas outside metropolitan Dhaka will be suitably chosen from Tongi, Savar, Joydevpur and Mymensingh areas. The two areas within metropolitan Dhaka will be suitably chosen from Uttara, Gulshan, Banani and Uttar– Dhakin Khan areas. Some of the above areas would require proper pipeline isolation from adjoining areas, which in turn would involve certain physical modifications of the distribution network. The tendering for engagement of private concerns would need to undergo administrative approval process and the award to successful firms will be with in 31 March 2003. This is however not achieved.

3) Action program to meet TNGDP loan covenants: Loan No. 1293 – BAN(SF):

   Upon due examination by Asian Development Bank (ADB) the loan No. 1293 – BAN (SF) was issued providing for fulfillment of the following actions:-

   a) Increased in the assessed volume of gas consumed by non-metered domestic Consumers (basis rate) by a minimum of 20 percent. To achieve that the basis-rate will reflect the actual consumption by domestic consumers a further increase in the basis rate will be made before the end of 2004.

   b) Increased disconnection of delinquent customers.
   c) Repair and testing of the existing meters.

   d) Gradual installation of about 60,000 (sixty thousand) gas meters under the project as a first phase beginning with households that share the use of their kitchen with other households.

e) Privatization of meter reading, billing, collection and gas consumption assessment with powers of disconnection in gas management zone, i.e. delineated districts with known gas quantities supplied and consumed, following an auction among qualified private parties.

11 2.2 Meter Selection, Replacement And Maintenance

a) As per customer load Diaphragm Displacement meter should use with G-rating range G-1.6 to G-10 with maximum operating pressure 0.5 bar gauge.

b) Rotary Meter should be used with G-rating ranges G-10 to G-65 with maximum operating pressure 4 bar gauge.

c) Turbine Meter should be used with G-rating ranges G-40 to G-6500 and higher with maximum operating pressure 70-bar gauge.

d) Orifice Meter should be used where flow is steady and where are contractual obligation for using orifice as a billing meter like Individual Power Producer (IPP), gas intake metering station and custody transfer points.

e) It is advisable to use a rotary meter instead of a diaphragm meter when the customer demand load is G-10, and a use a turbine meter instead of a rotary meter for customer demands G-40 and G-65.

f) Each department should select the meter such that the meter digit should not turn over within one year.

g) The selected meter hourly load should not be less than the customer minimum gas demand.

h) Meter should be selected on the basis of minimum outlet pressure. If there are chances to increase the pressure then it is advisable to use a sonic nozzle down stream of the meter.

i) At the time of visiting customers RMS if it is seen from the index reading or from EVC logging data that the customer gas uses or load exceeds 120 percent of the customer approved maximum load. Then it is obligatory to use a sonic nozzle in the meter run.

j) Dual index type meter like mechanical index with read contact switch for EVC and mechanical index with proximity sensor or slot sensor for flow computer can be use.

k) Disorder meter should be replaced with a new one with in three working days.

l) Meter with G-rating higher than G-65 should be calibrated in the field at least one time every year.

m) Meter more than 10 years old should be replaced with a new one.

n) Meter less than 05 five years old can be repair with calibrated spares to use for 10 years.

11.2 3 Pipe Line Development Project

Construction of 1" to 8" × 116 km Distribution line will be completed with company's own financing at Muktagacha, Sarishabari, Kaliganj, Hazratpur and Bibirbazar of Keraniganj thana, Kamrangirchar area of Dhaka city, Savar, Gouripur/Shambhuganj and Monohardi industrial area including 1" - 6" × 60 km at Brahman Baria area under gas Distribution project.

11.2.4 Installation Of A Electronic Type Index

Mechanical index type of meters is used in the existing metering system. In this type of measuring module there are some fixed and changed gears. Delinquent customer's changes this changed gears matching mesh of the two gears and slow down the meter permanently. This is a problem for the existing metering system, which can be minimized by installing electronic type index system or a dual type index system..

11.2.5 System And Management Activities

The management of the company initiate various programmes such as: improvement of the existing gas marketing process for better customer services, installation of domestic meters at customer premises, increase the number of offices under metro Dhaka and regional sales divisions, to install pre-paid meter, construction of customers gas line by firms acceptable to the company as well as customers, training of officials, recruitment of experienced manpower for improving customers services, modification of CGS/TBS/DRS for adequate gas supply to new customers, elimination of low pressure problems, arrangement for gas bill payment through the bank/credit card using web site information.

Though enough efforts have been under taken to reduce system loss, expected result could not however be achieved due to shortage of efficient manpower, absence of congenial working atmosphere, inadequate logistic support, construction of by-pass line by dishonest customers, illegal re-connection from disconnected risers, unauthorized use of gas/load/installation, CMS and meter tampering etc.

CHAPTER – 12

DISCUSSION, CONCLUSION AND RECOMMENDATION

Purchase point gas metering orifice meters with three-pen chart recorder are used as a fiscal meter. The gas flow rate is calculated from this chart by manual calculations. So there may have chances to commit an error. Flow computer with electronic transmitter are not used to minimize this error. Since a large amount of gas is purchased, a very small error will cause big amount of gas loss gain. For bulk customers, gas metering turbine meter with a two-pen chart recorder are used and gas flow are calculated manually. Flow computer with electronic transmitters are not used to get better accuracy.

Sometimes due to third party damage or in the case of an under or over sized meter, un-metered gas passes through the CGS, TBS and DRS to the sales system or area and input to that region are not correctly measured, rather an estimation is made from the past use.

Measurement uncertainty of the meter and the secondary instruments are not included in the system loss calculation formula or process. But as per the internationally accepted formula or practice this should be included in the system loss calculation process.

Line packs of TGTDCL gas system are not calculated on daily or monthly basis. The change of line pack is not included in the system loss calculation process. But as per the internationally accepted formula or practice this should be included in the system loss calculation process. Leakage, purges, vented are not calculated and included in system loss calculation process but this should be included. Companies own use is not recorded correctly. Some of the places there are no meters to measure gas flow. Estimation is made for this purpose.

The main parts of the system losses are from the non-bulk customers. And all of these losses are pilferage loss by so many indigenous method as described earlier. Sometimes TGTDCL officials are related to these offences. Regionwise gas network isolation is not completed. And region wise input – output calculation are not adopted with responsibility of the regional manager.

Present administrative reforms are not favourable to reduce system loss. At the same time, the presently political powered CBA system is not favourable to reduce system loss.

12.1 Conclusion

It is clear that the main part of the system loss is pilferage loss. TGTDCL undertook a number of programs to reduce this evil practice. But every time the company failed to reduce the system loss within the internationally accepted level (± 2%) and in TGTDCL it (system loss) is always more than 8%.

It is thought that within the Semi-Governmental administrative reforms, technical ability and CBA activity of TGTDCL it is not possible to reduce system loss to the desired level.

Therefore, it will be wise to transfer the transmission portion of the company to GTCL and isolate the distribution network region wise with improving the existing metering system as discussed in Chapter – 09 and divide the company into few smaller companies. Eventually, then smaller companies may be privatized.

Profit oriented goal of the private company may be able to reduce the system loss to the internationally accepted level

12.2 Recommended Action Program To Reduce System Loss

The following action programme can be made to reduce system loss:-

- Formation of a system loss monitoring cells with appropriate manpower also extended and strengthens the activity of UFG reduction monitoring cell. Survey of actual number of different categories of live customers to ascertain the extent of unauthorized usage of gas. Identification of load intensive customers like lime, glass, re-rolling mills etc. and analysis of their operational behavior and gas consumption pattern Load approval and re-approval should be on the basis of this consumption pattern Assessment of the actual gas use pattern by domestic customers through consumption survey by installation of meters at selected locations. And flat rate gas bill should be declare on the basis of this assessment.

- Market area isolation for off-transmission and off-distribution networks. Metro Dhaka distribution system/sub-system isolation and input-output analysis. Allocation of clear responsibility to metro Dhaka zone/sub-zone and regional distribution offices for gas input-output balance through complete system isolation

- Improvement of the existing metering system by installation of a cabinet type RMS for industrial and commercial customer with EVC with the gas meter and a sonic nozzle in the metering run.

- Formation of a taskforce to assist the UFG monitoring cell with appropriate manpower and equipment. Vigorous and frequent inspection of customer premises by taskforce with high official of the company is to be made at regular interval.

- Rationalization of consumption patterns of customers. Ensuring effective magistracy support for customer control. Strengthening legal services. Public motivation/awareness campaign through mass media about ways and means of gas use and avoid loss.

- Streamlining meter reading collection activities. For system balance calculation of CGS, TBS, DRS gas flow rapid collection of meter reading is essential.

- Introduction of effective punishment system in the form of transfer, suspension, and dismissal, as appropriate for the company employees found responsible for increase of system loss. Introduction of suitable reward system in the form of extra-gratia, cash award, promotion, honour awards, as appropriate, for the company employees contributing to the reduction of system loss. Ensured regular transfer of longtime jobbers in particular fields. Suspend the action of collective burgeoning agent.

- Up-gradation of all bulk metering installations (Purchase and sales meters). Distribution leakage survey. In this context assessment of existing cathodic protection (CP) system and necessary up-gradation activities should be made to reduce leakage. Establishment of a sound line pack calculation method with a software development. Creation of a systematic condensate accounting and reporting method and its equivalent gas calculation procedure.

- Inspection teams to find out unauthorized gas use by industrial and commercial and domestic customers both in Metro-Dhaka and outside Metro-Dhaka area. Customer meters older than ten (10) years can be gradually replaced and those older than five (05) years are brought under accuracy checks. Strengthened the activity of disconnection team to disconnect of delinquent customers by magistracy support.

- Modernization of customer RMSs with utmost pilferage protection. Establishing a comprehensive customer inspection and monitoring process. Modernize of daily and monthly gas accounting and reporting procedures. Up-grade the regional input metering station and metering system isolation. Conducting a comprehensive customer and load survey.

- Installation of further domestic meters after proper evaluation of the out comes of the program at hand (60,000 meters). Engagement of expatriate consultants to under takes the appropriate works as a package of the above activities.

- Gas Act covering the additional require legislation should be prepare. This will include the following. Expedite the recovery of unpaid bills. Empower gas transmission and distribution companies to disconnect delinquent/nonpaying consumers and limit jurisdiction of civil courts to issue injunctions preventing disconnection in such cases. Provide assistance for effecting disconnection of delinquent/nonpaying consumers. Criminalize theft of gas and tampering with gas meters, etc. including punishing abettors. Empower personnel of private meter reading, billing, and collection companies to have access to the premises of consumers. Administrative action such that the company can be benefit from the legislation.

- A customer database should be prepared. Update the customer ledger and expedite the revenue collection.
- Transfer transmission portion with bulk-customers to GTCL. Regional wise isolate the company and make a number of small company and then sale this small company part by part to private owners.

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APPENDIX – A

System Loss Calculation Procedure

Sl. No.	Item	Amount
1.	Gas Purchase	
2.	Own use	
3.	Net throughput (1-2)	
4.	Sale	
(a)	Power	
(b)	Fertilizer	
(c)	Industrial	
(d)	Commercial	
(e)	Seasonal	
(f)	Domestic (Metered)	
(g)	Domestic (Single burner)	
(h)	Domestic (Double burner)	
(i)	Condensate (equivalent)	
5.	Unaccounted for Gas (3-4)	
6.	Technical System loss (Estimated)	
7.	Dom. Tarift loss	
8.	Total (6 + 7)	
9.	Net UFG due to non-Tech loss (5-8)	

APPENDIX – A

Statement of Gas Delivery/Input to the Non-Bulk Sector for the FY 2002-2003

I By Netting off Method (NOM)

Sl. No.	Particulates	Months												
		July	Aug.	Sept	Oct.	Nov.	Dec	Jan.	Feb	Mar.	Apr	May	June	Total
1	Total Gas purchased from fields/other sources	578.11	601.39	563.72	619.513	579.738	608.97	615.51	579.7	604.99	626.19	619.94	598.55	7196.32
2	Company's own use for system operation	0.472	0.381	0.318	0.315	0.33	0.371	0.424	0.38	0.315	0.464	0.417	0.416	4.639
3	Net throughput in the Transmission System = (1)–(2)	577.63	601.01	563.4	619.162	579.408	608.6	615.08	579.32	604.67	625.73	619.53	598.13	7191.68
4	Sales to Power stations	309.91	282.26	257.63	291.935	260.155	272.11	274.99	263.28	289.8	308.47	288.48	291.77	3390.77
5	Sales to Fertilizer Plants	68.341	120.55	110.14	120.689	108.263	125.11	116.71	115.25	123.5	111.72	113.5	89.664	1323.45
6	Total Sales to Bulk Sector = (4) + (5)	378.25	402.81	367.77	412.624	368.418	397.22	391.7	378.53	413.3	420.19	401.99	381.43	4714.22
7	Total Delivery/ Input to Non-bulk Sector=(3) – (6)	199.38	198.2	195.64	206.538	210.99	211.38	223.38	200.79	191.37	205.55	217.54	216.7	2477.46

APPENDIX – A

Statement of Gas Delivery/Input to the Non-Bulk Sector for the FY 2002 - 2003

II. By Source Summation Method (SSM)

Sl. No.	Particulars	Delivery pressure (psig)	Months												
			July	Aug.	Sept	Oct	Nov	Dec	Jan.	Feb.	Mar.	Apr.	May	June	Total
01	CGS Demra (TGTDCL)	300/150	59.695	58.93	56.694	66.459	65 923	66.44	77.317	67.463	54.98	57.14	66 406	53.789	751.236
02	CGS Demra (BGSL)	300/150	27 59	28.343	26 858	27.236	25.933	27.071	26.529	25.005	31.565	27.458	31.741	44.304	349.233
03	CGS Joydevpur	150	59.041	61.79	58.542	62.87	63 039	62.187	67.833	63.197	62.521	65.899	67 35	65.783	760.052
04	TBS Tarabo	150	17.038	17.362	16.861	17.722	17.761	16.468	18.616	17.193	15 582	18.698	19 655	18.421	211.377
05	TBS Dhanua	150	1.407	1.536	1.521	1.57	1.983	1.875	2.316	2.363	2 282	2 64	2 803	3.131	25.427
06	TBS Elenga	150	9.202	9.39	8.889	9.541	9.294	9.233	10.147	9.48	9.181	9 791	10 043	9.482	113.673
07	TBS Shiddhirganj	150	11 078	10.182	10.675	6.207	9.979	11.323	8.411	7.658	4.789	14 586	6 86	5.464	107.212
08	DRS B. Baria	50	1.85	1.858	1 783	2.001	1.936	3.191	4.125	4.125	4.125	2.685	3.192	2.043	32.914
09	DRS Ashuganj	50	0.161	0.264	0.25	0 223	0.223	0 237	0.25	0.215	0 237	0 236	0 249	0 239	2 784
10	DRS APS (Dom.)	50	0.053	0.043	0 041	0.044	0.045	0.048	0.05	0.043	0.043	0.041	0.043	0.041	0.535
11	DRS ZFCL (Dom.)	50	0.154	0.102	0.095	0.102	0.104	0.12	0 131	0 111	0.104	0 105	0.118	0 09	1 631
12	DRS B. Bazar	50	0.913	0.887	0 834	0 921	0.928	0.969	0.962	0 873	0.711	0.873	0.881	0.897	10 649
13	DRS Narsingdi	50	4.15	3.013	2.58	2.928	3.136	0.159	0 357	2.87	3 179	3 179	3.179	3 179	37.909

Contd.

Sl No.	Particulars	Delivery pressure (psig)	Months												
			July	Aug.	Sept.	Oct.	Nov.	Dec	Jan.	Feb.	Mar.	Apr.	May	June	Total
14	DRS UFFL (Dom.)	50	0 15	0.144	0.148	0.156	0.168	0.18	0.194	0.16	0.161	0.161	0.175	0.163	1 96
15	DRS Madhabdi	50		2.677	2 911	3.019	3.362	3.08	3 081	3.061	3.08	3.257	3.348	3.209	34.055
16	DRS Sonargaon	50	1.797	1 829	1.817	1.577	1.773	2 05	2.225	2.308	2.323	1.568	1 852	1.889	23.008
17	DRS HPS (Dom.)	50	0.009	0.009	0 009	0.015	0.014	0.016	0 017	0.015	0 016	0.019	0.021	0 021	0.181
18	DRS Mymensingh	50	1 022	1.023	1.06	1.131	1.163	1.267	1.339	1.159	1.128	1 111	1.153	1.127	13.683
19	DRS Bhaluka	50	2.031	1.963	1.97	2.001	1.869	1.614	1.894	1.764	1.617	1 832	1 903	1.871	22 336
20	DRS Gaffargaon	50	0.054	0.059	0 064	0.066	0.066	0.083	0 083	0.074	0.088	0.079	0.088	0 13	0.934
21	DRS Trishal	50													
22	DRS Kishoreganj	50	0.369	0.391	0.389	0.416	0 428	0.48	0.516	0.446	0.454	0 513	0.461	0.464	5.327
23	DRS Netrokona	50													
24	DRS Jamalpur	50	0 356	0.37	0.346	0.384	0.39	0.431	0.47	0 413	0.422	0.422	0.435	0 413	4.852
25	DRS Sherpur	50													
26	DRS FCL (Dom.)	50	0.05	0.05	0 044	0.05	0 053	0.06	0 066	0.055	0 048	0.049	0 05	0.047	0 622
27	**Total Delivery/Inpur to the Nun-bulk Sector**		199.48	203.42	159.54	207.71	210.509	212.48	231.2	211.34	200	213.48	223.44	217 59	2526.19

APPENDIX – A

Overall Gas Input, Sales and UFG in the Non-Bulk Sector

Sl. No.	Particulars	Months												
		July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb	Mar.	Apr.	May	June	Total
(a)	a) Net throughput (overall T&D System)	577.633	601.011	563.403	619.162	579.408	608.599	615.082	579.322	604.671	625.73	619.526	598.129	7191 68
(b)	b) Gas input (non-bulk)*	195 49	199.352	191 629	203.556	206 298	204.74	226.858	207 113	196	209 37	218.971	213.245	2472.62
(c)	Gas sold (non-bulk)	147 174	158.643	148.77	150.748	152.609	153.193	157.025	162 81	148.145	163 901	164 368	169.73	1877.12
c.1	Metered	97.421	108.565	99.035	100.713	102 276	102.687	106.326	111.861	96.858	112.1	112.248	117 187	1267.28
c.2	Un-metered	49.753	50.078	49 735	50.035	50 333	50.506	50 699	50.949	51.287	51.801	52.12	52.543	609 839
(d)	Gross UFG = (b) – (c)	48.316	40.709	42.859	52 808	53.689	51.547	69.833	44.303	47.855	45.469	54 603	43.515	595.506
(e)	Gross UFG as % of (a)	8 36%	6.77%	7.61%	8.53%	9.27%	8.47%	11.35%	7 65%	7.91%	7.27%	8.81%	7.28%	8 28%
(f)	Gross UFG as % of (b)	24.72%	20.42%	22.37%	25.59%	26 02%	25.18%	30.78%	21.39%	24 42%	21.72%	24.94%	20.41%	24.08%
(g)	Tech. loss = 1.25% of (b)	7.22	7.513	7.043	7 74	7.243	7.607	7.689	7.242	7 558	7.822	7.744	7 44	89.898
(h)	Loss due to improper dom. tariff base	1 515	1.523	2.069	2.08	2 09	2.098	2 105	2.114	2.125	2.144	2.155	2.17	24.188
(i)	Net UFG = (d)–(e)–(f)	39 581	31.673	33.747	42.988	44.356	41.842	60.039	34 947	38.172	35.503	44.709	33.868	481.425
i.1	Net UFG as % of (a)	6.85%	5 27%	5.99%	6 94%	7.66%	6 88%	9.76%	6.03%	6.31%	5.67%	7 21%	5.66%	6.69%
i.2	Net UFG as % of (b)	20.25%	15.89%	17.61%	21.19%	21.50%	20.44%	26 47%	16.87%	19.48%	16.96%	20.42%	15 88%	19.47%

(*) SSM figures of Annex Table – 1, slashed down by 2%

Appendix – B

Action A.1: Improvement of Area Wise Input Metering

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Field survey and identification	■												--	• Operations • Planning
(b) Fixing/refixing with ex-stock meters and accessories		■											--	
(c) Procurement of requisite no. of new metering equipment		■	■	■	■	■							USD 1.0 Million	
(d) Upgradation with new metering equipment							■						--	
(e) Continued input metering		■	■	■	■	■	■	■	■	■	■	■	--	
													USD 1.0 Million	

APPENDIX – B

PROGRAMME BUDGET

Sl. No.	Description		FEX (mill USD)	LC (Mill Tk.)
01	Procurement of metering equipment for improvement of input measurement	(Procurement)	1.00	--
02	Procurement of metering equipment for improvement of customers end measurement	(Procurement)	3.00	--
03	Extensive Leakage Survey	(Services)	0.50	--
04	Cathodic Protection Survey	(Services)	0.50	--
05	Pipeline re-habilitation	(Procurement) (Services)	--	30.00
06	Improvement of odorization	(Procurement) (Services)	0.25	--
07	Creation of Customer Database Facilities	(Procurement) (Services)	0.25	--
08	E-office Management System	(Services)	--	--
09	Assessment of merit of legal suits by Legal Consultants	(Services)	--	1.50
10	Disconnection of delinquent/ defaulting Customers and riser killing	(Services)	--	2.00
11	Implementation of HRD Programme	(Services)	--	2.00
12	Procurement of requisite transport and office Equipment	(Procurement)	--	50.00

Contd.

Contd.

Sl. No.	Description		FEX (mill USD)	LC (Mill Tk.)
13	Development of Media Campaign Programme	(Services)	--	0.50
14	Campaigns in Print/Electronic media	(Services)	--	2.00
15	Opening Company Website	(Services)	--	0.10
		Total:	5.60	88.10
	Above estimated cost of the Programme is equivalent is nearly 4 – 5 months prevailing system loss in monetary terms		= 41.29 Croers (approx)	

Appendix – BI

Action A.2: Improvement of Customer Metering

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Changing meters more than 10 years old	■	■	■				■	■	■	■	■	■	--	• Operations
(b) Calibrating/changing meters more than 5 years old	■	■	■				■	■	■	■	■	■	--	• Operations
(c) Study aimed at identifying, evaluating and developing improved customer metering equipment/ system	■	■											--	• Operations
(d) Procurement of improved metering equipment/ system				■	■	■							USD 3.0 million	• Operations • Admin
(e) Inspection and necessary field sealing/re-sealing of all industrial and commercial customers RMSs	■	■	■	■	■	■	■	■	■	■	■	■	--	• Marketing • Regional Sales
													USD 3.0 million	

Appendix – B

Action A.3: Minimization of Operational Loss

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Extensive Leakage survey													USD 0.5 million	• Operations
(b) Cathodic Protection survey													USD 0.5 million	• Operations
(c) Pipeline rehabilitation													Tk 30.00 million	• Operations • Planning
(d) Improvement of odorization													USD 0.25 million	• Operations
(e) Strengthening pipeline and station maintenance operations													--	• Operations
													USD 1.25 Million + Tk 30.00 million	

Appendix – B

Action B.1: Strengthening of Customer Management

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Creation of Customer Database Facilities			■	■	■	■	■	■					USD 0.25 million	• Finance (CD) • Marketing • Regional Sales • Vigilance
(b) Extensive Customer inspection and analysis			■	■	■			■	■	■	■		--	• Marketing • Regional Sales
(c) Customer load actualization										■	■	■	--	• Marketing • Regional Sales
(d) Customer administration by Grouping customers according to class/type of industries		■	■										--	• Marketing • Regional Sales
(e) Establishing E-office Management System					■	■	■	■	■	■			USD 0.25 million	• Finance
													USD 0.30 Million	

Appendix – B

Action B.2: Time Bound Programme Administration

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Development and implementation of System Loss Accounting procedure		▬											--	• Marketing • Regional Sales • Vigilance • Operations
(b) Identification of factors responsible for system loss in sales areas against input		▬	▬										--	• Marketing • Regional Sales • Vigilance
(c) Submission of quarterly import/collection reports				▬	▬	▬	▬	▬	▬	▬	▬	▬	--	• Marketing • Regional Sales • Vigilance
													--	

Appendix – B

Action B.3: Customer Administration Drive

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Vigilance of load intensive customers		■	■	■	■								--	• Marketing • Regional Sales • Vigilance
(b) Assessment of merit of legal suits by legal consultants		■	■	■	■	■							Tk 1.50 Million	• Secretariat • Regional Sales • Marketing
(c) Out of Court settlement of appropriate cases		■	■	■	■	■	■	■	■	■	■	■		Existing Committee
(d) Aggressive pursuance for withdrawal of injunctions		■	■	■									--	• Secretariat
(e) Disconnection of delinquent/defaulting customers and riser killing			■	■	■	■							Tk 1.50 Million	
													Tk. 3.50 Million	

Appendix – B

Action C.1: Restructuring Company Organization/Methods

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Implementation of need based organogram along with detailed job description													--	• Admin. • Committee
(b) Implementation of Strong organizational set-up for Time bound Action Programme													--	
(c) Implementation of revised delegation of authorities													--	
(d) Strengthening general office Management System													--	

Appendix – B

Action C.2: Augmenting Manpower and Logistics

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Disposal of long outstanding promotion cases	▬	▬											--	• Admin.
(b) Recruitment of necessary and appropriate manpower				▬	▬	▬	▬						--	
(c) Development of comprehensive Human Resource Development programme	▬	▬	▬	▬									--	
(d) Implementation of HRD programme			▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	Tk 2.00 million	
(e) Procurement of requisite transport and office equipment				▬	▬	▬	▬						Tk 50.00 million	
													Tk 52.00 million	

Appendix – B

Action C.3: Media Campaign and Customer Relation

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Development of campaign programme and materials	▬	▬					▬	▬					Tk 0.50 million	• Secretariat
(b) Campaign in Print and Electronic media on gas safety and loss/wastage control			▬	▬	▬	▬			▬	▬	▬	▬	Tk 2.50 million	
(c) Opening Company Website			▬	▬									--	• Finance (Computer Dept)
													Tk 2.50 million	

Appendix – B

Action C.3: Media Campaign and Customer Relation

Description of Sub-task	FY 2003 – 2004				FY 2004 – 2005				FY 2005 – 2006				Budgetary involvement	Responsible Div
	I	II	III	IV	I	II	III	IV	I	II	III	IV		
(a) Development of campaign programme and materials	▬	▬					▬	▬					Tk 0.50 million	• Secretariat
(b) Campaign in Print and Electronic media on gas safety and loss/wastage control			▬	▬	▬	▬			▬	▬	▬	▬	Tk 2.50 million	
(c) Opening Company Website			▬	▬									--	• Finance (Computer Dept)
													Tk 2.50 million	

APPENDIX – C

2.1 Terminology

In order to understand the fundamental of gas measurement or metering and system loss the following terms and definitions are necessary. Some of these terms are discussed below:-

2.1.1 Gas

Gas is one of the three natural states of mater-solid-liquid-gas. It has neither shape nor volume that is independent of the container in which it is restrained.

2.1.2 Natural Gas

Natural gas is a mixture of hydrocarbon and non-hydrocarbon gases found in the porous geological structure of the earth. The main component of Natural gas is methane gas.

2.1.3 Pressure

Pressure is the force extorted on a unit area, i.e. pounds per square inch, bars, kilogram per square centimeter.

2.1.4 Atmospheric Pressure

The pressure extorted by the atmosphere at the surface of the earth is due to the weight of air. This generally recognized as 14.73 psia or 30″ of mercury.

2.1.5 Gauge Pressure

Gage pressure is the pressure measured above the local atmospheric pressure.

2.1.6 Absolute Pressure

Absolute pressure is the total pressure measured from zero pressure at the datum point. When its pressure exceeds the local atmospheric pressure it can be regarded as the sum of the local atmospheric pressure and the gauge pressure.

2.1 7 Vacuum

Vacuum is a condition in which the pressure is always less than the local atmospheric pressure.

2.1.8 Differential Pressure

Differential pressure is the difference between two pressures.

2.1.9 Static Pressure

Static Pressure is the pressure measured at any point in a vessel or pipe, whether the fluid is still or flowing.

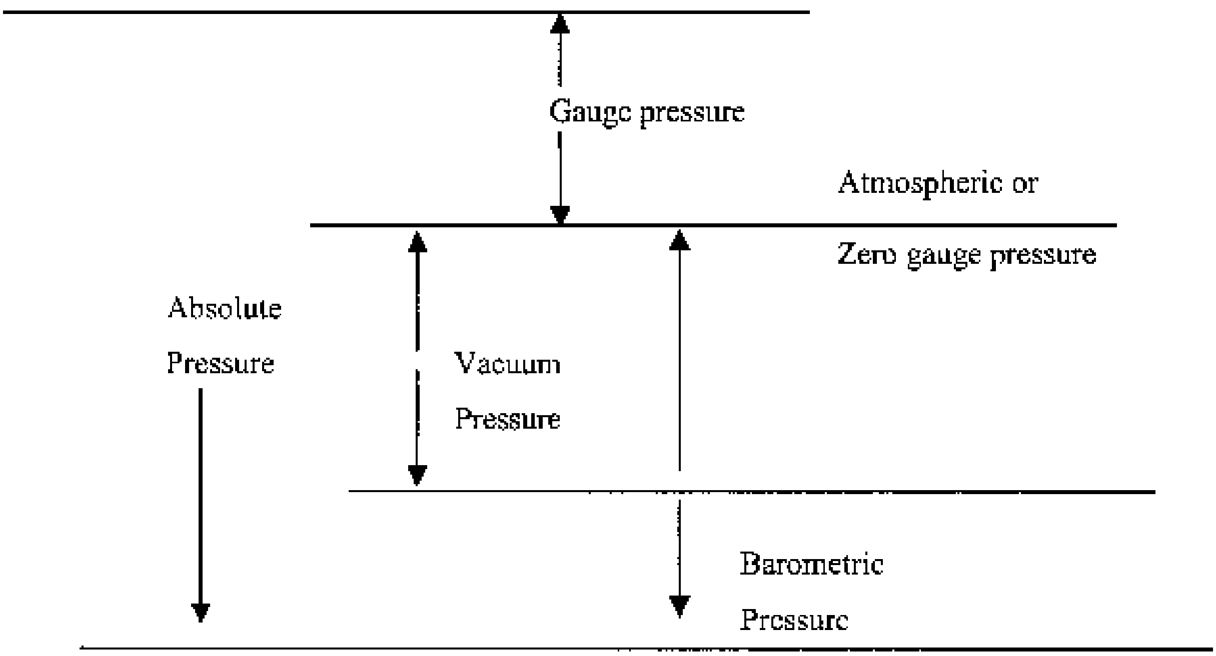

Figure C.1: The relation ship between absolute pressure and gauge pressure

From the Figure C.1: It is clear that

Absolute pressure = Gauge Pressure + Atmospheric Pressure.

2.1.10 Temperature

Temperature is the degree of heat or cold measured with respect to an arbitrary zero.

2.1.11 Ambient Temperature

Ambient temperature is the temperature of the surrounding air.

2.1.12 Absolute Temperature

Absolute temperature takes as its zero-minus 273.15 degrees C (centigrade) or minus 459.67 degrees F (Fahrenheit). This is transcribed as – 273 degrees C and – 460 degree F for engineering calculations. The absolute scales of temperature are Kelvin for degree C and Rankine for degrees F.

Absolute temperature must be used in all calculations relating to the gas law equations.

2.1.13 Zero Absolute Temperature

Absolute zero temperature is the point at which all-molecular activity ceases.

2.1.14 Volume

Volume is the product of refined measurements taken in three directions each at right angles to the other two.

2.1.15 Specific Volume

Specific volume is the volume of a specific weight of the fluid. It is the volume per unit mass.

2 1 16 Mass

Mass is the quantity of matter in a body. It is measured in any convenient unit i.e. pounds mass or kilograms mass.

2.1.17 Specific Weight

Specific weight is the weight of a unit volume of a substance.

2.1.18 Density

Density is the mass of a substance per unit volume.

2.1.19 Specific Gravity

The specific gravity of a fluid is the ratio of the weight of a specified volume of one fluid to the weight of an equal volume of a second (reference) fluid. Both fluids must be at the same temperature and pressure condition.

2.1.20 Mol – Volume

The mole-volume is the volume of a gas that will have a weight equal numerically to its molecular weight.

2.1.21 Compressibility

Compressibility is the ability of a material to reduce in volume when subjected to an increase in pressure.

2.1.22 Super Compressibility Ratio

Super compressibility ratio is the factor used to reflect the difference between the theoretical specific weight of a gas proportional to absolute pressure and the actual specific weight, temperature remaining constant.

2.1.23 Cubic Feet

The measurement of gas volume of the Imperial system.

2.1.24 Cubic Meters

The measurement of gas volume of System International (SI) standard or system.

2.1.25 Standard Pressure

The standard base pressure is generally recognized as 14.73 psia or 1 0136 Bara.

2.1 26 Standard Temperature

The standard base temperature is generally recognized as

60 degrees F
15.5556 °C
520 degree Rankine.

2 1.27 Compressibility Factor

For non-ideal gases, which include all natural gases, a dimensionless factor is added to this gas law. This correction factor z, known as the compressibility factor, compensates for variations from the ideal gas laws under conditions of high pressures and high and low temperature.

2.1 28 Measurement

The determination of the existence or magnitude of a variable.

2.1.29 Accuracy

Accuracy is how close to true from the meter can measure. This is usually stated in percentage value.

2.1.30 Flow Range Or Rangability

This is the ratio of maximum and minimum flows over which the meter will maintain the specified accuracy or linearity.

2.1 31 Linearity

Linearity is the ability of a meter to maintain a constant calibration factor throughout its specified flow range.

2.1.32 Pulse

A pulse represents only a small incremental volume of flow. For a turbine meter as each of the magnets pass the coil a separate and distinct voltage pulse is created.

2.2 33 Pulse Density

The quantity of pulses generated by a meter for a given volume of throughput.

2.1.34 Repeatability

Repeatability is a meter's ability to replicate the same reading each time, given that the same flow conditions exist.

2.1.35 Resolution

The resolution of a meter is its ability to measure small increments of total flow.

2.1.36 Totalizer

A mechanical or electronic device for integrating and displaying the volumetric throughput of a flow meter.

2.1.37 Calibration

It means that compare the value or instrument with a standard.

2.1.38 Alarm

Advice or function that signals the existence of an abnormal condition. It can be visual or audible, and its purpose is to attract the attention of the operator.

2.1.39 Controller

A device that varies the output in order to regulate a controlled variable in a specific manner.

2.1.40 Control valve

A device that directly manipulated the flow of one or more fluid process streams.

2.1.41 Converter

A device that receives information I one form of instrument signal, and change it into another.

2.1.42 Function

The purpose or action performed by a device.

2.1.43 Identification

A sequence of letters or numbers used to designate an individual instrument or loop.

2.1.44 Instrument

A device used directly or indirectly to measure and/or control a variable.

2.1.45 Instrumentation

A collection of instruments.

2.1 46 Local instrumentation

Refers to an instrument operating at the point of use.

2.1.47 Loop

A combination of instruments or control functions arranged so that signals is passed from one to another.

2.1.48 Manual Loading Station

A manually adjusted controller with a variable output signal.

2.1.49 Measurement

The determination of the existence or magnitude of a variable.

2.1.50 Monitor

A general term for an instrument used to sense the magnitude or status of one or more variable.

2.1.51 Panel

A structure that houses a number of instruments together with operator and process interfaces, and internal wiring.

2.1.52 Pilot Light

A lamp that indicates a normal condition relating to an individual instrument or group of instruments.

2.1.53 Primary element

A sensor.

2.1.54 Process

An operation or sequence of operations involving a change when compared to the original datum.

2.1.55 Process Variable

Any change other than instrument signals.

2.1.56 Relay

A device that passes on information in an unchanged form.

2.1.57 Scan

To sample in a predetermined manner each of a number of variables.

2.1.58 Sensor

The part of a loop or instrument that first encounters the value of a process variable and determines a corresponding output.

2.1.59 Set Point

An input variable that determines the value of the output variable.

2.1.60 Switch

A device that connects, disconnects, selects or transfers one or more circuits.

2.1.61 Test-Point

A process connection to which no instrument is permanently attached.

2.1.62 Transducer

A device that receives information in the form of one or more physical quantities and converts the information and produces an output signal.

2.1.63 Transmitter

A device that responds to a process variable through a sensor and has an output, which varies in relation to the process variable.

ABBREVIATIONS

1. CGS = City Gate Station
2. TBS = Town Bordering Station
3. DRS = District Regulating Station
4. CMS = Customer Metering Station
5. RMS = Regulating and Metering Station
6. M&R = Metering and Regulation
7. VS = Valve Station
8. PS = Power Station
9. API = American Petroleum Institute
10. ANSI = American National Standard Institute
11. AGA = American Gas Association
12. ISO = International Standard Organization
13. ASME = American Society of Mechanical Engineers
14. ASTM = American Standard Testing Materials
15. IGE = International Gas Engineers
16. OIML = Organization International Metrology Legal
17. TGTDCL = Titas Gas Transmission and Distribution Company Limited
18. BGFCL = Bangladesh Gas Field Company Limited
19. SGFCL = Sylhet Gas Field Company Limited
20. GTCL = Gas Transmission Company Limited
21. BGSL = Bakhrabad Gas Systems Limited
22. JGTDSL = Jalalabad Gas Transmission and Distribution System Limited
23. CNG = Compressed Natural Gas
24. LNG = Liquefied Natural Gas
25. LPG = Liquefied Petroleum Gas
26. ADB = Asian Development Bank
27. PDB = Power Development Board
28. APS = Ashuganj Power Station
29. GPS = Grorashal Power Station

NOMENCLATURE

Symbol	Represented Quantity	Units
D	Internal pipe bore or diameter	Inch
d	Orifice plate bore	Inch
C_d	Discharge co-efficient	
C	Speed of sound	ft/sec
d	Relative density	
E_V	Velocity of approach factor	
F_b	Basic orifice factor	
F_r	Reynolds number factor	
F_{gr}	Relative density factor	
F_{PV}	Super compressibility factor	
F_{Pb}	Pressure base factor	
F_{tb}	Temperature base factor	
F_{tf}	Flowing temperature factor	
GC	correction factor	
hw	Differential pressure (inches of water at 60^0F)	inch H_2O
K	Pulse per volume	
k	isentropic exponent	
M	Molar mass	Kg.Kmol
m	Mass of gas	Kg
n	Numbers of moles	mol
n_{CO_2}	CO_2 concentration of sample % (mol)	mol%
n_{N_2}	N_2 concentration of sample % (mol)	mol%
P	Absolute pressure	psia
Q	Flow rate	ft^3/sec
Q_f	Flow rate at flowing conditions	ft^3/sec
q_v	Volume flow rate at actual conditions	ft^3/sec
q_b	Volume flow rate at base conditions	std.ft^3/sec

R_a	Universal gas constant	
Re	Reynolds number	
R_{eD}	Reynolds number referenced to pipe diameter	
R_{ed}	Reynolds number referenced to orifice bore	
S	Compressibility ratio	
T	Absolute gas temperature	^{o}R
t	Time	sec
V	Volume at P and T	ft^3
V_b	Volume at base condition	ft^3
W	Wobbe index	MJ/ ft^3
X_i	Mol fraction of ith component in mixture	
Y	Expansion factor	
y_i	Mol fraction of any component in the vapor phase	
Z	Compressibility factor	
β	Beta ratio d/D for orifice plate	
ε	Expansion factor	
γ_D	Expansion co-efficient of pipe material	
γ_D	Expansion co-efficient of orifice material	
ΔP	Differential pressure	inch of WIC
ρ	Density at P and T	lbm/ft^3
ρ_a	Density of air	lbm/ft^3
ρ_g	Density of gas	lbm/ft^3