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# Evaluating the Technical Challenges of River Crossing for the Bakhrabad-Siddhirganj Gas Transmission Pipeline Project.

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## ABSTRACT

This paper presents the results of a study focused on the recently constructed 60 km X 30 inch Bakhrabad-Siddhirganj gas transmission pipeline. It was laid from Bakhrabad gas field, Comilla, to Siddhirganj power station, Narayanganj. It was commissioned by Gas Transmission Company Limited (GTCL). Despite meticulous planning, the pipeline had to cross six rivers of various depths and widths. Horizontal Directional Drilling (HDD) technology was used for all river crossing projects. This study attempted to categorize the challenges in terms of the nature of the problems and their reasons, frequency, degree of severity etc. The problems identified included the Right-of-Way (ROW), selection of crossing point, sub-soil investigation and selection of work procedure, pipe mis-alignment, delay in rig mobilization, stuck pipe, magnetic interference in pilot hole, and buoyancy control. The challenges and remedial measures of the six projects are briefly discussed in this paper.

**Keywords**: Gas Transmission Pipeline, River Crossing, HDD method, RightofWay, Stuck pipe

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# 1. INTRODUCTION

Water course crossing is a unique and difficult component of pipeline construction projects. It requires devoted crew and specialized equipment, specific engineering design and specific planning and regulatory approval. Pipelines are used for a number of purposes [1]. These include gas, oil and water lines. Bangladesh government took steps to supply gas to the existing and upcoming power plants in the eastern side of Dhaka i.e. to Meghnaghat, Haripur and Siddhirganj areasthrough a 60kmX30″ pipeline from Bakhrabad gas field. This pipeline project is implemented by the state owned organization Gas Transmission Company Limited (GTCL) and financed by the World Bank. [3] . This study identifies and analyse the challenges and their respective mitigation measures taken for all six river crossings. This study also categorises the challenges based on the degree of difficulties and the frequency of occurrences [2] .

# 1. HORIZONTAL DIRECTIONAL DRILLING (HDD)

HDD is a steerable trenchless method of installing underground pipes, conduits and cables in a shallow arc along a prescribed bore path by using a surface-launched drilling rig, with minimal impact on the surrounding area. Trenchless methods, which have been progressing rapidly in the last few decades, provide efficient alternatives that overcome most or all of these challenges; they are usually less expensive and faster to conduct, they reduce or eliminate the traffic congestion that lead to business interruption and higher exhaust emission [3].

## 2.1 HDD METHODOLOGY FOR PIPELINE INSTALLATION.

The oil, gas and petrochemical industries are an important market for the HDD industry. For pipeline construction, major water crossings, swamps and environmentally sensitive areas pose significant challenges. Utility companies now use HDD extensively for installation of power, natural gas, water, sewer and telecommunication. Recent advancements in equipment and tracking systems make the use of HDD cost-efficient for projects that involve larger products and stricter placement tolerances. The tasks associated with the HDD project are shown in Figureure.1 [4].

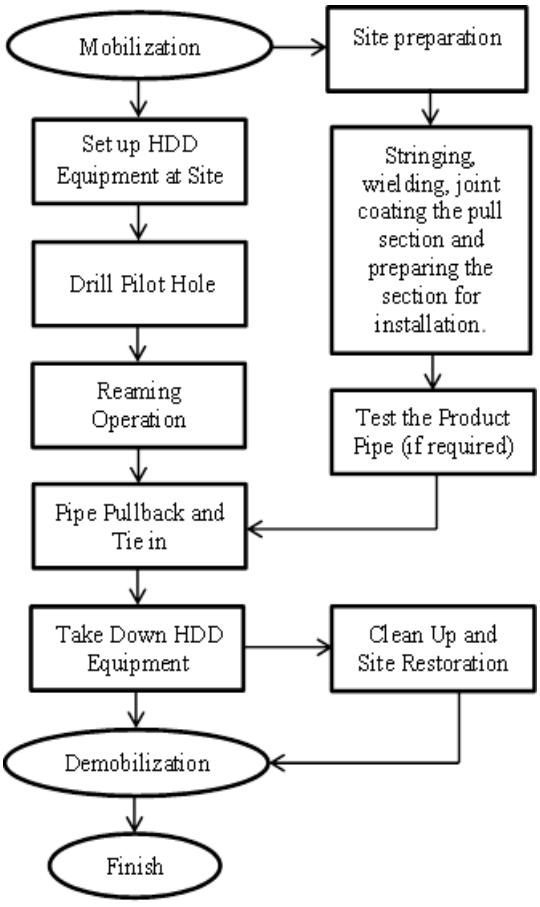


Figure 1. Task associated with HDD projects [4].

# 2. CASE STUDIES

The pipeline in question has a maximum capacity of 600 MMscfd with operating pressure of 1000 psi.A 60km X 30″ pipeline route is selected, considering minimum effects on the existing structures, roads, rivers etc. [2]. There are six rivers across this pipeline route as mentioned in Table 1.The challenges and their mitigation measures for all six river crossing are presented in the following sections.

Table 1.River crossings by HDD method for Bakhrabad- Siddhirganj pipeline [5]

| SL. No. | Name of the River | Crossing Length (meter) | Location |
|---|---|---|---|
| 1 | Shitallakhya River | 556.32 | Siddhirganj power plant, Narayanganj |
| 2 | Old Brahmaputra River | 665.41 | Langolbondth, Bandar, Narayanganj |
| 3 | Kajla River | 657.84 | Meghnaghat, Sonargaon, Narayanganj |
| 4 | Meghna River | 1593.18 | Meghnaghat, Sonargaon, Narayanganj |
| 5 | Asharier River | 856.80 | Bhabanipur, Gazaria, Munshiganj |
| 6 | Meghna-Gomuti River | 1941.87 | Daudkandi, Comilla |

## 3.1 SHITALLAKHYA RIVER CROSSING

**Challenge:** During erection of the power plants, 22m steel sheet piles were driven as embankment protection on both sides of the Shitallakhya river. The presence of ferrous object created magnetic interference with the steering tools of HDD.

**Mitigation of Challenge:** To avoid magnetic interference, Tru-Tracker guidance method was used. Typically the Tru-Tracker is used for land segment and the in-hole steering tool is used under river steering. The steering system gives the driller information of drilling bit or jet in reference to ground level in terms of depth, azimuth and inclination and these data are cross checked with the Tru-Tracker readings. The final profile was verified from the data generated by the surveying software.

## 3.2 OLD BRAHMAPUTRA RIVER CROSSING

**Challenge:** Entry and exit point of pipeline route on the bank of Old Brahmaputra river was found 34ft offset from each other during survey for drilling profile design.

**Mitigation of Challenge:** Old Brahmaputra riverruns between two upozillas of Narayanganj district. Both side of the river was accorded 8m wide land strip for ROW. However, there was a 34ft mismatch between the two sides of the river. To minimize the mismatch effect, drill entry point was shifted to left by approximately 20ft. It required acquiring new land as shown in Figure.2, and the remaining 14ft mismatch was adjusted from the bottom of the river by applying curved crossing method.

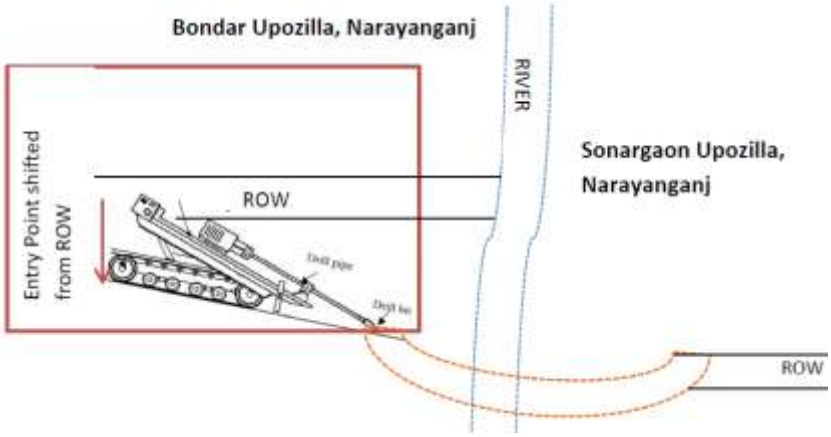


Figure 2. HDD entry point shifted 20ft from ROW

## 3.3 KAJLA RIVER CROSSING

**Challenge:** Straight ROW was not available due to Tengarchar village. Only 200m straight ROW was available instead of 700m for pipe string preparation from designed exit point. Bundle pulling also stuck up due to curvature of the pipe string.

**Mitigation of Challenge:** A temporary ROW with curvature was selected such that Tengarchar village was not affected. This temporary ROW was rented on monthly basis from land owner. During pipe string preparation it was kept sand stacked at the outer side of the curve segment to protect the village.


Figure 3 (a). Pipe pullback preparation at curve segment

Three site booms each having 90Tons capacity were used at the outer side of the curvature segment for lifting pipe and also to neutralize the centrifugal effect during pipe pullback operation as shown in Figure.3(a). The pipe string was bent with approximately 90-100° curvature. Due to this high curvature, the 30″ product pipe was rotated while pulling.Due to this rotation, the 6″steel conduit was also rotated over the 30″ product pipe in a helical shape. It touched the borehole wall and risked borehole collapse. To avoid this, the 6″ steel conduit was disconnected from the pull head for risk free HDD execution as shown in Figure.3 (b). Only the 30″ product pipe was pulled until the leading end of the product pipe reached the surface entry point. Separate borehole was created by pilot drilling 1.5m away from product pipe borehole. The 6″ conduit pullback was completed separately.


Figure 3(b). 6″ Steel conduit disconnect from pulling head at kajla river

## 3.4 MEGHNA RIVER CROSSING

**Challenge:** Difficulties of HDD pipe string preparation due to non-availability of straight ROW. It was necessary to prepare approximately 1.62km of one continuous straight 30″ pipe string, but only 800m was available.

**Mitigation of Challenge:** Three sides of the Meghnaghat power plant area is surrounded by the Meghna and the Asharier river. The entrance side is connected with Dhaka-Chittagong national highway. The other side of the Meghna riveris densely populated, and the Kajla river flows within 1km from the Meghna river bank. The 800m long segment of the 30″ pipe string was prepared by welding on site. Remaining part of the pipe string was divided into 21 short sections, each consisting of 3 pieces of 30″ pipe. These were fabricated near the bank of the Asharier rive by welding as shown in Figure.4 (b).

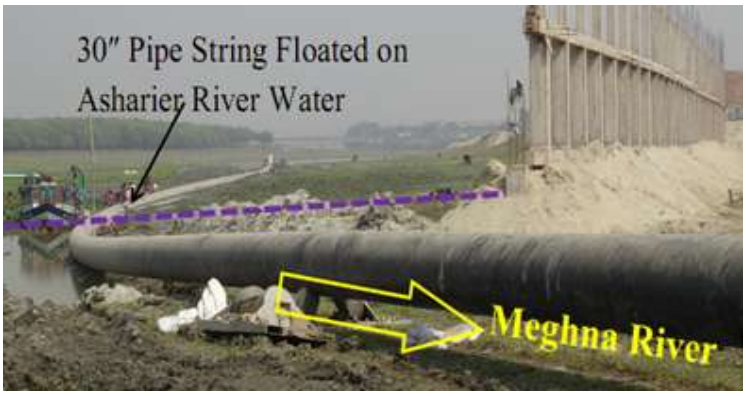


Figure 4(a). Pipe string of Meghna river floated on Asharier river

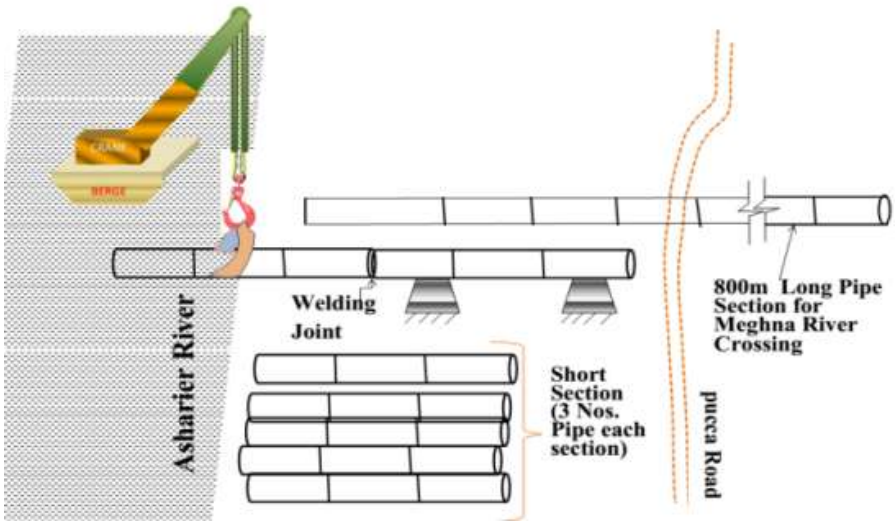


Figure 4 (b). 30″ Pipe string preparation on Asharier river water

A berge was used on the Asharier river with one crane and anchored near the bank where short sections were fabricated. One short section was lifted by crane and aligned with the next short section that was positioned on land by supports as shown in Figure.4 (b). Then the bergewas moved towards the trail end. The next short section was fitted with the previous section and the same procedure repeated up to 21st short section. Thus it was possible to make the required 1.62km long single pipe string as shown in Figure.4 (a).

## 3.5 ASHARIER RIVER CROSSING

**Challenge:** Rig site of Asharier river crossing was selected inside marshy agricultural land and there was no road communication to move the rig unit and accessories.

**Mitigation of Challenge:** Water way was the only option to mobilize the rig unit and accessories. 100m x 50m land area was developed by river sand.A temporary ramp and a jetty were constructed on the bank

of the Asharier river for unloading the rig unit and its accessories from the berge as shown in Figure.5 (a) and (b).

Figure.5 (a). Rig Unit mobilization by Barges


Figure 5(b). Rig unit unload arrangement from barges.

## 3.6 MEGHNA-GOMUTI RIVER CROSSING

**Challenge-1:** Stuck reamer at 690m from exit point.

**Mitigation of Challenge-1:** Sub soil investigation report claimed silt sand under Meghna-Gomuti river. A 24″ fly cutter type reamer was used together with a 16″ barrel type reamer to enlarge the borehole after the pilot hole as shown in Figure.6 (a). The reamer assembly got stuck inside the bore hole at 680m from the drill exit point. In the retrieval process, rig machine was given thrust towards exit point by drill pipe and at the same time vibrating hammer was used togive jerking load from exit site for shaking off the reamer. Excavator and side boom was connected with vibrating hammer by wire rope that pulled the entire stuck section towards exit point as shown in Figure 6(b). This procedure was continued until the

reamer assembly reachedthe drill exit point.

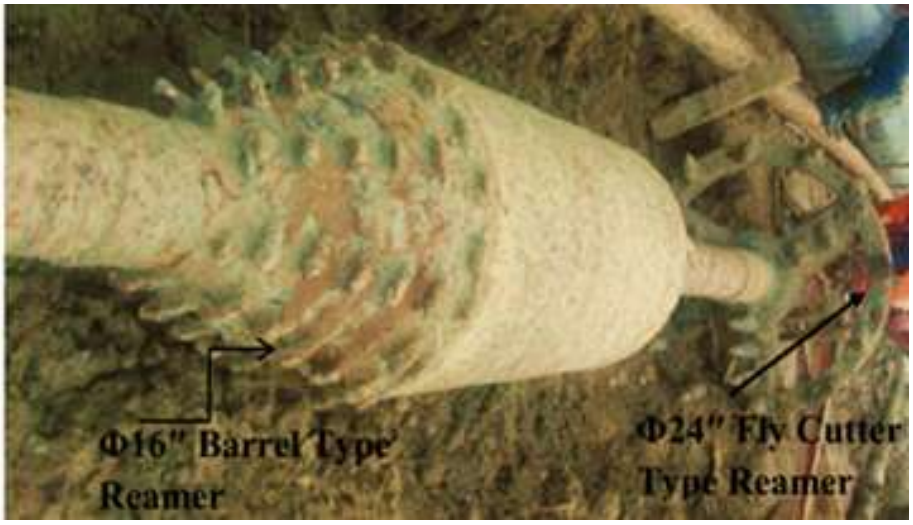


Figure 6 (a). Fly cutter and barrel type reamer assembly for 24″ reaming.

Figure 6(b). Vibrating hammer assembly at drill exit site

**Challenge-2:** Stuck up reamer again at 1,246m from exit site, retrieval using donut wiper and vibrating hammer technique.

**Mitigation of Challenge-2:** Using wire line pilot hole process, the existing bore hole was retraced and surveyed. Second step reaming operation was commenced with the same reamer combination as shown in Figure.7. Reamer got stuck again at 1,246m from the exit point. A special donut wiper with inner diameter of 32″ and jets pointing to the stuck pipe was fabricated on site as shown in Figure.7.

Figure 7. Donut wiper assembly

The donut was then hooked to high pressure bentonite pump and was pushed down with rig using 30° rocking motion. This removed the collapsed soil from the pipe. Additional drill pipes were added just as in drilling procedure and the donut was run as far as it could go, which was approximately 300m. Vibrating hammer was connected with trail end of drill pipe by a swivel. Rig machine gave thrust towards exit point by drill pipe and at the same time vibrating hammer provided jerking load from the exit site for shaking the reamer.

## 3. SUMMARY OF CASE STUDIES

This study reveals that ROW related challenges were most common during river crossing by HDD method. Problems included ROW mismatch, magnetic interference, non-availability of straight ROW,and higher entry/exit angles. These could be avoided by proper planning at the time of route survey. Some challenges such as buoyancy control during pipe pullback, reamer type and combination selection were not avoidable due to uncertainities. However, these are also possible to minimize by selecting appropriate process/method based on site condition. List of major challenges and their impact are described in table 2.

Table 2. Case studies summary table.

| Type of Challenge | Degree of Difficulty | Frequency of Occurrences | Remarks |
|---|---|---|---|
| Stuck up drill pipe | Severe | 2 | Uncertain |
| ROW related problem | Moderate | 4 | Avoidable |
| Pipe string preparation | Difficult | 1 | Avoidable |
| Rig mobilization | Moderate | 1 | Not avoidable |

# 4. CONCLUSION

This study identified four types of major challenges faced during six river crossing projects.It is found that ROW and crossing point selection are the most common problems, which are avoidable by careful planning. The second kind of challenges includes different type of process selection based on site condition i.e. reamer type and combination selection, buoyancy control method etc. These challenges are possible to resolve during HDD execution period by selecting correct process/method depend on site condition, sub soil investigation reports etc. This study should help in better designing, implementation and troubleshooting of the future river crossings by HDD method in Bangladesh perspective.

# NOMENCLATURE

| | |
|---|---|
| BHA | Bottom Hole Assembly |
| GTCL | Gas Transmission Company Limited |
| HDPE | High Density Poly Ethylene |
| HDD | Horizontal Directional Drilling |
| MOP | Maximum Operating Pressure |
| MMscfd | million Standard cubic foot per day |
| ROW | Right-of-Way |

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# Rules and Regulation of Transmission and Distribution of Natural Gas and its Application in Bangladesh

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## ABSTRACT

Gas transmission & distribution system are gas pipeline system and associated facilities designed for gas supply to consumers. Gas transmission & distribution system is a link between gas fields and gas consumers. In Bangladesh there are 21 operating gas filed producing nearly 2700 MMSCFD gas. There are total 23733.1 Km pipe line ( Transmission- 2536.26km, Distribution -2,371.80 km, Feeder Main and Service line- 16,609.52 km, Others-2001.95 km) supplying natural gas to nearly 3332966 (Captive Power-1477, Power-81, Fertilizer-9, Industrial- 5976, Commercial – 17865, CNG-572, Domestic-3306890 and Tea-96) legal customers and more than 300000 illegal customer in Bangladesh daily. During legal connection, customers the rules and regulation for transmission & distribution of natural gas sometime applied but in illegal connection, the customers as well as the contractor ignore rule and regulation, which may cause an accident in the energy industries. The government should take necessary steps to stop illegal gas connection as well as ensure the safety of the legal transmission & Distribution line.

**Key Words**: Natural gas, Transmission & Distribution, Rules & Regulation, Illegal Connection.

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# INTRODUCTION

Natural gas has powerful importance according to its economic and environmental benefits. It is one of a major source of electricity among energy sources of coal, nuclear and petroleum. The importance of natural gas is that when it burns, it releases cleaner energy than dirty coal and other polluting energy resources. In addition, if natural gas is used widely in the world, pollution that causes global warming during the combustion will be less and our world will be livable. Positive environmental effects and several possible applications of natural gas will make this energy source increasingly important to meet demand of energy in many countries in the world. [1]

Bangladesh is highly dependent on indigenous natural gas for its primary energy supply as well for power generation. Indigenous natural gas resources provide approximately 72% of Bangladesh's commercial energy supply and imported oil provides the balance [1]. Natural gas contributes to over 62 % of power generation capacity and approximately 39.46% of natural gas production is used for centralized power generation while fertilizer (6.33%), industry (16.42%) and commercial/households (14.89%) and captive power generation (16.87%) are the other major consumers of natural gas.[3,5]

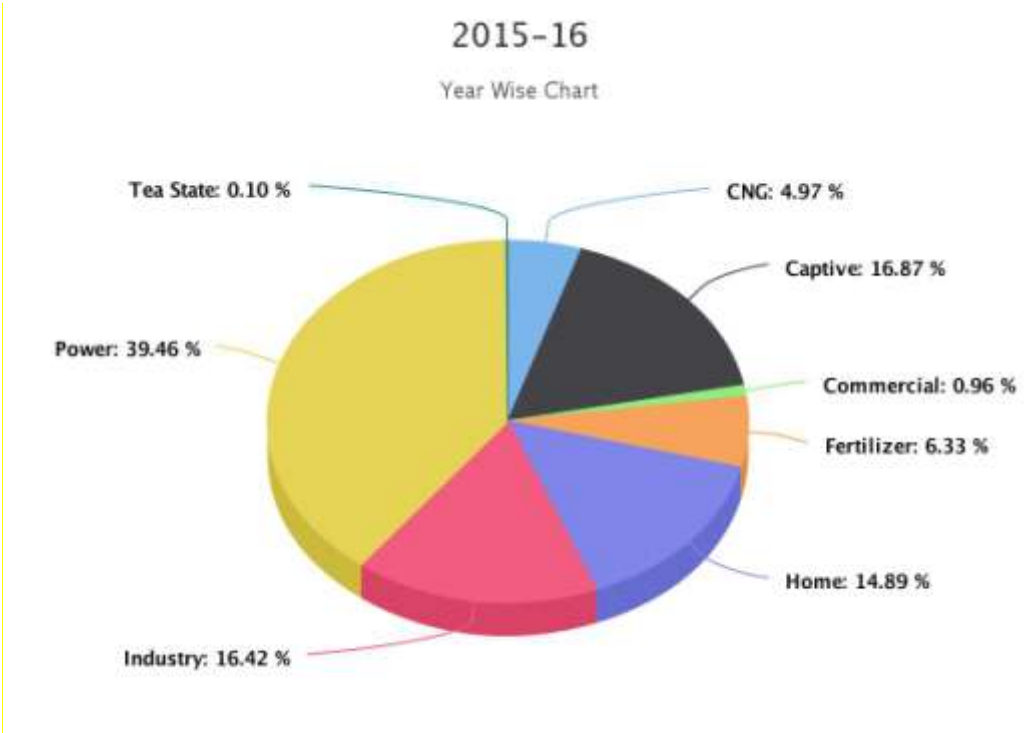


Figure 01: Natural Gas Used in Different Sector in Bangladesh [5]

The user of the natural gas are located more than 100 km away from the filed produce. Transmission and distribution of natural gas is not an easy task because several law, rules and regulation are needed to flow during transmission or distribution of natural gas. The following laws are most common in Bangladesh.

## TRANSMISSION AND DISTRIBUTION

Gas transmission and distribution system is a gas pipeline system and associated facilities designed for gas supply to consumers. A gas transmission system is a link between gas fields and gas consumers.

Transmission pipelines carry natural gas across long distances and occasionally across interstate boundaries, usually to and from compressors or to a distribution center or storage facility. Transmission lines are large steel pipes (usually 2" to 42" in diameter; most often more than 10" diameter) that are federally regulated. They carry unodorized gas at a pressure of approximately 200 to 1,200 psi.[6]
Distribution pipelines, also known as "mains," are the middle step between high pressure transmission lines and low pressure service lines. Distribution pipelines operate at an intermediate pressure. This type of pipeline uses small to medium sized pipes (2" to 24" in diameter) that are federally regulated and carry odorized gas at varying pressure levels, from as little as 0.3 up to 200 psi [2,6]. Distribution pipelines typically operate below their carrying capacity and are made from a variety of materials, including steel, cast iron, plastic, and occasionally copper.

## NATURAL GAS TRANSMISSION AND DISTRIBUTION LINE IN BANGLADESH

There are 26 discovered gas field in Bangladesh among 21 are at operated condition producing nearly 2700 MMSCFD gas and 13000 BBL condensate which is less than our total demand per day [19] . There are 13 companies operating under Petrobangla, dealing in oil and gas exploration (mainly BAPEX) , production (BAPEX, BGFCL, SGFL), transmission (GTCL,TGTDCL,JGTDCL) distribution (TGTDCL,BGDCL,JGTDCL,PGCL,KGDCL,SGCL) , conversion(RPGCL) as well as development and marketing of coal and granite (BCMCL,MGMCL) [18]. There are total 23733.1 Km pipe line ( Transmission- 2536.26km, Distribution -2,371.80 km, Feeder Main and Service line- 16,609.52 km, Others-2001.95 km) [13] supplying natural gas to nearly 3332966 (Captive Power-1477, Power-81, Fertilizer-9, Industrial- 5976, Commercial – 17865, CNG-572, Domestic- 3306890 and Tea-96) legal customers and more than 300000 illegal customer in Bangladesh daily [7,8,9,10,11,12].

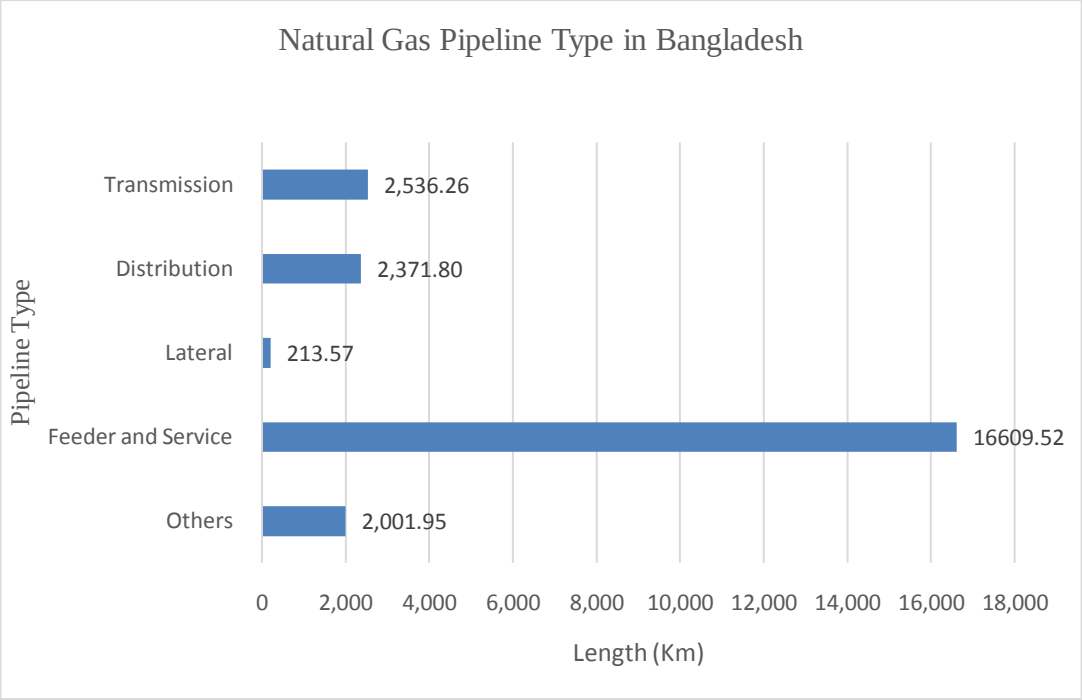


Figure 02: Natural Gas Pipeline Type in Bangladesh [13]

Table 01: Number of customer list by company and sector. [7, 8, 9, 10, 11, 12].

| Company Name | Customer Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Captive Power | Power | Fertilizer | Industrial | Commercial | CNG | Domestic | Tea |
| Titas Gas T & D Co. Ltd (June 2015) | 1080 | 35 | 3 | 4590 | 10913 | 331 | 1880353 | 0 |
| Bakhrabad Gas Distribution Company Ltd.(June 2016) | 76 | 18 | 1 | 159 | 2140 | 89 | 487036 | 0 |
| Jalalabad Gas T & D System Ltd. (April 2016) | 108 | 14 | 1 | 101 | 1692 | 56 | 221718 | 94 |
| Pashchimanchal Gas Co. Ltd, | 36 | 7 | | 78 | 332 | 28 | 118982 | - |
| Karnafully Gas Distribu tion Co. Ltd., (May | 177 | 5 | 4 | 1048 | 2786 | 68 | 595801 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2016) | | | | | | | | |
| Sudarban Gas Co. Ltd. | | 2 | | | 2 | | 3000 | 0 |
| **Total** | **1477** | **81** | **9** | **5976** | **17865** | **572** | **3306890** | **96** |

# LAW, RULES, REGULATIONS AND STANDARDS REGARDING TRANSMISSION AND DISTRIBUTION IN BANGLADESH

Transmission and distribution of natural gas is not an easy task because several law, rules and regulation are needed to flow during transmission or distribution of natural gas. The following laws are most common in Bangladesh.

1. Carbide Rules 2003
2. Explosive Act 1884
3. Gas Cylinder Rules 1991
4. Natural gas safety Rules 1991
5. Natural gas safety Rules 2003
6. Petroleum Rules 1937
7. CNG Rules 2005
8. LPG Rules 2004

**Pipeline Materials, Design and Construction**

During transmission or distribution of natural gas, the company need to flow the following steps.

**I. General properties of Pipe line Constructing Materials:**

The pipe materials has following properties [14, 15]

a. The property of pipe materials cannot change with temperature
b. The pipe materials cannot attain any chemical reaction with transferring gas or liquid

**II. Pipe Standardization:** [14, 15]

a. If the pipe recognised standard specification it may be used steel, plastics or other materials
b. Must fulfil API code
c. The standardized pipe used in past may be used.

**III. Pipe Design:** [14, 15]

a. The design parameters for steel pipe will be determined in accordance with the following equation

$$P = 2St/D \times F \times E \times T$$

Where

P = Internal Design Pressure, psig; S = Specified minimum yield strength, psi; D = Nominal outside diameter of the pipe, inches; t = Specified wall thickness of the pipe, inches; F = Design Factor determined according to 49 CFR 192.111; E = Seam joint factor determined according to 49 CFR 192.113; T = Temperature factor determined according to 49 CFR 192.115

b. The design parameters for Plastic pipe will be determined in accordance with the following equation

$$P = 2St/ (D-t) \times 0.32$$

Where

P = Internal Design Pressure, psig; S = Specified minimum yield strength, psi; D = Nominal outside diameter of the pipe, inches; t = Specified wall thickness of the pipe, inches

**IV. Pigging System:** [14, 15]

a. All 300-psig transmission or main line must have pigging system
b. For offshore pipeline there must have two pigging platform.

**V. Valve attachment:** [14, 15]

a. In populated area within 10 km and other place 30 km.
b. Must have control ability easily
c. Should be protected from any hazard

**VI**. **Compressor station Design**: [14, 15, 16]

a. Compressor station constructed by anti-firing materials
b. Compressor station must 20 m away from restricted building
c. Positioning Valve, Meter, and electric circuit within compressor station must follow Petroleum Rules 1937 (Rule 105)
d. High maintenance capability

**VII. Path design for Pipeline (ROW):** [14, 17]

a. Must be safe for environment
b. Before ROW selection must attain survey (both case)
c. Must maintain minimum land acquisition as below:

Table 02: Minimum land acquisition for pipeline [14, 15]

| Pipe size | 150 psig-300 psig | >300 psig |
|---|---|---|
| <20 inches | 2 m | 3 m |
| >20 inches | 3 m | 3.5 m |

Figure 03: Illegal Gas Connection never flow the Rules and Regulation [4]

d. Plastics pipe must fill up by soil or other materials

e. If anyone break the distance rule take action according to rules Petroleum Act, 1934 (section 23)

**VIII. Minimum depth:** [14, 15]

The pipeline must place below surface area according the table given:

Table 03: The pipeline depth below surface [14, 15]

| External Diameter of Pipe (cm) | Maximum allowable pressure ($kg/cm^2$) | | | | |
|---|---|---|---|---|---|
| | < 7 | 7-9 | 10-15 | 16-24 | >25 |
| | Depth (cm) | | | | |
| <20 | 90 | 95 | 100 | 105 | 110 |
| 21-40 | 91 | 96 | 101 | 106 | 112 |
| 41-60 | 92 | 97 | 102 | 107 | 115 |
| 61-80 | 93 | 98 | 103 | 108 | 120 |
| >80 | 94 | 99 | 104 | 109 | 125 |

Figure 04: Illigal gas connection never flow the Rules and Regulation. [4, 20]

**IX. Pipe line define signs:** [14]

a. Put a red sign which define pipe line not over 500 m in general place and not over 200 m in a densely populated area.
b. Must put sign in a road, pond, river or railroad.
c. In offshore case take extra care of pipe.

**X. Minimum Distance between two pipes:** [14]

a. Minimum 0.5 m distance between two cross over pipeline
b. Minimum 1.5 m distance between two parallel pipeline
c. Try to avoid drainage line.
d. Maximum depth of transmission and distribution line not over 2 m.

**XI. Pipe line welding:** [14, 15])

a. Experienced person are required for pipe welding
b. The welder must have experienced last 6 months welding performance.
c. API standard rule must follow (Rule 1104)
d. Welding pipe must have sustainability above the transmission pressure.

**XII. Pipe line Testing:** [14, 15]

a. When the transmission pressure above 20.5 kg/cm2, for testing need to use water and need to maintain pressure more than 24 hours.
b. When the transmission pressure below 20.5 kg/cm2, for testing water, gas or air may be used and need to maintain pressure more than 24 hours.
c. The testing pressure is 1.25X transmission pressure for beside populated area.
d. The testing pressure is 1.5X transmission pressure for populated area

**XIII. Pipe line Corrosion Remove**: [14, 15]

a. Use proper coating to remove corrosion which are environmental friendly
b. Examine the coating every three years.
c. Need to use cathode protection system within one year (Based on ANSI code 01-72)

d. Check power system within every 75 days
e. Every pipeline must connect a testy rod.

**XIV. Pipe line Management:** [14]

a. After 25 years of construction, test the pipeline within every 5 years.
b. Always transmit gas within the acceptable limit.

**XV. Distribution Rules:** [14, 15]

a. Nobody can storage gas or condensate without storage license by Pressure Vessel rules-1995
b. Condensate storage and transmission based on Petroleum Rules, 1937
c. Acceptable distribution pressure 0.1 kg/cm2 -4.00 kg/cm2
d. Distribution pipe diameter not more than 5 cm
e. Always use safety valve, relief valve for safety.

## CONCLUSION

Energy is the prime factor for developing a country. Without proper rule and regulation, no nation can reach their goal in energy sector as well as economic sector because economic sector directly related with energy sector. For that purpose, the Bangladesh government took some steps to make proper rules such as Carbide Rules 2003, Explosive Act 1884, and Gas Cylinder Rules 1991, Natural gas safety Rules 1991, CNG Rules 2005, and LPG Rules 2004, which has some limitation and less applicity during illegal business. Only the proper rules and government proper steps can develop our energy sector as well as our country.

## ACRONYMS & ABBREVIATIONS

**BAPEX**: BANGLADESH PETROLEUM EXPLORATION AND PRODUCTION COMPANY LIMITED;**BBL**: BARREL; **BCMCL**: BARAPUKURIA COAL MINING COMPANY LIMITED; **BGFCL**: BANGLADESH GAS FIELDS COMPANY LTD; **CNG**: COMPRESSED NATURAL GAS; **GTCL:** GAS TRANSMISSION COMPANY LIMITED; **JGTDCL**: JALALABAD GAS TRANSMISSION AND DISTRIBUTION COMPANY LIMITED; **KGDCL**: KARNAPHULI GAS DISTRIBUTION COMPANY LTD; **LPG**: LIQUEFIED PETROLEUM GAS; **MGMCL**: MADDHAPARA GRANITE MINING COMPANY LIMITED; **MMSCFD**: MILLION STANDARD CUBIC FEET PER DAY; **PGCL**: PASHCHIMANCHAL GAS COMPANY LIMITED; **RPGCL**: RUPANTARITA PRAKRITIK GAS COMPANY LIMITED; **SGFL**: SYLHET GAS FIELDS LIMITED; **SGCL**: SUNDARBAN GAS COMPANY LIMITED; **TGTDCL**:TITAS GAS TRANSMISSION & DISTRIBUTION COMPANY LIMITED.

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# Working Challenge in Petroleum Industry Due to Heat Stress and Pipeline Leakage; Bangladesh

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## ABSTRACT

Petroleum refining industries are increasing day by day speedily in Bangladesh. This article deals with heat stress and pipeline leakage problem. It is reduced the working ability of the laborers by the cause of the heat stress and pipeline leakage problem that create the numerous losses for industry. In industries during summer season automatically temperature raise due to increasing kinetic energy and pressure of gas and highly heat absorbing pipeline system such as iron. It may rise temperature from 2-3$^0$ C compare with surrounding environment. It is observed that the leakage of the pipeline, storage tank due to the corrosion ,pipeline rupture, connection failure, pinhole, crack, welding effect etc. For the emission of gas such as $CH_4$, $SO_2$, $NO_3$, $NH_3$, $H_2S$, CO, etc, it is occurring breathing problem with product loss, property damage and environmental damage. Pipeline leakage can be protected by catholic protection, using anti-corrosive agents; thermal imaging system, reinforced thermoplastic pipe (RTP) and heat stress can be controlled by high resistance insulator. It is recommended that protecting corrosion of iron pipe replaced by reinforced thermoplastic pipe (RTP), thermal imaging system for controlling pipeline leakage, and reducing heat stress high resistance insulator can be used for petroleum industries in Bangladesh.

**Keywords:** Working ability, Heat stress, Pipeline leakage, Reinforced thermoplastic pipe (RTP), Thermal imaging.

## 1. INTRODUCTION

The heat index specifies thermal comfort. Humidity is a fact for evaporation process and when the relative humidity is elevated the evaporative process is restricted which reduces the cooling effect of perspiration. Climate change imposes impact directly on heat stress and it has significant ramifications for the large workforce employed in diverse industrial settings [1, 2]. The changes of humidity and temperature in the working area due to climate change are the cause of occupational health and work productivity concerns [3,4,5].

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Heat stress is a physical hazard and potential health risk that can lead to a range of conditions from discomfort, headache, syncope, progressive loss of mental alertness, heat stroke and even death in extreme cases [4]. Occupational heat stress for worker's are directly increased by the cause of climate changes that impact on workers health and productivity [1,4,6].According to Bennet and McMichael, heat stress which is the cause of climate changes has negative impact on occupational health and safety [6].Besides damages of pipeline are the major cause of workers and environmental losses. With the damage of environment, it is the causes of productivity losses and hence income loses due to damages of pipeline. Internal and external corrosion of pipeline, rupture of pipeline, wielding affect, natural problem of environment are the main causes of pipeline leakage and failure. Sources of failure include Structural problem 40%, Operator error 6%, others 25%, outside force damage, 27% and lastly Control problems 2% [7].Ikporukpo [8] observed the causes of pipeline leaks versus pipeline ruptures and the proportion for each. In failures resulting in product loss, leaks constituted 86.8% of failures and ruptures 13.2%. Corrosion is the predominant cause of leaks.

# 2. PROBLEM ANALYSIS

### 2.1. Pipe line leakage

Pipe leakage or pipeline failure problem is the most important problem in petroleum industry. There are many factors that are the causes of pipeline leakage. The major causes of failure of pipeline include: Ageing, Corrosion, Mechanical failures – welding defects, pressure surge problems, stress, wall thickness, etc. According to EGIG [9] the causes of gas pipeline accidents are: external interference, corrosion, construction defects, material failure and ground movement. 42% of failures were mechanically induced, 18% by corrosion, third party activity contributed 24%, 10% through operational error and 6% by natural hazards. Figure 1 shows the leakage of pipeline due to corrosion.

Fig 1: Leakage of pipe due to corrosion [39].

A summary of the various causes of oil pipeline failure in the Niger delta region of Nigeria are given in the Table 1.

Table 1: The various causes of oil pipeline failure in the Niger delta region [10].

| Mechanical Failure | Corrosion | Operational Failure | Third-party Activity | Natural Hazard |
|---|---|---|---|---|
| Construction failure | Internal | System | Accidental | Subsidence |
| Material failure | External | Human | Malicious | Flooding |
| Structural failure | | | Incidental | Others |
| | | | Acts of Vandalism | |

**2.2. Heat Stress**

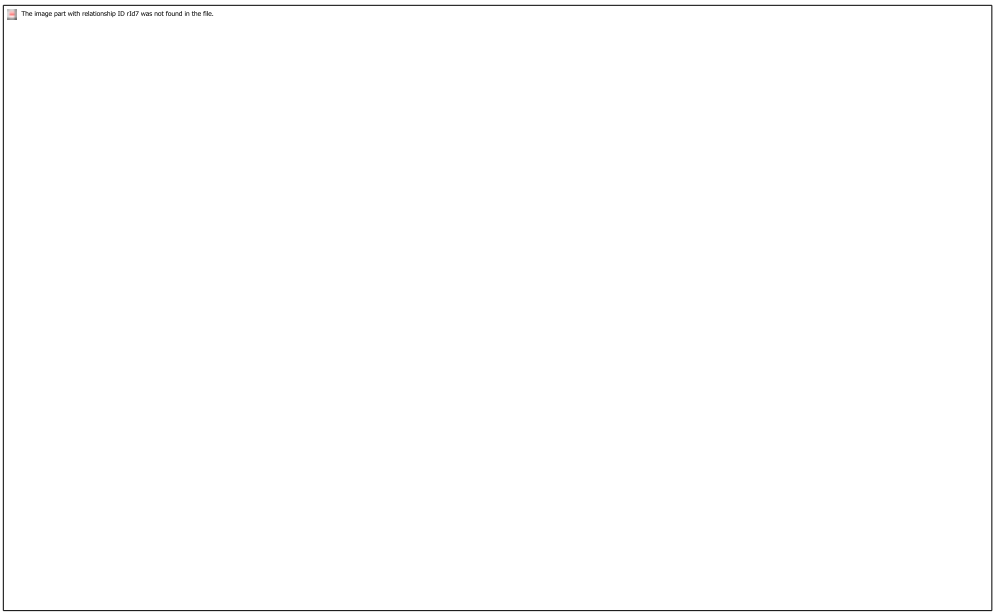
Workers who are exposed to extreme heat or work in hot environments may be at risk of heat stress. Exposure to extreme heat can result in occupational illnesses and injuries. Heat stress can result in heat stroke, heat exhaustion, heat cramps, or heat rashes. Heat can also increase the risk of injuries in workers as it may result in sweaty palms, fogged-up safety glasses, and dizziness The heat stress index is defined as the relation of the amount of evaporation (or perspiration) required as related to the maximum ability of the average person to perspire (or evaporate fluids from the body in order to cool themselves).The heat index point out thermal comfort. The evaporative process is restricted when the relative humidity is raised, which reduces the cooling effect of perspiration. The heat index does not take into account the radiant heat load which is primarily attributed by working in direct sunlight [5,32].

Table.2: Heat index, Risk level due to temperature and workings [11]

| Temperature | Risk Level | Workings |
|---|---|---|
| Less than 33°C | Lower (Caution) | Basic heat safety and planning |
| 33° to 39°C | Moderate | Implement precautions and heighten awareness |
| 39° to 46°C | High | Additional precautions to protect workers |
| Greater than 46°C | Very High to Extreme | Triggers even more aggressive protective measures |

The protective work that's must be done when temperature are raised and its risk level is shown in Table 2 .And heat index chart relative to air temperature and relative humidity are given in the Table 3.

Table 3: Heat Index Chart [11].




# 3. METHODOLOGY FOR IDENTIFICATION OF PROBLEMS

### 3.1. Pipeline leakage identification

Leakage detection types can be different with each other by its application. It can be categorized into mainly optical and non-optical method for detecting pipeline leakage. Acoustic monitoring [12,13] gas sampling [14], soil monitoring [15], flow monitoring [16,17], and software based dynamic modeling [18,19] are the main types of non-optical method for detecting pipeline leakage. According to Reichardt et al., optical leakage detection method mainly two types, active and passive method [20]. Tunable Diode Laser Absorption Spectroscopy (TDLAS) [21], Laser Induced Fluorescence (LIF) [22], Coherent Anti-Raman Spectroscopy (CARS) [23], Fourier Transform Infrared Spectroscopy (FTIR) [24], and evanescent sensing [25] are the types of active system to detect leakage. Thermal imaging [26] and multi-wavelength imaging [27, 28, 29, 30] are the two major types of passive leakage detecting method in petroleum industry. The relative comparison among the detector and detecting techniques are given in the table 4[31].

Table 4: Relative comparisons among the pipeline leakage detection methods [31].

| Detecting Technique | Working Base | Merits | Limitations |
|---|---|---|---|
| Acoustic sensors | Detects leaks based on acoustic emission | 1.Portable<br>2.Location identified<br>3.Continuous monitor | 1. Not suitable for small leaks.<br>2.Prone to false alarms<br>3. High cost |
| Gas sampling | Flame Ionization detector used to detect natural gas | 1.No false alarms<br>2.Very sensitive<br>3.Portable | 1.Time consuming<br>2.Expensive |
| Soil monitoring | Detects tracer chemicals | 1.Very sensitive | 1. Need chemicals and |

| | | | |
|---|---|---|---|
| | added to gas pipe line | 2.No false alarms<br>3.Portable | therefore expensive |
| Flow monitoring | Monitor either pressure change or mass flow | 1.Low cost<br>2.Continuous monitor | 1.Prone to false alarms<br>2.Unable to pinpoint leaks |
| Thermal imaging | Passive monitoring of thermal gradients | 1.No sources need<br>2.Portable<br>3.Remote monitoring | 1. Expensive detector<br>2.Requires temperature difference |
| Multi-spectral imaging | Passive monitoring using multi wavelength infrared imaging | 1.No sources need<br>2.Portable<br>3.Remote monitoring | 1.Expensive detectors<br>2.Difficult data interpretation |

### 3.2. Heat Stress Evaluation:

When heat is absorbed from the environment and the temperature of working area increase at faster rate due to work activity), environmental factors (e.g. air temperature, humidity, air movement, radiant heat), and worker factors (e.g. extent of acclimatization and hydration) then Heat stress occurs [11,32]. The causes of temperature rise are, Environmental Factors(High air temperatures, Low air movement, High relative humidity, Radiant heat from hot objects such as machinery), Employee Factors **(**Incomplete acclimatization**,** Dehydration**,** Excessive or inappropriate clothing**,** Medical Condition**,** Individual Susceptibility {age, overweight, poor physical condition}),Engineering Factors **(**Kinetic Energy of gas**,** Pipeline networking system**,** Heat absorbance capacity of using materials). Wet Bulb Globe Temperature (WBGT) is a portable heat stress monitor, (Quest Temp 34; QUEST Technologies, Oconomowoc, WI, USA), that has an accuracy level of $\pm 0.5^0$C between $0^0$C and $120^0$C of dry bulb temperature and ±5% relative humidity (RH) between 20% and 95% RH measurement. The WBGT shows the four main thermal components affecting heat stress: air temperature, humidity, air velocity and radiation, as measured by the dry bulb, wet bulb and globe temperatures. Many international organizations use WBGT for defining heat exposure thresholds or limits for workers [33,34], and now globally, the WBGT index is the most commonly used heat index in heat stress assessments [3,35,33,34].

## 4. RISK REDUCTION METHODS

### 4.1. Leakage Prevention

Pipeline leakage creates a lot of problem. That's why prevention of leakage problem is an important concern in petroleum industry. Cathodic protection and coating of pipeline are the major types of pipeline leakage prevention due to corrosion. Anti-corrosive solutions using is one of the active way for preventing corrosion. Corrosion is an electrochemical process that leads to destruction of material on the metallic surface. The formula of corrosion is

**Fe (metal)** $\longrightarrow$ **$Fe^{2+}$ (soil) + 2e-**

Pipelines corrosions are endangered by interplay of influences like aggressive substances in the soil, galvanic connectors or sulphate-reducing bacteria in the ground. According to the Canadian Energy

Pipelines Association's fact sheet on corrosion: Cathodic protection is a technique used to control the corrosion of a metal surface by using another piece of metal to draw corrosion away from the pipe through the use of a carefully calibrated electrical current. [36].Coating system is the making an external layer on pipeline as a result, the pipe being protective. Thermal-sprayed aluminum (TSA) and painting are the types of coating system of pipe. TSA coatings have several advantages over organic coatings (conventional paint). The piping is protected against corrosion under insulation (CUI) for a service life of 25 to 30 years instead of 5 to 13, which is usual the limit of an organic coating. Furthermore, after application, conventional paint needs 24 hours to dry, whereas the TSA-coated equipment can be insulated immediately after the treatment. The investment costs are about 1.05 to 1.20 times the costs of conventional painting. Cathodic protection for steel pipe is effective for buried in soil pipeline network while it is limited to surface pipeline network due to safety concern and shortage of catalysts. Also it cannot prevent atmospheric corrosion.

Another process can be adopted that is Reinforced Thermo Plastic pipe instead of steel pipe. It is made of high strength fiber polythene. The relative feature of RTP and Steel pipe are shown in Table 5 [37] .A typical construction of RTP pipe is shown in the Fig 2.

Fig 2: Typical Reinforced Thermoplastic Pipeline (RTP) system for gas distribution construction. [38].

Table 5: Relative feature of RTP and Steel pipe [37]: Legend: + no or favorable impact on quality and safety level; - no or negative impact on quality and safety level.

| Parameter | Steel | RTP |
|---|---|---|
| Cathodic protection monitoring | + | - |
| Susceptible against chemical attack | - | - |
| Susceptible against corrosion | - | + |
| Stresses cause swelling of material | - | + |
| Pressure test | + | - |
| Joint testing | + | - |
| Permeation | + | - |

### 4.2. Heat Stress Control

Increasing of temperature can be control by performing area cooling, shade and shielding, ventilation in the working site area. One of the most important heat stress control process is shade system in the working area. Radiant heat load can be reduced as much as 10°C degrees when working in shade versus the direct sunlight [11,32]. Hot materials in regular working areas are the sources of radiant heat and these should be insulated to reduce heat load. Re-insulation, either temporary- or permanent should be done as soon as possible after repairs. When the work is in one fixed location such as a valve or control box, spot cooling equipment such as misting fans can be utilized. It is so important that the cool air flow streams need to be directed towards the workers and the discharge ducts should be as close as practical to the work area. Increasing airflow through a work area help to increase the evaporation rate and cooling of the people.

## 5. CONCLUSIONS

This study is focused on heat stress due to temperature rising and damages of pipeline. Corrosion is one of the major causes of pipeline leakage problems, make hazards in petroleum industries and a barrier to operate and to make profit with product loss. That's why leakage problem should be prevented. In this case pipeline coating is the satisfied way to prevent leakages of pipeline. Using Reinforced Thermo Plastic (RTP) pipe instead of iron or steel pipe in the petroleum industry is the more effective in pipeline safety concern. Heat stress losses efficiency of workers and hence it is the cause of loss of making profit in the petroleum industry. So temperature control is the major fact in the industry. Shielding on the whole working zone and proper ventilation system are the best way for controlling the temperature and heat stress problems.

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# Bibiyana- Dhanua 137km x 36'' Gas Transmission Line: A Simulation Study and Economic Analysis

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## ABSTRACT

Most of the gas fields in Bangladesh are located in the eastern part of the country. The backbone of gas transmission network started from the Sylhet region to Ashuganj main hub and then to the capital city Dhaka, greater Chittagong region and some western regions like Bogra, Tangail, Rahshahi. Considering the length, the downstream locations face low pressure and inadequate flow problem. In 2014, to overcome this, Gas Transmission Company Limited (GTCL), Bangladesh has set up the largest transmission pipeline Bibiyana- Dhanua (B-D) 137km x 36'' parallel to Bibiyana-Muchai-Ashuganj-Dhanua transmission pipeline. This parallel line will facilitate gas transmission directly from greater Sylhet region to the western part of Bangladesh. Bibiyana is the largest gas field in Bangladesh with 2P reserve of 5.754 TCF as reported by Petrobangla and currently producing 1240MMscfd gas. GTCL has implemented the Bibiyana-Dhanua Gas Pipeline project with an aim of supplying additional gas to greater Dhaka and western regions and thereby, lone dependency on Ashuganj hub will be reduced. Taking into consideration present gas reserve in Bangladesh, the parallel Bibiyana- Dhanua 137km x 36'' pipeline is solely dependent on the reserve of the Bibiyana gas field. B-D line has been designed to handle 640 MMscfd of gas, but currently this pipeline is transmitting around 200-300 MMscfd of gas only. This study focused on a simulation study to find out the maximum gas handling capacity of 36" pipeline for a given upstream and downstream pressure restriction. Based on present gas production from Bibiyana gas field, this study finds the optimum transmission pipeline size for the existing gas supply situation. This study also ends up with an economic analysis to calculate the Net Present Value (NPV) and Benefit Cost Ratio (BCR) of the B-D line project.

**Keywords**: Gas Transmission Line, Economic Analysis, Wheeling Charge

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# INTRODUCTION

Bangladesh is considered a natural gas rich country and 26 gas fields have been discovered in Bangladesh out of which 21 fields are producing gas at present through 102 producing wells [1, 2]. Countrywide total 2740.6 MMscfd gas is supplied through the entire network [1] of over 2406.82 km [3] of pipe. Gas Transmission Company Limited (GTCL), a company of Petrobangla, implemented the Bibiyana-Dhanua Gas Pipeline project. With the implementation of this project, it will be possible to supply added amount of gas to greater Dhaka and western regions. As a result, the lone dependency on Ashuganj hub will be abridged. A 137-km gas transmission line with a 36-inch diameter has been set up over Habiganj, Kishoreganj, Mymensingh and Gazipur districts, including a 67-km Haor area in Habiganj and Kishoreganj districts. The Bibiyana-Dhanua pipeline was commissioned on November 2014. Initially, it was planned to supply around 300 million cubic feet of gas through this pipeline which will gradually rise to maximum 640 million cubic feet every day [4].

Currently, out of 1240MMscfd gas production, Bibiyana Gas Field is delivering around 900 MMscfd gas to North South Pipeline Corridor through North South and Rashidpur –Ashuganj Pipeline and around 300 MMscfd of gas has been transmitted through B-D pipe line to the western zone.

# NETWORK MODELING

A model to simulate pipeline system operation is constructed covering the existing system. For the simulation, virtual network model has been built for existing pipeline network along with extended pipeline by using commercial software "PIPESIM".

A virtual network model comprises of physical model and fluid model. Pressure drop corresponding volumetric flow rate, diameter, wall thickness, efficiency factor etc. are considered to build the physical model. For the simulation, a prerequisite "Black Oil Fluid Model" is defined by the amount of water and liquefiable hydrocarbons along with gas composition. The fluid used in the model is a mixture of natural gas of several gas fields taken from Ashuganj Gas Manifold Station (AGMS) in September 2010 and the defined gas compositions are shown in Table1.

Table1: Composition of the fluid used in the model

| Element | Mole % | Element | % Mole |
|---|---|---|---|
| Nitrogen | 0.331 | n-Butane | 0.086 |
| $CO_2$ | 0.101 | i-Pentane | 0.049 |
| Methane | 96.518 | n-Pentane | 0.032 |
| Ethane | 2.091 | Hexane | 0.092 |
| Propane | 0.458 | Heptane | 0.074 |
| i-Butane | 0.159 | Octane | 0.011 |

Considering the flow characteristics (like turbulent/laminar flow, flow rate, operating pressure, percentage of pressure drop and length/diameter of pipeline) Beggs and Brill Revised Fluid Flow correlation has been used for horizontal flow assuming there is no vertical flow in the network. Subsequently, Panhandle 'B' correlation has also been used for single phase flow considering the fluid is 100% gas. Effect of temperature gradient is not considered.

## MODEL VALIDATION

Before go further with the model network for existing gas transmission pipeline, it is very important to validate the model. For this purpose, simulated pressure data at different junctions, District Regulating Station (DRS) and City Gate Station (CGS) are compared with field data from the existing outlets. The field data is denoted as the data from the Gas Transmission Company Limited (GTCL) data sheet on a specific date.

The simulated and actual pressure data as well as calculated pressure data are plotted in the graph shown in Figure1 to compare with each other at particular off-take/outlet point.

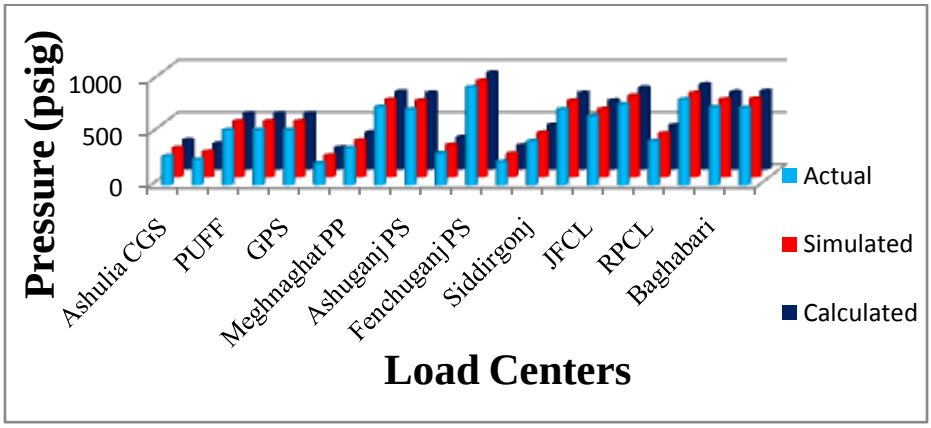


Figure1: Pressure of different demand centers.

The simulated value of gas flow and pressure for different major junctions of the transmission network are also matched with the actual data and presented in table 2.

Table 2: Actual and simulated gas flow, pressure data at major junctions

| Name of the junction | Type | Gas Flow(MMscfd) | | | Pressure (psig) | | |
|---|---|---|---|---|---|---|---|
| | | Actu | Simul | Erro | Act | Simul | Erro |
| Muchai Manifold | Junction | 1123 | 1120 | 0.27 | 1087 | 1085 | 0.18 |
| Ashugonj MS | Junction | 1486 | 1485 | 0.07 | 860 | 855 | 0.58 |
| Bakhrabad Hub | Junction | 850 | 848 | 0.24 | 850 | 848 | 0.24 |
| Elenga TBS | Junction | 85 | 84 | 1.18 | 770 | 765 | 0.65 |

From the comparative presentation shown in the figure 1, it can be said that, simulated value is quite equal to real value, though there is a little variation (in the range of 0.1% - 1.9% error). This variation may be occurred due to the variation of some factors i.e. average temperature, specific gravity, compressibility factor, minor deviation from horizontal pipeline etc. Besides this, there may have some error with field data as, sometimes, calibration and human error are being associated with it. From the table 2, percentage of error/difference between actual and simulated value of gas flow and pressure for different major junctions of the transmission network indicates a good match. So, simulation network model is considered as valid and can be used for further analysis.

## FLOW RATE AND PRESSURE SCENARIO OF THE EXISTING PIPELINE NETWORK WITH 137 KM × 24"OF BIBIYANA- DHANUA PIPELINE

The 137 km× 36" Bibiyana- Dhanua pipeline is designed by GTCL to carry maximum 640 MMscfd of gas. Production capacity of Bibiyana gas field is about 1200 MMscfd and currently this field is producing around 1240 MMscfd [9].So, it can be said that this field is producing at maximum rate and if this gas field continues this plateau rate, it would be possible to produce gas for next 8 years from the remaining reserve considering current reserve to production ratio. It is clear that, Bibiyana gas field is not capable to transmit designed volume of gas through B-D pipeline.

Presently about 260MMscfD gas is supplied through BD line [1].Considering a maximum supply of 350 MMscfd through B-D line, Panhandle B equation shows that 24-inch pipe line is capable enough to meet the present upstream and downstream pressure scenario. In this section, 24 inch instead of 36-inch diameter pipeline is considered for Bibiyana to Dhanua pipeline to check the handling capacity of gas along with pressure at different demand center. The comparison between two cases, the simulated pressure data for 24 inch and 36 inch diameter pipelines is shown in the figure 2.

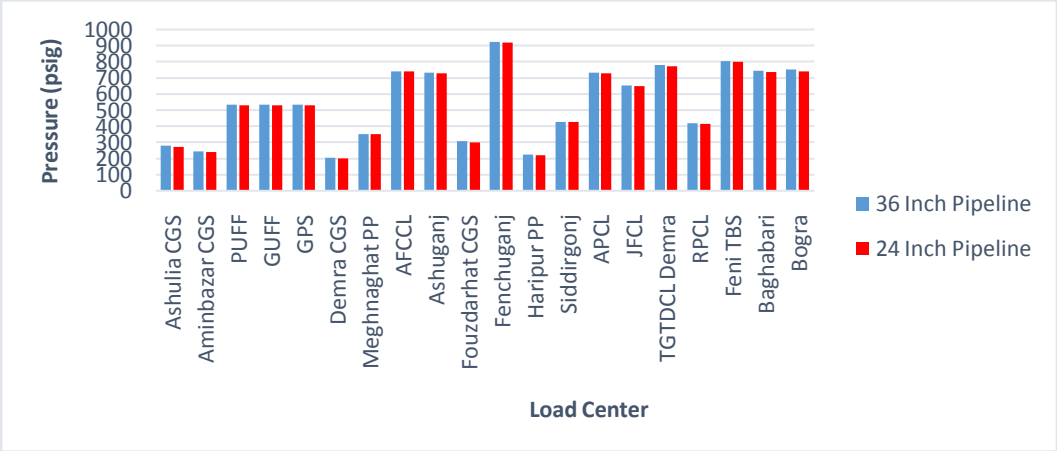


Figure 2: Pressure of different demand centers

From the analysis it is observed that the difference between these two cases is very small, maximum 2.9%. The overall matching is seemed to be very close. So, the existing network is capable to meet the present pressure scenario with (24" × 137 km) BD pipeline.

## PREDICTION: MINIMUM PRESSURE IN KHULNA AT PRESENT DEMAND CONSIDERING B-D LINE 24" IN DIAMETER.

This case study is made for additional 177 km pipeline with existing network from Iswardi to Khulna which has already been constructed except Padma River Crossing [5]. After successful completion of HDD (Horizontal Directional Drilling) Padma River crossing, this 177kmpipeline section will be hooked-up with the existing network and will be brought under operation to supply gas to Bheramara power plant and Kushtia, Jhenaidah, Jessore and Khulna region.

Currently, in Khulna, the requirement of gas is about 40MMscfd for 150 MW power generation and other industrial & commercial demands. For the first phase of production, a lump sum 30 MMscfd gas is considered for 360 MW Bheramara gas based power plant. Again for Kushtia, Jhenaidah and Jessore 5 MMscfd are set for each as there is no bulk consumer at this moment in these areas. Therefore, it is anticipated that total 210 MMscfd gas would be needed to cope up the demand in West Zone right now [6].

In this study the diameter of BD line is considered 24 inch for 137 km pipeline instead of 36-inch diameter to analyze the pressure drop profile and predicts the minimum pressure in Khulna. The simulated pressure data corresponding gas demand for the different demand centers of West Zone is tabulated in Table 3.

Table 3: Expected gas demand with required pressure at different centers of West Zone.

| **Name** | **Gas Flow (MMscf/d)** | **Pressure (psig)** | **Name** | **Gas Flow (MMscf/d)** | **Pressure (psig)** |
|---|---|---|---|---|---|
| Bharamara | 30 | 350.31 | Sirajgonj | 50 | 361.95 |
| Iswardi | 5 | 333.95 | Jessore | 5 | 304.9 |
| Rajshahi | 2 | 344.96 | Kustia | 3 | 343.17 |
| Bogra | 20 | 358.61 | Jhinaydah | 5 | 340.3 |
| Baghabari | 50 | 350.85 | Khulna | 40 | 315 |
| Total Gas demand in the west zone is about 210 | | | | | |

From the simulated result it is observed that the minimum pressure in Khulna at present demand is 315 psig, which is quite enough to meet the requirement of Distribution Company's required pressure (300 psig). In addition to, the pressure in different off take points of the West Zone is above against the required pressure. So, from the analysis it can be said that with (24" × 137 km) BD pipeline the network is capable to meet the present demand in West Zone maintaining required pressure in Khulna.

## COSTING OF BIBIYANA-DHANUA PIPELINE

'Investment cost' and 'operating and maintenance (O&M) costs' are the two parameters that are considered in pipeline costing. Note that depreciation is not to be included in the analysis, as costs are only considered on a cash-flows basis. The revised cost [7] of Bibiyana - Dhanua gas transmission pipeline is summarized in Table 4.

Table 4: Cost of Bibiyana-Dhanua pipeline

| **Component** | **Cost(Taka in millions)** | |
|---|---|---|
| | **36"OD × 137 km** | **24"OD × 137 km (rational costing, approximated)** |
| Pay of Officer and Staff | 85 | 56 |
| Supply and service | 80 | 52 |
| Land acquisition | 954 | 636 |
| Land requisition and Compensation | 382 | 253 |
| Pipeline Materials (Pipes, Valves, Fitting etc.) | 5400 | 3600 |
| Vehicles and Equipment | 25 | 7 |
| Pipeline Construction | 1405 | 936 |
| Civil Works | 270 | 180 |
| Regulation and Metering Station | 1350 | 900 |
| River Crossing | 1300 | 850 |
| SCADA | 450 | 300 |
| CD-VAT, IDC and Land Charge | 2610 | 1740 |
| Contingency and others | 45 | 30 |
| Total Cost | 14356 | 9584 |
| Cost per Km length/inch diameter of pipeline | 2.9 | 2.9 |

For the economic study, following assumptions are made:

1. Wheeling charge is considered to be 0.156 TK/CM and assumed to be constant through the whole prediction period
2. Daily gas supply through BD pipeline is 440 MMscfd and will be continued for 4 years
3. For next 15 years, the gas supply will be 640 MMscfd
4. 12% bank interest rate

Taking the above assumptions into calculation, the results for financial and economical cases are tabulated in table 5.

Table 5: Economic Analysis of B-D line

| Economic Analysis of B-D line | Net Present Value (NPV) (lakh taka) | Benefit Cost Ratio (BCR) |
|---|---|---|
| Financial | -95556.56 | 0.34 |
| Economic | -50239 | 0.58 |

From the analysis it is clear that 36" × 137 km Bibiyana – Dhanua transmission Pipeline is a loss project as Net Present Value (NPV) for both economic and financial is negative. The installation cost for the B-D pipeline is about 14356 million taka if pipe line diameter is 36 inch, whereas for 24 inch diameter pipeline, the installation cost will be 9584 million taka. From the previous analysis (shown in prediction section) it is exposed that the purpose of B-D pipeline can be fulfilled by installing 24" pipeline instead of 36" pipeline. Therefore, GTCL could minimize cost of about 33% by installing 24-inch diameter pipeline as 36-inch diameter pipeline was over designed.

## COST RECOVERY PROJECTION OF BIBIYANA-DHANUA PIPELINE

For cost recovery projection analysis, different case scenarios are assumed to find out the wheeling charge for break even the project. Table 6 shows the different rate of wheeling charge for different cases.

Table 6: Cost recovery projection

| **Field life** | **Transmission charge(TK/CM)of BD line for Break Even the project** | | | | |
|---|---|---|---|---|---|
| | **Q= 200 (MMscfd)** | **Q= 300 (MMscfd)** | **Q= 400 (MMscfd)** | **Q= 500 (MMscfd)** | **Q= 640 (MMscfd)** |
| 5 year | 1.235 | 0.823 | 0.617 | 0.494 | 0.43 |
| **8 year** | **0.9** | **0.6** | **0.449** | **0.36** | **0.27** |
| 10 year | 0.79 | 0.527 | 0.395 | 0.316 | 0.22 |
| 15 year | 0.657 | 0.438 | 0.329 | 0.263 | 0.14 |

Maintaining current production rate from Bibiyana gas field, 8 years will be required to produce the remaining reserve. In that case, if it is planned to recover the cost within this time, minimum wheeling charge would be Tk 0.6/ CM for gas production rate of 300MMscfd which is 4 times more than the current charge. Furthermore, if designed volume of gas, 640 MMscfd is supplied for 8years, then the wheeling charge would be TK 0.27/CM, is also higher than the present charge. If gas supplied is

continued at this rate for 15 years, then it is possible to transmit gas through this line with current wheeling charge which seems impossible.

## CONCLUSION

The existing Gas Transmission pipeline network after commissioning of BD line along with newly constructed pipeline from Iswardi to Khulna via Bheramara, Kustia, Jhenaidah and jessor is analyzed. The study shows that with 24"OD × 137 km pipeline from Bibiyana to Dhanua can achieve the present and future demand of West Zone network maintaining 350 psig pressure in Khulna, which is quite enough to meet the requirements of Distribution Company's required pressure at the inlet of their network.

An economic analysis in the form of Net Present Value (NPV) and Benefit Cost Ratio (BCR) for both economic and financial has been performed for construction of Bibiyana to Dhanua Gas Transmission Pipeline. From the analysis it can said that BD line will be a loss project.

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