ANALYSIS OF THE ON STREAM PIGGING PROJECT OF BAKHRABAD-CHITTAGONG (175 KM, 24″ DIA) HIGH PRESSURE GAS TRANSMISSION PIPELINE.

ASHOKE KUMAR BISWAS

MASTER OF PETROLEUM ENGINEERING

Department of Petroleum and Mineral Resources Engineering
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DHAKA-1000, BANGLADESH

April, 2011

ANALYSIS OF THE ON STREAM PIGGING PROJECT OF BAKHRABAD-CHITTAGONG (175 KM, 24″ DIA) HIGH PRESSURE GAS TRANSMISSION PIPELINE.

A Thesis

Submitted to the Department of Petroleum and Mineral Resources Engineering

In partial fulfillment of the requirements for the Degree of

MASTER OF PETROLEUM ENGINEERING.

By

ASHOKE KUMAR BISWAS

Roll No: 100513001(P)

DEPARTMENT OF PETROLEUM AND MINERAL RESOURCES NGINEERING

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DHAKA-1000, BANGLADESH

April, 2011

RECOMMENDATION OF THE BOARD OF EXAMINERS

The project entitled **"ANALYSIS OF THE ON STREAM PIGGING PROJECT OF BAKHRABAD-CHITTAGONG (175 KM, 24″ DIA) HIGH PRESSURE GAS TRANSMISSION PIPELINE"** submitted by Ashoke Kumar Biswas, Roll No: 100513001(P), Session: October 2005, has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **MASTER OF PETROLEUM ENGINEERING**.

Chairman (Supervisor) : ----------

Dr. Mohammed Mahbubur Rahman
Associate Professor
Department of Petroleum and Mineral Resources Engineering
BUET, Dhaka-1000
Bangladesh.

Member : ----------

Dr. Mohammad Tamim
Professor & Head
Department of Petroleum & Minerals Resources Engineering,
BUET, Dhaka-1000
Bangladesh.

Member : ----------

Dr. Ijaz Hossain
Professor
Department of Chemical Engineering,
BUET, Dhaka-1000
Bangladesh.

Date: April , 2011

DECLARATION

It is hereby declared that this project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Ashoke Kumar Biswas

ACKNOWLEDGEMENT

It gives me great pleasure to express my my heartfelt gratitude and profound appreciation to Dr. Mohammed Mahbubur Rahman, Associate Professor, Department of Petroleum & Mineral Resources Engineering, BUET for his valuable guidance, encouragement and supervision throughout the entire work.

I would like to convey my deep sense of gratitude to Dr. Mohammad Tamim, Professor & Head, Department of Petroleum & Mineral Resources Engineering, BUET, for his valuable suggestions in accomplishing this work.

I would like to thank Dr. Ijaz Hossain, Proffesor, Department of Chemical Engineering, BUET, for his suggestions and cooperation of this work.

I would like to express my grateful thanks to the authority of Gas Transmission Company Limited (GTCL) for giving me permission to pursue Master of Petroleum Engineering Degree at BUET and for providing me reports and necessary data.

I would like to express my gratitude to Engr. S. Faheem (Director Operation), Engr. Nizamul Hasan Sheriff (GM, ESD), Engr. Md. Shariful Islam (DGM, SCADA-Telecom), Engr. Md. Nazrul Islam (DGM, PP), Engr. Nowsher Azad (DM, SCADA), Engr. A. K. M. Mizanur Rahman (AE, SCADA) of GTCL for their kind cooperation in providing me with good suggestions and requisite data.

ABSTRACT

The Bakhrabad-Chittagong (BKB-CHT) high pressure gas transmission line was first commissioned in 1983. It is a 175 km long, 24" dia, 960 psig) gas pipeline which was built to supply gas from the Bakhrabad Gas field, Muradnagar, Commilla to Chittagong City Gate Station (CGS), Faujderhat, Chittagong. Gas is being supplied to the consumer of Commilla, Chandpur, Lakhsam, Feni, Maizde, Choumuhoni, Laksmipur, Chittagong as well as the huge area of the South-East part of Bangladesh by the different off-takes along the pipeline.

On stream pigging operation was first accomplished to BKB-CHT pipeline in July, 1990 and second time it was done in February, 1994. Significant amount of condensate, sludge and water were recovered from this pipeline during these operations. After thirteen years, on stream pigging operation to BKB-CHT pipeline was done during 12 -13 November, 2007 by Gas Transmission Company Ltd (GTCL). The anticipated amount of condensate, sludge etc. were not recovered from this pipeline during the latest pigging operation. It is therefore necessary to analyse the latest pigging operation to understand the effectiveness, and to find out the reasons for such large differences of the outcomes compared to the previous operations**.**

The investigation reveals that in the beginning years the gas processing at Bakhrabad Gas Field was inadequate. The pipeline was not being used at its full capacity. Due to these reasons, there was scope for accumulation of large amount of condensate. Therefore during the first and second pigging operations, large amounts of condensate were recovered (7,11,000 and 3,87,000 litres respectively). The third (3^{rd}) pigging operation however did not yield the anticipated quantities. The probable reasons are:

- After the second pigging operation, BKB Gas Field Process Plant are being operated in sufficient capacity.
- In 1997, Ashuganj- Bakhrabad 30ĕ pipeline was commissioned. So since 1997, BKB-CHT pipeline have been being operated in actual capacity range.
- Since 1997, most of the gas feed to BKB-CHT pipeline was from AB pipeline and this gas was coming from other gas fields such as Titas, Habiganj, Rashidpur, Kailashtila and Jalabad Gas Field. Thus gas from these sources are already processed at origin. Moreover, some liquid is recovered at the Ashuganj Menifold

Station. Therefore when the total mix of gas is fed onto BKB-CHT pipeline it is almost dry.

- After the second pigging operation, BKB Gas Field, Salda Gas Field and Meghna Gas Field have been supplying dry gas.
- Sufficient capacity heater are being used at ICS Feni and CGS Faujderhat after second pigging operation.
- During the year 2005-2006, average 3000 gallons/month of condensate were collected at CGS Faujderhat and average 1000 gallons/month of condensate were collected at ICS feni. Therefore it is possible that whatever amount of condensate accumulated in the pipeline were removed during this period.
- Since 1997, average 225-250 mmscfd gas was supplied through the BKB-CHT pipeline. So condensate and Sludge could not accumulate inside the pipeline and were collected at ICS feni and CGS Faujderhat. So almost all the condensate were collected after the second pigging operation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

A-B	Ashuganj - Bakhrabad
AGMS	Ashuganj Gas Manifold Station
A-M	Ashuganj ï Monohordi
APS	Ashuganj Power Station
BAPEX	Bangladesh Petroleum Exploration and Production Company limited
B-B	Brahmaputra Basin
BKB	Bakhrabad
BBGF	Beanibazar Gas Field
BCMCL	Boropukuria Coal Mining Company Limited
BFA	Bakhrabad Franchise Area
BGF	Bibyana Gas Field
BGFCL	Bangladesh Gas Field Company Limited
BGSL	Bakhrabad Gas System Limited
BOGMC	Bangladesh Oil, Gas and Mineral Corporation
CGS	City Gate Station
CHT	Chittagong
CNG	Compressed Natural Gas
CUFL	Chittagong Urea Fertilizer Limited
FGF	Fenchuganj Gas Field
GIIP	Gas Initially in Place
GUFF	Ghorashal Urea Fertilizer Factory
HGF	Habiganj Gas Field
IOC	International Oil Company
JFA	Jalalabad Franchise Area
JFCL	Jamuna Fertilizer Company Limited
JGF	Jalalabad Gas Field
JGTDSL	Jalalabad Gas Transmission and Distribution System Limited
KAFCO	Karnafully Fertilizer Company Limited
KTL	Kailashtilla
M	Midline
MLV	Mid Line Valve
MCC	Master Control Centre

MHRCL	Madhyapara Hard Rock Company Limited
MOEMR	Ministry of Energy and Maneral Resources
M&R	Metering and Regulating
MW	Megawatt
NGFF	Natural Gas Fertilizer Factory
N-S	North -South
OD	Outside Diameter
PFA	Pachimanchal Franchise Area
PGCL	Pachimanchal Gas Company PMR
PUFF	Palash Urea Fertilizer Factory
PSC	Production Sharing Contract
RPCL	Rural Power Company Limited
RPGCL	Rupantarita Prakritik Gas Company Limited
SCADA	Supervisory Control And Data Acquisition
SGFL	Sylhet Gas Field Company Limited
TFA	Titas Franchise Area
TGF	Titas Gas Field
TGTDCL	Titas Gas Transmission and Distribution Company Limited
VS	Valve Station
ZFCL	Zia Fertilizer and Chemical Complex Limited

UNITS AND SYMBOLS

cft	Cubic feet
cum	Cubic Meter
Kg	Kilogram
Kwh	Killo Watt Hour
MMSCFD	Million Standard Cubic Feet per Day
M.Ton	Metric Ton
MW	Mega Watt
TCF	Trillion Cubic Feet
%	Percentage

CHAPTER 1: INTRODUCTION

A pig is defined as "A device that moves through the inside of a pipeline for the purpose of cleaning, dimensioning, or inspecting" (Girard India 2009). There are various reasons to pig a pipeline. After the pipeline is built, it is necessary to run pigs to remove any debris left in the line from new construction; items such as lunch boxes, tools, welding rods, dead animals trapped in the line, mill scale or welding icicles etc. Pigging is also performed while a pipeline is in operation in order to increase the operational efficiency and lifetime of the pipeline.

As time passes special cleaning applications may arise. Pre-Inspection pigging is done before running an In-Line Inspection tool to ensure smooth running of the tool. Under certain conditions pipelines may require chemical cleaning or a train of gel pigs may be used for certain cleaning conditions. Advanced pigging devices, called intelligent pigs, are run through the pipeline to collect various types of data from inside the pipe. The pig moves inside the pipe while collecting data like the speed of the pig, inside condition and wall thickness of the pipe, rate of fluid inside etc are measured at regular intervals. When the pigging process is over, the complete set of data for all the measurable parameters is retrieved for post pigging analysis about the condition of the pipeline.

The Bakhrabad-Chittagong (BKB-CHT) high pressure gas transmission line was first commissioned in 1983. It is a 175 km long, 24" dia, 960 psig (highest transmission pressure) gas pipeline which was built to supply gas from the Bakhrabad Gas field, Muradnagar, Commilla to Chittagong City Gate Station (CGS), Faujderhat, Chittagong. Gas is being supplied to the consumer of Commilla, Chandpur, Lakhsam, Feni, Maizde, Choumuhoni, Laksmipur, Chittagong as wel as the huge area of the South-East part of Bangladesh by the different off-takes along the pipeline (BGSL 2007).

On stream pigging operation was first accomplished to BKB-CHT pipeline in July, 1990 and second time it was done in February, 1994 and both cases, a huge amount of condensate, slug and water were recovered from this pipeline during these operations. After thirteen years, on stream pigging operation to BKB-CHT pipeline was done during 12 November -13 November, 2007 by Gas Transmission Company Ltd (GTCL). The anticipated amount of condensate, slug etc. has not been recovered from this pipeline during the latest pigging operation (GTCL, 2007). It is therefore necessary to analyse the

latest pigging operation to understand the effectiveness, and to find out the reasons for such large differences of the outcomes compared to the previous operations.

1.1 Objective with specific aims and possible outcomes

1.1.1 Objectives

(a) To assess the latest pigging operation on the BKB-CHT pipeline.

(b) To identify any problem or shortcoming in planning and execution of the latest project.

(c) To make recommendation on the on stream pigging.

1.1.2 Outcomes

(a) Understanding about the effectiveness of on stream pigging.

(b) Gaining the better insight of pigging process.

(c) Effective execution of future pigging operation.

1.2 Outline of Methodology

(a) Review of the pigging technology and practice.

(b) Data collection and review of the previous pigging projects at BKB-CHT line.

(c) Review the planning and execution of the latest pigging project on BKB-CHT Pipeline.

(e) Compare the previous and the latest projects.

(f) Analysis of the outcomes for finding out the reasons of differences compared to expected outcomes.

(g) Finding out the problems or shortcomings of the latest project.

(h) Recommendation for future pigging operations.

CHAPTER 2 REVIEW OF THE PREVIOUS PIGGING PROJECTS

2.1 First on stream pigging operation on BKB-CHT pipeline (1990)

In first phase at BKB gas Field, five (05) wells and in second phase three (03) wells were drilled and supplied gas to BGSL franchise area. At that time Glycol dehydration plant was used to process gas and its capacity was 60(sixty) MMSCFD. At initial time 40-60 MMSCFD gas was supplied from BKB Gas Field but it increased rapidly within very short time. Later four, 60 MMSCFD capacity, solid silica dehydration plant was installed. Since small fraction of the pipeline flow capacity was used during initial two years, condensate was accumulated in the lower portion of the pipeline than normal level. When flow rate of the gas was increased, velocity of gas increased. The condensate that was accumulated in the lower portion of the pipeline surged the CGS Faujderhat as well as down stream of other stations of the pipe line (BGSL Pigging Report 1990).

A committee was formed on 25th March, 1990 for on stream pigging of BKB-CHT pipeline on urgent basis. The committee visited the pipeline, CGS Chittagong , ICS Feni and BKB Gas Field. The committee analyzed all existing facilities and shortcomings, difficulty of condensate collection, storage and delivery and sludge storage facility and decided to perform on stream pigging project on BKB- CHT pipeline (BGSL Pigging Report 1990).

2.1.1 Necessity of first on stream pigging operation

Gas was supplied during six years to chittagong City and surrounding area. But no condensate was found at CGS Chittagong before 1989. The committee found out the following reasons for necessity of on stream pigging on BKBï CHT Pipeline:

- Insufficiency of process plant of BKB Gas Field.
- Operation of pipeline under design capacity, condensate was being accumulated in the pipeline (Condensate formation).
- During pigging of BKB-Demra pipeline, significant amount of condensate (45,000 gallons) was recovered (BGSL 1990).
- 5000 gallons of condensate was collected at the different terminal stations at different times of BKB-Demra pipeline before first pigging in 1989. So, 50000 gallons of condensate were transmitted through the BKB-Demra pipeline during

pigging and before pigging which was about two percent (2%) of the pipeline inner volume (BGSL 1990).

- On the other hand, significant amount of condensate was recovered at CGS Chittagong during the year 1989 and it was about 2000 gallon.
- The lower portion of the pipeline might be filled up with condensate (River crossing, Creak crossing) and condensate column reached near CGS Chittagong.

2.1.2 Criteria and Reasons for the estimation of accumulated condensate inside the pipeline:

- BKB-Demra pipeline was commissioned on September, 1985 (BGSL 1990).
- 45,000 gallons of condensate was collected during the first pigging operation of BKB-Demra pipeline in 1989 (BGSL 1990).
- 5000 gallons of condensate was collected at the different terminal stations at different times of BKB-Demra pipeline before first pigging in 1989 (BGSL 1990).
- So, 50000 gallons of condensate were transmitted through the BKB-Demra pipeline during pigging and before pigging which was about two percent (2%) of the pipeline inner volume. The inner volume of the pipeline, $V = \pi r^2 h$.
- Considering these data, the committee estimated that almost 2,24,419 gallons of condensate was accumulated inside the pipeline which was 2% of the inner volume of BKB-CHT pipeline. The inner volume of the BKB- CHT pipeline, $V=\pi r^2 h$ or $V = (3.1416*24^2*108.5*1760*3)/(4*144) = 17,98,843$ ft^3 = 17,98,843 ft^{3*}28.32 litres/ ft^3 = 50943234 litres. So 2% of V= 1018864.78 litres = 1018864.78 litres/4.54 litres/gallons = 2,24,419 gallons (BGSL 1990).
- On the other hand, the committee considered that BKB-CHT pipeline was commissioned about $1\text{-}1^1/_2$ years before BKB-Demra pipeline. During this time, Gas produced from BKB Gas field was processed by Glycol dehydration plant. The collecting capacity of liquid hydrocarbon of this plant was 0.6 barrels/MMCF. Later stage, three , 60 (sixty) MMCF solid silica dehydration plant processed gas and supplied gas to the pipeline. The collecting capability of liquid hydrocarbon of these plants was 2.0 barrels/MMCF. So (2.0-0.6)=1.4 barrels/MMCF condensate was transmitted with gas to BKB- CHT pipeline during about two years. During this time, 18,964.73 MMCF gas was transmitted through the pipeline. So, (18,960.73*1.4) barrels = 26,550 barrels or (26,550*34.973)

gallons = 9,28,544.73 gallons extra condensate was transmitted through the BKB-CHT pipeline (BGSL 1990).

- By decreased in temperature of the flowing gas from the gas field , 10% of the entraint condensate was accumulated inside the pipeline which was 92,854.43 gallons (BGSL 1990).

- 25% of the flow capacity of the pipeline was used during initial few years. So most of the condensate was accumulated from BKB Gas Field to ICS feni (onepetro n.d.).
- The temperature of the flowing gas reached at ground temperature within initial few miles for entraint condensate (BGSL 1990).

2.1.3 Preparations for pigging operations

2.1.3.1 Fabrication

To perform safe, smooth and efficient pigging operation, collection of accumulated condensate, storage and delivery of condensate, uninterrupted gas supply to the consumers during pigging operation, some fabrications was done at BKB Gas Field, ICS Feni and CGS Chittagong. During certain time of pigging operation gas was supplied to the consumers of the Chittagong City through Barabkundu TBS which was 16 (sixteen) miles up stream from CGS Chittagong. For this reason, 4" and 6" dia., 16 (sixteen) kilometers pipeline was replaced by 8" dia. pipeline (BGSL 1990). Otherwise, when the Pig crossed barabkundu TBS, it was uncertain to supply gas to the consumers of Chittagong City The line diagram of BKB- CHT pipeline are shown in appendix-C.

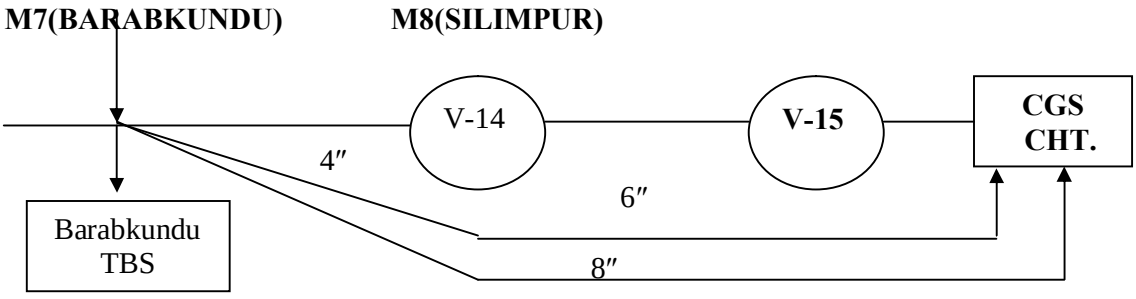


Fig 2.1: Replaced pipeline from Barabkunda TBS ï CGS CHT.

2.1.3.2 Calculation of the probable quantity of accumulated condensate inside the pipeline

Bangladesh Oil, Gas and Mineral Resources formed technical committee headed by Managing Director, BGFCL estimated the probable quantity of accumulated condensate inside the pipeline.

- The inner volume of the pipeline $V=\pi r^2h$ or $V = (3.1416*24^2*108.5*1760*3)/(4*144) = 17,98,843\ ft^3 = 17,98,843\ ft^{3*}28.32$ litres/ $ft^3 = 50943234$ litres. So 2% of V= 1018864.78 litres = 1018864.78 litres/4.54 litres/gallons = 2,24,419 gallons.
- 2% of the inner volume of the pipeline 2,24,419 gallons gallons
- The collected condensate from the terminal stations (only TBS and CGS) of the pipeline was about 13,990 gallons (400 barrels) (BGSL 1990).
- 10% of the entraint condensate accumulated inside the pipeline was 92,854.43 gallons (BGSL 1990).
- Total accumulated condensate inside the pipeline was (2,24,419+92,854.43)= 3,17,273.43 gallons
- Total accumulated condensate inside the pipeline except already collected was 3,03,283.43 gallons
- Accumulated condensate inside the pipeline from BKB Gas Field to ICS Feni was 1,81,970 gallons (60%) and from ICS Feni to CGS Faujderhat was 1,21,313 gallons (40%). Total was 3,03,283.43 gallons (BGSL Pigging Report 1990).

2.1.3.3 Calculation the Speed of the pig

The speed of the pig of on stream pigging is mainly dependant on demand of down stream, pressure of the pipeline and drain out time of condensate. The demand of the down stream are more important. During the time of first pigging, 85-90 MMSCFD gas was transmited through the pipeline. The main consumer, CUFL consumed 50MMCFD. But the committee suggested to keep CUFL in shutdown during pigging operation for the following reasons:

- No pigging operation had been done since long time and 25% capacity of the pipeline was used to supply gas and rest was filled up with condensate, sludge, water etc. (onepetro n.d.).

- This significant amount of condensate and sludge could make surge at CUFL station.
- To keep CGS faujderhat in safe from surging.

V_{pig} = $(1447 \times F \times 14.65)/(Pavg \times 1.13 \times D_i^2)$ ----------(i)

V_{pig} = Pig Speed in miles/hr

F = Gas flow in MMSCFD

P_{avg} = Operating pressure in psig

D_i = internal dia. in inch

(BGSL Pigging Report, 1990)

Original Equation,

V = 14.7349(Qb/D2)(Pb/Tb)(ZT/P) SI Unit-----2.29. (Menon, Engr. Shashi n.d.)

- **Speed of the pig when down stream flow 85 MMSCFD:**

  At 800 psig pressure : 4 miles/hr

  At 500 psig pressure : 6 miles/hr

- **Speed of the pig when down stream flow 35 MMSCFD:**

  At 800 psig pressure : 1.8 miles/hr

  At 500 psig pressure : 2.4 miles/hr.

  Considering the present real situation, the committee suggested to perform pigging operation at 2.4 miles/hr, 500 psig pressures.

- **Line pack Determination**

  Formula:

  Q = $1.96 \times (P_1 - P_2) \times D_i^2 \times L$----------(ii)

  Q = Volume in scft

  P = Operating pressure in psig

  D_i = Internal pipe dia. in inches

  L = Length of the pipeline in miles

  (BGSL Pigging Report, 1990).

- **Original Equation,**

  Q = 0.7854(Tb/Pb)(Pavg/ZavgTavg)(Di2×L) Unit scft ..3.32 (Menon, Engr. Shashi n.d.)

  D = ft, Tavg = flowing temperature in Kelvin,

L = ft , Zavg = Average Compressibility factor.

Pavg = 2/3(P1+P2 ï (P1P2)/(P1+P2)) Unit psigé é 2.14 (Menon, Engr. Shashi n.d.).

- **Collection of BKB-CHT pipeline data:**

Length	:	108.5 Miles (175 KM)
ND	:	24 Inch.
Wall Thickness	:	Varies from 0.344 Inch to 0.438 Inch.
Pipeline Fittings Class	:	Class 400 Series.
Pipe Specification	:	API LX ×56, Japan Origin.
Operating Pressure	:	950 Psig.
Flowing Capacity	:	355 MMSCFD.
No. of Line Valve	:	15 Nos.
No. of Off takes	:	7 Nos.
No. of River Crossing	:	4 Nos.
No. of Road Crossing	:	8 Nos.
No. of Rail Crossing	:	3 Nos.
No. of Creek/Khal Crossing	:	110 Nos.

(BGSL Pigging Report 1990).

- **Specification of the Pig:**

Service Condition:

- Medium: Sweet Natural Gas, Accumulated Condensate, Water and Sludge (rust, sand etc.) at the bottom of pipeline.
- Temperature: 60^0 F-130^0F
- Pressure: 960 psig-150 psig.
- Ring Run: Not less than 75 KM.
- Internal Condition of the pipe: Moderately Corroded inside surface and should be able to negotiate a 5% - 10% deformation in the pipeline configuration and bends of R = 5D minimum.

  Traveling Speed: 5 Miles/hr

  (BGSL Pigging Report 1990).

- **Pig Type**

Polyurethane/ Neoprene Rubber Cup for running through 24″ N.D. pipeline having mention service condition (BGSL Pigging Report 1990).

2.1.4 Execution Methodology of the pigging operation

2.1.4.1 Step by Step pigging of the pipe line

Probability of significant amount of accumulated condensate, Difficulty of collection and storage of condensate, the committee suggested to perform pigging step by step. The pigging operation was done as the following steps.

- **First step (Feni ICS to CGS Chittagong, 54 miles):**

  Length of this section of the pipeline : 54 miles.

  Estimated accumulated condensate : 1,81,970 gallons.

  No of TBS : 01 (Barabkundu TBS).

  No. of Line Valve : 07 Nos.

  No. of Off takes : 03 Nos. (Sonagazi, Mirsarai and Barabkundu).

  No. of River Crossing : 03 Nos.(Kalidas Paharia, Muhuri and Feni).

  No. of Creek/Khal Crossing : 65 Nos (BGSL Pigging Report 1990).

2.1.4.2 Pig Monitoring Points

- Sonagazi Off takes
- MLV 9
- MLV 11
- MLV 12
- Mirsarai off take
- MLV 13
- Barabkundu Off takes
- MLV 14 (BGSL Pigging Report 1990).

2.1.4.3 The distance of the important points from ICS Feni

Table: 2.1

Poins	Place	Distance
(1) Road crossing 4	Feni ï Noakhali Road (Mohipal)	0.66 miles
(2) Road crossing 3	Feni ï Sonagazi Road	3.66 miles

(3) Sonagazi Off takes	Beside Feni ï Sonagazi Road	3.95 miles
(4) MLV 8	West bank of Kalidas Paharika river	6.15 miles
(5) Kalidash paharika	100 yards south from Feni bypass road	6.24 miles
(6) MLV 9	Kalidash Paharika river east bank	6.35 miles
(7) MLV 10	East bank of Muhuri river	11.50miles
(8) Muhuri river	Muhuri river bridge	11.18 miles
(9) MLV 11	Between Muhuri & Feni river	11.84 miles.
(10) Feni river	Feni by pass	12.82 miles
(11) MLV 12	East bank of Feni river	13.14 miles
(12) Road crossing	East Hinguly	17.18 miles
(13) Road crossing 1	Zorarganj	17.18 miles
(14) Mirsarai off take	Mithachara	21.34 miles.
(15) MLV 13	Sitakundu	30.45 moles
(16) Barabkundu TBS	Near CIB	37.50 miles
(17) MLV 14	Near Faujderhat over bridge	53.82 miles
(18) Rail crossing 3	Near Faujderhat CGS	53.82 miles
(19)Road crossing	Near Faujderhat CGS	53.90 miles

(BGSL Pigging Report 1990).

2.1.4.4 Reaching time of the pig at monitoring points

35 MMSCFD gas flow at down stream and 500 psig pressure at up stream, the natural pig speed would be 2.4 miles/hr. the reaching time at different monitoring points was calculated by assuming speed 2.4 miles/hr. But for the accumulated condensate at the riverbed points of the pipeline, the real speed would be different than calculated time. Reaching Time calculated by assuming pig speed 2.4 miles/hr.

Table 2.2:

Monitoring Points	Distance from the ICS Feni	Reaching Time	Remarks
(1) Sonagazi Offtake	3.95 miles	1.64 hrs	Level land
(2) MLV 9	6.35 miles	2.64 hrs	Pig would have to cross Kalidash Paharika river
(3) MLV 11	11.84 miles	4.93 hrs	Muhuri river
(4) MLV 12	13.14 miles	5.47 hrs	Pig would have to cross Feni river
(5) Mithachara offtake	21.34 miles	8.89 hrs	From Feni river east bank, all level land
(6) MLV 13	30.45 miles	12.68 hrs	Level land
(7) Barabkundu Off takes	37.50 miles	15.62 hrs	Level land

After Pig crossing Barabkundu, gas would supply through alternative line from Barabkundu TBS to CGS Faujderhat. This time the huge amount of condensate would be in front of the pig and gas pressure would low behind the pig . This time pig would cross some creak. So the pig speed would very slow and take more time. At some time, the pig speed would be less than 01 mile/hr. It would take 24 hrs to cross from Barabkundu TBS to CGS Faujderhat. So from ICS Feni to CGS Faujderhat, It would take (16+24) hrs about two days (BGSL Pigging Report 1990).

.

2.1.5 Second step (BKB Gas Field to ICS Feni)

- Length of this section of the pipeline : 54.8 miles.
- Estimated accumulated condensate : 1,21,313 gallons.
- No of TBS : 02 (Comilla & Laksam)
- No. of Main Line Valve : 07 Nos.
- No. of Off takes : 03 Nos. (Comilla, Chandpur, Laksam).
- No. of River Crossing : 01 No.(Dakatia River).
- No. of Creek/Khal/ Pond Crossing : 71 Nos (BGSL Pigging Report 1990).

2.1.5.1 Pig Monitoring Points

- Comilla Offtake
- Chandpur Offtake
- Laksam Offtake,
- MLV 5
- MLV 7 (BGSL Pigging Report 1990).

2.1.5.2 The distance of the important points from BKB Gas field

Table- 2.3: The distance of the important points from BKB Gas field

Poins	Place	Distance
(1) Road crossing 7	Dhaka-Comilla High Way (Kutumbopur)	9.60 miles
(2) Comilla Offtake, Comilla TBS, MLV2	Kutumbopur	9.76 miles
(3) Chandpur Offtake (Comilla Chandpur Road),	Bijra	27.07 miles
(4) MLV 3, Laksam Offtake, Laksam TBS	Perul	30.83 miles
(5) Road crossing 5, Rail crossing 2	Perul	31 miles
(6) MLV 4		31.3 miles
(7) MLV 5	Gunobati, Chaudhagram	
(8) Rail crossing 1	Gunobati, Chaudhagram	

(9) MLV 6, Dakatia River, MLV 7	Gunobati, Chaudhagram	

(BGSL Pigging Report 1990).

2.1.5.3 Reaching Time at different monitoring points

35 MMSCFD gas flow at down stream and 500 psi pressure at up stream, the natural pig speed would be 2.4 miles/hr. By assuming speed 2.4 miles/hr. By assuming speed 2.4 miles/hr, it is possible to calculate the reaching time at different monitoring points. But for the accumulated condensate at the river bed points of the pipeline, the real speed would be different than calculated time.

Table-2.4: Reaching Time at Monitoring points

Monitoring Points	Distance from the BKB Gas Field	Reaching Time	Remarks
(1) Comilla Offtake/TBS	9.76 miles	4.06 hrs	Level land
2) Chandpur Offtake	27.07 miles	11.27 hrs	Level land
(3) Laksam Offtake/TBS	30.83 miles	12.84 hrs	Level land
(4) MLV 5	42.9 miles	17.84 hrs	Level land
(5) MLV 7	44 miles	18.33 hrs	Kalidash river
(6) ICS Feni	54.8 miles	22.83 hrs	

The committee thought that pig wuold have to move significant amount of condensate after crossing ICS Feni.. So the actual time required would be more than calculated time. The committee thought that it would take almost 48 hours or two days from ICS Feni to CGS Faujderhat..So the total time taken would be four days with one day stoppage time from BKB Gas Field to CGS Faujderhat (BGSL Pigging Report 1990).

2.1.6 Results & Discussions on 1st pigging operation

- Seven days (9th July,1990 ï 15th July, 1990) was taken for first pigging operation through BKB ï CHT Line (BGSL Pigging Report 1990).
- 7,11,000 litres of condensate collected from the first pigging operation which was performed during (BGSL Pigging Report 1990).
- Sludge Recovered: Not Significant Amount.
- The committee thought that four days would be required for pigging operation but it was taken six days. from Feni ICG ï CGS CHT. section.
- Pig speed was too low.

2.2 Second on stream pigging operation

2.2.1 Necessity of second on stream pigging:

After the commissioning of BKB-CHT pipeline and Chittagong Ring main Line in 1984, it was first being performed on stream pigging operation during 09.07.1990 to 15.07.1990. During this pigging operation, 7,11,000 litres of condensate was collected at CGS Chittagong (BGSL Pigging Report ,1990)

During July 1990-February 1994, average 90 MMSCFD gas was supplied to BKB-CHT pipeline from Bakhrabad (BKB) Gas Field (BGSL 1994). This gas was supplied at 120^0F ï 130^0F from Bakhrabad Gas field and was found huge amount of liquid condensate with gas. On the other hand, ESA Consultant (British Gas) which was financed by World Bank in GIDP found 0.315 barrel condensate/million cubic feet gas (BGFCL 1994). As a result, significant amount of condensate was coming out with gas in transmission pipeline. This condensate was accumulated inside the pipeline. On 06.10.93 and 7.10.93 it was difficult to supplied gas to down stream for condensate surging at CGS Chittagong. For this incident, two axial flow regulators and one Tartarini Regulator were damaged (BGSL 1994).

Liquid condensate with flowing gas increased velocity of the gas and might created sonic velocity to damage diaphragm of the regulators of CGS Chittagong, HPDRS, CMS of Ring Main and it would be difficult to supply gas to chittagong city (BGSL 1994).

The meeting headed by Additional Secretary of the ministry of Electricity, Energy and Mineral Resources on 11.01.94 decided that BKB-CHT pipeline would be on stream

pigged from 03.02.94. So, BGSL authourity arranged on sream pigging operation from 03.02.94 to 09.02.94. For this pigging operation, central committee, sub- committee and all other relevent committee were formed on 01.02.94 (BGSL, 1994).

2.2.2 Preparations for pigging operations

2.2.2.1 Manpower and Logistics of the Central Committee and Sub Committee of pigging operation

- **Central Committee**

Table-2.5: Manpower and Logistics of Different Committee

(1) Engr. Zainal Abedin, Manager (Transmission) & Convenor of the Pigging committee	Car No. Jeep-02-0107	Nick Name: Oskar
(1) Engr. shahidul Abedin, Manager & Member of the Pigging committee	Car No. Jeep-02-0109	Nick Name: Delta -01
(1) Engr. Kh Abdus Saleque, Manager(Planning) & Member of the Pigging committee	Car No. Jeep-02-0103	Nick Name: Delta -02
(1) Engr. Azijul Haque Deputy manager (Cathodic Protection), & Member of the Pigging committee	Car No. Jeep-02-1231	Nick Name: Tango -01
(1) Engr. Jameel Ahmed Alim, Deputy manager (Trans. West) & Member of the Pigging committee	Car No. Jeep-02-0104	Nick Name: Tango -02

- **Sub Committee**

Table-2.6: Nick Name of the Sub committee

Sub committee-A	Nick Name : Alpha
Sub committee-B	Nick Name : Bravo
Sub committee-C	Nick Name : Charle
Sub committee-D	Nick Name : Dragaon
Sub committee-E	Nick Name : Echo

Sub committee-F	Nick Name : Foster
Sub committee-G	Nick Name : Golf
Sub committee-H	Nick Name : Hotel
Sub committee-I	-
Sub committee-J	-
Sub committee-K	-
Sub committee-L	-
Sub committee-M	-

(BGSL Pigging Report 1994).

- **Information of pigging operation to all Consumers**

All bulk consumers were informed about pigging operation to take necessary precaution. On the other hand, news was published at daily newspaper about pigging operation.

- **Fire Fighting arrangement**

Fire service and Civil Defense arranged sufficient safety measure. On the other hand BGSL authority arranged sufficient fire fighting equipments at all stations.

- **Condensate Storage arrangement**

There were two condensate storage tanks in CGS, Chittagong (Each capacity was 15000 gallons). Another four storage tanks were collected from Meghna Petroleum Co. Ltd.

2.2.3 Execution Methodology

- **Step by step pigging operation of the pipeline**

Probability of huge amount of accumulated condensate, collection of condensate, difficulty of preservation and deliverability of condensate, the committee suggested to perform pigging step by step and the pigging operation was done by the following sequences.

2.2.3.1 Sequence of operation (Section A : Bakhrabad Gas Field to ICS Feni)

Description of this Section:

- Length of this section of the pipeline : 54.8 miles.
- No of TBS : 02 (Comilla & Laksam)
- No. of Main Line Valve : 07 Nos.
- No. of Off takes : 03 Nos. (Comilla, Chandpur, Laksam).
- No. of River Crossing : 01 Nos.(Kalidas Paharia, Muhuri and Feni).
- No. of Creek/Khal/ Pond Crossing : 71 Nos.
  (BGSL Pigging Report 1994).

Sequence of Operation:

- Pig loading at gas field :
- 10:00 hours on 02.02.94 team Alpha would load the pig under guidance of Delta
- Confirmation of gas flow shut down from 210 MMSCFD to 60 MMSCFD by 2300 hours on 04.02.94 (To be confirmed by manager transmission).
- Confirmation of Gas production shut down from Feni Gas Field (To be confirmed by deputy manager, LDC, Feni) by 0730 hours on 04.02.94. Bakhrabad Gas field would start reduction of delivery pressure to BKB-CHT Pipeline from 0000 hours of 04.02.94. Pig would be launched at 0800 hours at prevailing pressure at the moment.
- Monitoring team to be in position and radio communication to be established between launching team, Monitoring team, ICS Feni and Chittagong CGS.
- By launching from gas field at 0800 hours. Instant speed of the pig would be compute and transmitted to monitoring team by Delta.
- Team óCô (Charle) under guidance of Tango would primarily be stationed at MLV-2. Comilla Offtake valve to be clossed after launching of the pig from gas field.
- Team óDô (Draugon) under guidence of Tango would be stationed at Chandpur Off- take, MLV-3 and MLV-4 (Laksham).
- 8.Team Charle after completion of monitoring at MLV-2 would move to Gunobati for monitoring MLV-6 and MLV-7.

- Team óAô would to move to Feni after completion on of Pig loading at Gas Field and would load the pig at ICS Feni on 03.02.94. After loading the Pig at Feni, Team óAô would proceed to CGS CHT. leaving behind 02 (two) fitters with tools.
- The Estimated Time of Arrival of at ICS, Feni at 1700 hours to 2100 hours on 04.02.94 (BGSL Pigging Report 1994).

2.2.3.2 Actual Time Taken : 21 Hours(BGSL Pigging Report 1994).

2.2.4 Section B : ICS Feni to CGS Chittagong.

Description of this Section:

- Length of this section of the pipeline : 54.0 miles.
- No of TBS : 03
- No. of Main Line Valve : 08 Nos.
- No. of Off takes : 04 Nos (BGSL Pigging Report 1994).

Sequence of Operation:

- Commencement of reduction of gas consumption by CUFL from 49 MMSCFD to be confirmed by 0500 hours of 05.02.94. Rate should be reduced such that by 0800 hours the rate is 40 MMSCFD. Pig would be launched at an withdrawal load of 60-65 MMSCFD. CUFL would continue reducing gas consumption by 1400 hours at such a rate that is reduced to 10 MMSCFD.

- Pig monitoring team Dragon under guidance of Tango would take position at MLV-9 by 0730 hours of 05.02.94. Dragon would subsquently move to MLV-12, 13, 14 in sequence. However, the time of such movement would be monitored by Tango.

- Team Charlie under guidence of Tango would position themselves at MLV-11 by 0730 hours on 05.02.94. They had to move Barabkundua TBS under directive of Tango. Charle would continue remain at Barabkundu TBS till completion of pigging operation and would ensured uninterrupted gas flow through Barabkundu TBS after passing of Pig from this point.

- 04.E.T.A of pig at Barabkunda at 0900 hours of 05.02.94. Gas by pas to Chittagong distribution system would commence and team Echo would shut down Chittagong Ringmain H.P. DRSøs in the following sequence. Halisher, EPZ, Kalurghat and Nasirabad, H.P. DRS at CGS Chittagong would closely monitored and would closed if required. Teams would remain stand by at Kalurghat and Nasirabad H.P. DRS and would constantly monitored down stream pressure. If required, the team would carefully feed gas to distribution system. This would continue till receiving the Pig at CGS, Chittagong.
- Gas supply from Ring Main to Bulk Consumers after commencement of gas by-passing from Barabkunda TBS. CUFL would consume at the rate of 4 MMSCFD and KPM would reduce gas consumption to a minimum of 5 MMSCFD and TSP may continue at usual rate. However depending on situation gas flow to KPM would be suspended from 0600 hours of 06.02.94.
- E.T.A of Pig at CGS, Chittagong on 07.02.94. (Midnight).
- Time Taken 64 hours.
- Total Time Would take (21+64)=85 hours almost four days(BGSL Pigging Report 1994).

2.2.5 Results & Discussions on 2nd pigging operation

- Six days (4th February, 1994 ï 9th February, 1994) were taken for second pigging operation but the pigging committee thought that it would take four days.
- 3,87,000 litres of condensate were recovered.
- 2690 cft of sludge was recovered.
- Elements of the Sludge Sample which was recovered from 2nd pigging operation:

Table 2.7: Sample of sludge which was recovered from 2nd pigging operation.

Sl. No.	Elements	BUET	BAPEX	ERL	BKB Gas Field
1.	CARBONACEOUS MATTER(ORGANIC)%WT	55.09	38.79	41.322	NOT GIVEN IN % WT
2.	DUST OF SILICA GEL % WT	-----	0.96	0.458	-DO-
3.	SAND/ MUD % WT.	9.16	23.03	26.113	-DO-
4.	MILL SCALE (RUST) AS F_2C_3 % WT.	25.10	30.22	23.097	-DO-
5.	MUD AND OTHERS UNIDENTIFIED SUBTANCES % WT	10.65	07.00	-----	-------

Sludge recovered was significant amount against 1990 pigging operation. In the sample of sludge it was found that dust of silica gel, mill scale , carboneous matter (organic) and mud were significant (BGSL Pigging Report 1994).

CHAPTER 3 : REVIEW THE PLANNING & EXECUTION OF THE THIRD (3rd) PIGGING PROJECT

3.1 Introduction

The Bakhrabad-Chittagong (BKB-CHT) high pressure gas transmission line was first commissioned in 1983. It is a 175 km long, 24" dia, 960 psig (highest transmission pressure) gas pipeline which was built to supply gas from the Bakhrabad Gas field, Muradnagar, Commilla to Chittagong City Gate Station (CGS), Faujderhat, Chittagong. In 1984 Bakhrabad Gas System Limited (BGSL) developed Feni Gas Field and constructed Bakhrabadï Demra high pressure gas transmission pipeline to supply gas to Titas system to meet the increasing demand of gas in greater Dhaka. On successful completion of the development of Feni Gas Field , it started commercial operation on May,1984 and gas supply to Titas system through BKB-Demra pipeline was started on September,1985. Gas is being supplied to the consumer of Commilla, Chandpur, Lakhsam, Feni, Maizde, Choumuhoni, Laksmipur, Chittagong as well as the huge area of the South-East part of Bangladesh by the different off-takes along BKB-CHT pipeline the pipeline (BGSL 2007).

3.2 Necessity of the latest on stream pigging:

On stream pigging was first accomplished to BKB-CHT pipeline in July, 1990 and second time it was done in February 1994. Both cases, a huge amount of Condensate, Sludge and Water were recovered from the pipeline. During the year 1995 to 2005, average 1500 gallons/month of Condensate were collected at CGS Faujderhat, Chittagong and average 100 gallons/month of Condensate were collected at ICS Feni. During the year 2005 to 2006, average 3000 gallons/month of Condensate were collected at CGS Faujderhat, Chittagong and average 1000 gallons/month of Condensate were collected at ICS Feni. The last few months of the year 2006, it was too difficult to perform normal operation of CGS Faujderhat and ICS Feni due to significant amount of condensate with gas. This high velocity condensate and sludge frequently damaged filters and transmitters of the metering run. Thirteen years also have passed since the second pigging operation which was perform in 1994. For these reasons, the 13th annual meeting of GTCL at first took decision to pig on stream of BKB-CHT pipeline. Later the 215th GTCL Board Meeting held on 25th February, 2007 decided to perform on stream pigging to BKB-CHT pipeline during 12 November -13 November, 2007 (GTCL 2007).

3.3 Estimation of expected condensate:

- The Bakhrabad-Chittagong (BKB-CHT) high pressure gas transmission line was first commissioned in 1983.
- On stream pigging was first accomplished to BKB-CHT pipeline in July, 1990 and recovered 7,11,000 litres of condensate (BGSL 1990) and second time it was done in February 1994 and recovered 3,87,00 litres of condensate and 2690 cubic feet of sludge (BGSL 1994).
- Salda-Bakhrabad Gas Transmission pipeline was commissioned in 1997 and Salda Gas Field started its commertial operation to feed gas to BKB-CHT pipeline in 1997(BGSL 2007).
- Salda-Meghna Gas Transmission pipeline was commissioned in 1997 and Meghna Gas Field started its commertial operation to feed gas to BKB-CHT pipeline in 1997 (BGSL 2007).
- Ashuganj- Bakhrabad 30ĕ pipeline was commissioned in 1997 (GTCL Monthly Progress Report, 2007).
- Since 1997, most of the gas feed to BKB-CHT pipeline was from AB pipeline and this gas was coming from others gas field such as Titas, Habiganj, Rashidpur, Kailashtila and Jalabad Gas Field. Thus gas from these sources are already processed at origin. Moreover, some liquid is recovered at the Ashuganj Menifold Station . Therefore when the total mix of gas is fed into BKB-CHT pipeline it is almost dry.
- For the estimation of the probable quantity of accumulated condensate inside the BKB-CHT pipeline of first pigging operation, the committee considered 2% of inner volume of the pipeline.
- For the estimation of the probable quantity of accumulated condensate inside the BKB-CHT pipeline of second pigging operation, the committee considered 0.315 barrel of condensate/million cubic feet gas was transmitted through the gas (BGSL 1994).
- So, for third pigging, the committee considered the amount of condensate accumulated inside the BKB-CHT pipeline which was the 2% of inner volume of the BKB-CHT pipeline and also considered 0.2 barrel of condensate/million cubic feet gas was transmitted through the gas.

Considering the 2% of inner volume of the BKB-CHT pipeline:

- The inner volume of the pipeline $V=\pi r^2 h$ or V = $(3.1416*24^2*108.5*1760*3)/(4*144)$ = 17,98,843 ft^3 = 17,98,843 ft^{3*}28.32 litres/ ft^3 = 5,09,43,234 litres. So 2% of V= 10,18,864.78 litres .
- 2% of the inner volume of the pipeline 10,18,865 litres.
- So, considering 2% of inner volume, the accumulated condensate inside the pipeline is 10,18,865 litres (GTCL 2007).

Considering 0.2 barrel condensate/MMSCF gas was transmitted through the BKB-CHT pipeline:

- For the estimation of the probable quantity of accumulated condensate inside the BKB-CHT pipeline of second pigging operation , the committee considered 0.315 barrel condensate/million cubic feet gas was transmitted through the gas (BGSL Pigging Report 1994). But after second pigging of BKB-CHT pipeline, most of the Gas feed to BKB-CHT pipeline from Ashuganj-Bakhrabad pipeline. This gas was mostly supplied from Titas, Habiganj, Rashidpur, Jalabad and Khailashtila Gas Field and it was second time filtered at Ashuganj Manifold Station. So for the estimation of accumulated condensate inside the BKB-CHT pipeline of third pigging, the pigging committee considered 0.2 barrels of condensate/MMSCF of gas was transmitted through the gas (GTCL 2007).
- During 1995-1996. gas transmitted through BKB-CHT pipeline was 90 MMSCFD. So total gas transmitted during this time was 90*365*2 MMSCF or 65700 MMSCF (BGSL 2007).
- During 1997-2007, gas transmitted from AB line to BKB-CHT pipeline was 4,16,297 MMSCF (GTCL Monthly Progress Report, 2007).
- During 1997-2007, gas transmitted from Salda, Meghna and Feni Gas Field to BKB-CHT pipeline was 30*365*11 MMSCF or 1,20,450 MMSCF (BGSL 1997-2007).
- So total gas transmitted through BKB-CHT pipeline was (65,700+4,16,297+1,20,450) MMSCF or 6,02,447 MMSCF.
- Considering 0.2 barrel of condensate/ MMSCF of gas transmitted with gas through BKB-CHT pipeline, the condensate transmitted through gas was 6,02,447*0.2 barrels or 1,20,489 barrels = 1,20,489*34.97 gallons = 42,13,514 gallons = 42,13,514*4.54 litres=191,29,355 litres.

- The 10% of entraint condensate was 19,12,935 litres.
- So the total condensate accumulated inside the pipeline was 19,12,935 litres.

The collected condensate from the terminal stations (only TBS and CGS) of the pipe line before 3rd pigging:

- During 1995-2005 average 1500 gallons/months of condensate was collected at CGS faujderhat and average 100 gallons/months of condensate was collected at ICS Feni. Total condensate collected during that time was (1500*12*11+100*12*11) = (1,98,000+13,200)=2,11,200 gallons (GTCL 2007).
- During 2006-2007 average 3000 gallons/months of condensate was collected at CGS faujderhat and average 1000 gallons/months of condensate was collected at ICS Feni. Total collected condensate during that time was (3000*23+1000*23) = (69,000+23,000)=92,000 gallons (GTCL 2007).
- So, total condensate collected during 1995-2007 at CGS Faujderhat and ICS Feni was (2,11,200+92,000) = 3,03,200 gallons= 3,03,200*4.54 litres = 13,76,528 litres.

Net Condensate accumulated inside the BKB-CHT pipeline:

- Cosidering 2% of inner volume of BKB-CHT pipeline, the net amount of condensate accumulated inside pipeline is -3,57,663 litres (10,18,865- 13,76,528) litres. Therefore no condensate is accumulated inside the pipeline.
- Considering 0.2 barrel condensate/MMSCF gas was transmitted through the BKB-CHT pipeline, the net amount of condensate accumulated inside pipeline is 5,36,407 litres (19,12,935- 13,76,528).
- So , the probable net condensate accumulated inside the pipeline is 5,36,407 litres (GTCL 2007).

3.4 DESCRIPTION OF THE BKB-CHT PIPELINE:

- Length : 108.5 Miles (175 KM)
- ND : 24 Inch.
- Wall Thickness : Varies from 0.344 Inch to 0.438 Inch.
- Pipeline Fittings Class: Class 400 Series.
- Pipe Specification : API LX ×56
  Japan Origin.
- Operating Pressure : 950 Psig.

- Flowing Capacity : 355 MMSCFD.
- No. of Line Valve : 15 Nos.
- No. of Offtakes : 7 Nos.
- No. of River Crossing : 4 Nos.
- No. of Road Crossing : 8 Nos.
- No. of Rail Crossing : 3 Nos.
- No. of Creek/Khal Crossing : 110 Nos (GTCLPigging Report 2007).

3.5 Preparations for pigging operation

- **Pigging date and formation of the committee**

The 13th annual meeting of GTCL took decision to pig on stream of BKB-CHT pipeline. As a result, GTCL took a working plan for on stream pigging. After that in different intra meetings of petrobangla, GTCL and BGSL was discussed briefly and made final working plan . At the meeting of Ministry of Energy and Mineral Resources on 31st October 2007, the decision was taken that the pigging operation would perform from 12th November 2007 to 17th November 2007 (GTCL Pigging Report 2007).

For this pigging operation, a committee was formed by the senior official of Petrobangla, GTCL and BGSL. Sub-committee and all other relevent committee ware also formed. Different sub committee and monitoring committee was form to perform pigging operation successfully and efficiently. These sub committee and monitoring committee performed by the guidance of the convenor of the pigging committee. By the suggestion of the convenor, Director Operation, GTCL prepared TOR and supplied checklist on 30.10.2007 to perform pigging operation (GTCL Pigging Report, 2007).

- **Fabrication**

To perform safe, smooth and efficient pigging operation, collection of accumulated condensate, storage and delivery of condensate, uninterrupted gas supply to the cunsumers during pigging operation, some fabrications was done at CGS Chittagong. Proper size Stud Bolt replaced with plug valve and Flanges at the pig receiver kicker line in CGS, Chittagong. Proper size Flange, Gasket and stud Bolt at inlet and outlet of condensate tank was also replaced. Two 4 inch dia. valve at inlet and two 2 inch dia valve

at outlet of the storage tank was replaced. Blind Flange with Gasket was also replaced at the other opening of the condensate line.

- **Condensate Storage:**

There were two condensate tanks at CGS Chittagong. Each tank capacity was 15000 gallons and total capacity was 30000 gallons. Two condensate tanks total capacity 32000 gallons was hired from Meghna Petroleum and was installed at CGS Chittagong. To be confirmed the effectivity of the condensate line , it has been experimented durin certain time between 100-300 psig. Condensate reserved in two storage tanks at CGS CHT was delivered to Padma Oil and after that sludge accumulated in the tanks was washed out. So total 62000 gallons of condensate handling capacity was confirmed during pigging operation.

- **Sludge Handling**

For handling sludge, Burn Pit line was experimented. Water and dust particle were washed out by Siphon and drain. On the other hand, permanent and temporary sludge pond were built. Two (2) inch dia. branch line was installed at Burn Pit to delivered Sludge from Burn Pit to temporary Sludge pond.

- **Condensate Delivery**

Twenty Tank Lorry had been arranged from Padhma Oil Company for disposal and sale of condensate during pigging operation.

- **Main Line Valve Stations and Off take points**

Water was drain out from Pit. Thirtee Main Line and five off take valves were cleaning and greasing to be effective . On the other hand, full opening of the Main Line valve and full closing of the by pass line valve were confirmed and pressure gauge were installed at monitoring points.

- **Scraper Trap Stations**

Greasing the Ball Valve of Pig Launcher at Bakhrabad Gas Field, ICS Feni and all related main valves were completed and tested effectiveness. Effectiveness of the Pig Launcher was also tested. O-ring was tested by opening End Closer and completed necessary greasing for closing hundred percent.

- **Fire Fighting Arrangement**

Special team of Fire Services and Civil Defence was present at BKB Gas Field, ICS Feni and CGS Chittagong during pigging operation. On the other hand, sufficient Fire Fighting Equipments were installed in the relevant plants.

- **Pig fitting**

Three pigs were fitted with 24 inch dia. pig frame and were transferred to BKB Gas Field on 11.11.2007 and were kept them in safe custody.

- **Lighting Arrangement**

Sufficient Lighting arrangement were installed at BKB Gas Field, ICS Feni , CGS Chittagong and all TBS during pigging operation for night time.

- **Scada Telecom**

Gas pressure, flow and all other data collection and communication, pig velocity, passing time of different monitoring points were confirmed by Scada Telecom.

- **Other works**

Before two days of the pigging operation, dated on 10.11.2007, a meeting held headed by Convenor of the pigging committee at GTCL Board room and the members of the committee discussed about the TOR of different sub committee and monitoring teams.The Convenor of the pigging committee visited BKB Gas Field on 6.11.2007 for for physicaly monitor the preparation . Pig Launcher, RMS and MLV-1 were tested.

3.6 Pigging Operation

For the on stream pigging of BKB ï CHT 24 inch dia. 108.45 miles long pipeline, relavent sub committee headed by Engr. Sanowar Hossain Chowdhury, GM (Development) reached BKB Gas Field at 6.00 PM on 11.11.2007. At that time Petrobangla, GTCL, BGSL and BGFCL higher authority were present. At 6:45 PM End closer of the Pig Launcher was opened. The Imam of the local Mosque arranged Monazat to Almighty Allah for successful operation of pigging. At 8:00 PM Pig was loaded and Pig Launcher and end closer valve were closed. BGFCL authority arranged to supply gas to BKB- Demra line which was produced from BKB Gas Field. All committee, sub

committee and monitoring teams were mobilized to nearer places so that they could easily reach their expected sites at specified time (GTCL Pigging Report 2007).

This on stream pigging operation was performed by two steps:

- At first step, BKB Gas Field to ICS Feni
- At second step, ICS Feni to CGS Chittagong.

3.6.1 First Step (BKB Gas Field to ICS Feni, 54.8 miles)

- At 8:00 am on 12.11.2007 specified people headed by GM (Development), GTCL reached BKB Gas Field and all monitoring teams were place in their specified places from BKB Gas Field to ICS Feni and made them ready. Local Mosque Imam arranged a Monazat and then started pigging operation. Gas pressure front and back of the equalizer line were equalized at pig launcher. Gas flow through vertical plug line which attached with by pass line and gas supplied to behind the pig through pig launcher kicker line and pig launched at 08:30 am on 12.11.2007.

- Pig was launched by 85 MMSCFD gas flow at 800 psi pressure. At that time the speed of the Pig was 4.66 miles/hr. Maintaining the steady speed of the pig , flow and pressure were increased/ decreased. To prevent condensate leakage through distribution line, Off take of GTCL and BGSL, the relevant valves were closed at -proper time and after crossing the valve were opened by the pig monitoring team. On 12.11.2007 at 8:12 pm pig was received at ICS Feni. Monitoring Points, Pig position, pig speed, crossing time, reaching time of monitoring centre and other operation works are shown in table-B.1 in Appendix-B

.

- After reaching the pig at ICS Feni, 24 inch dia. valve with Trap was closed. Pig was taken away from pig Receiver by opening the End Closer. Only some sludge was recovered from this section. The dimension of the pig and its cups were remained almost unchanged. Later Pig receiver was washed out and dried out water. At last End Closer was closed (GTCL Pigging Report 2007).

3.6.2 Second Step:(Feni ICS to CGS Chittagong (53.65 miles))

- All relevant monitoring teams were confirmed their position of specified places. Imam of local Mosque arranged a Monazat to Almighty Allah. Pig was loaded in Pig Launcher. It was launched from the kicker line by the supervision of General Manager (Development), GTCL at 9:00pm on 12.11.2007 by 755 psi pressure and 100 MMSCFD gas flow. The speed of the pig at that time was 5.72 miles/hr. For maintaining steady speed of the pig, the pressure and flow were increased or decreased as required.

- To prevent the leakage of the condensate through the distribution line, off take valves of Feni ICS, Mithachara off take and Barabkunda TBS were closed turn by turn. and when the pig crossed up to safe distance, off take valves were opened to supply gas to distribution line by the supervision of the monitoring team. Pig reached CGS Chittagong at 12:15 pm on 13.11.2007. The monitoring Points, distance from ICS Feni, speed of the pig, time taken to cross, reaching time of pig and other operational works are discussed in table-B.2 in Appendix-B.

- After reaching the pig at CGS Chittagong, 24 inch valve with pig receiver was closed and the pig was taken away. Very little sludge was recovered. Pig receiver was washed out and End colser was closed. During pigging operation of BKB-CHT pipeline, gas was supplied to Rawzan and Shikolbaha power station and other industrial or commercial consumer as well as residential consumers. On the other hand, gas was supplied to CUFL and KAFCO for utility services.

- The pressure and flow of the pipeline were controlled from BKB Gas Field through RMS in BKB Gas Field by the supervision of central committee formed by Petrobangla during pigging operation. To maintain the steady speed of the pig, the flow of gas to ring main was monitored. The list of pressure and flow at up stream and down stream during pigging operation is attached in appendix-B. The line diagram of reaching time of pig at different monitoring points is attached in Appendix-B.

3.7. Condensate collected

Very small amount of condensate and sludge were recovered from the latest pigging operation on BKB-CHT pipeline pipeline.

3.8 Conclusion

The dedicated special squad of GTCL performed pigging operation safely. Though on stream pigging operation is very risky and technologically sensitive, GTCL finished their job efficiently without any help of foreign experts. By analysis the performance of GTCL employees, it is clear to say that GTCL would be able to perform efficient on stream pigging operation in future without the help of foreign experts. From the latest pigging operation, very negligible amount of condensate and sludge are recovered for the following reasons:

- After the second pigging operation, BKB Gas Field Process Plant are being operated in sufficient capacity. Therefore amount of condensate fraction in the gas stream is small (BGFCL 2007).
- In 1997, Ashuganj- Bakhrabad 30ĕ pipeline was commissioned. So since 1997, BKB-CHT pipeline have been being operated in actual capacity range(actual range 300-350 MMSCFD) (GTCL 2007).
- Since 1997, most of the gas feed to BKB-CHT pipeline was from AB pipeline and this gas was coming from Titas, Habiganj, Rashidpur, Kailashtila and Jalabad Gas Field. This gas had to traveled long distance and second time filtered at Ashuganj Menifold Sration before feed to BKB-CHT pipeline (GTCL 2007).
- After the second pigging operation, BKB Gas Field, Salda Gas Field and Meghna Gas Field have been supplying dry gas (GTCL 2007).
- ICS Feni and CGS Faujderhat are using sufficient capacity heater in the respective plants (GTCL 2007).
- During the year 2005-2006, average 3000 gallons/month of condensate were collected at CGS Faujderhat and average 1000 gallons/month of condensate were collected at ICS Feni (GTCL 2007).
- Since 1997, average 225-250 mmscfd gas was supplied through the BKB-CHT pipeline. So condensate and Sludge could not accumulate inside the pipeline and were collected at ICS feni and CGS Faujderhat. So almost all the condensate were collected after the second pigging operation .

- After the second pigging operation in 1994, condensate (13,76,528 litres) and sludge were recovered at CGS Faujderhat and ICG Feni up to the third pigging in 2007 (GTCL 1994-2007).
- So before the third pigging almost all the condensate and sludge were collected at CGS Faujderhat and ICS Feni. Thus very little was left in the pipeline to be removed by the pigging operation.

CHAPTER 4: ANALYSIS OF THE OUTCOMES

4.1 Comparison of the previous and the latest pigging operation

The comparison of the previous and the latest pigging operation are shown in table-4.1

Table-4.1

	First Pigging operation	**Second Pigging operation**	**3rd (last) Pigging operation**
Duration	9th July 1990 ï 15th July 1990 (Seven days).	4th February 1994 ï 09th February 1994(Six days).	12th November 2007 ï 13th November 2007 (Two days).
Condensate recovered	7,11,000 Litres	3,87,000 Litres.	Negligible amount.
Sludge Recovered	Not significant	2690 Cubic feet(cft).	Not significant

4.2 Analysis of the outcomes

- From the first pigging operation, 7,11,000 litres of condensate recovered (BGSL Pigging Report, 1990).
- During 1991-1992 in BKB Gas field, gas was processed by Glycol dehydration plant. The collecting capacity of liquid hydrocarbon of this plant was 0.6 barrels/MMCF. Later stage, three (60 MMCF capacity each) desiccant plants processed gas and supplied gas to the pipeline. The collecting capability of liquid hydrocarbon of these plants was 2.0 barrels/MMCF. So (2.0-0.6) =1.4 barrels/MMCF condensate was transmitted with gas to BKB- CHT pipeline for about two years. During this time, 18,964.73 MMCF gas was transmitted through the pipeline. So, 26,550 barrels or 9,28,544.73 gallons extra condensate was transmitted through the pipeline. By decrease in temperature of the flowing gas from the gas field , 10% of the entraint condensate (92,854.47 gallons) was accumulated inside the pipeline (BGSL,1990).
- From the second pigging operation, 3,87,000 litres of condensate and 2690 cubic feet sludge were recovered (BGSL, 1994).

- ESA Consultant (British Gas) found 0.0315 barrel condensate/ cubic feet gas of BKB Gas Fielld was transmitted with gas through BKB-CHT pipeline (BGFCL 1994).
- After completion of second pigging project, it was shown that unexpected amount of sludge (2690 cubic feet) was collected than first pigging operation.
- The sample of the sludge of the second pigging operation was as follows (BGSL,1994).

Table-4.2: The sample of the sludge

Sl. No.	Elements	BUET	BAPEX	ERL	BKB Gas Field
1.	CARBONACEOUS MATTER (ORGANIC) %WT	55.09	38.79	41.322	NOT GIVEN IN % WT
2.	DUST OF SILICA GEL % WT	-----	0.96	0.458	-DO-
3.	SAND/ MUD % WT.	9.16	23.03	26.113	-DO-
4.	MILL SCALE (RUST) AS F_2C_3 % WT.	25.10	30.22	23.097	-DO-
5.	MUD AND OTHERS UNIDENTIFIED SUBTANCES % WT	10.65	07.00	-----	-------

- By analyzing the above data , it was clear that SiO_2 was flowing with natural gas and eroded the pipeline and all other stations equipments and fittings. As a result, the bends, line valves and ball valves were becoming thinner.
- On the other hand, carbonaceous matter was also flowing with gases and becoming H_2CO_3 with high velocity CO_2 .
- H_2CO_3 became electrolytes in water and H^+ corroded iron from the pipeline.
- In Mild Steel, carbon particle was present . So in presence of water, Carbon behaved like Cathode and Iron (Fe) behaved like anode. By this way, corrosion was continued through the pipeline.

- After the second pigging operation, BKB Gas Field Process Plant are being operated in sufficient capacity (BGFCL 2007).
- In 1997, Ashuganj- Bakhrabad 30ĕ pipeline was commissioned. So since 1997, BKB-CHT pipeline have been being operated in actual capacity range (GTCL 2007).
- Since 1997, most of the gas feed to BKB-CHT pipeline was from AB pipeline and this gas was coming from Titas, Habiganj, Rashidpur, Kailashtila and Jalabad Gas Field. This gas had to traveled long distance and second time filter at Ashuganj Menifold Station before feed to BKB-CHT pipeline.
- After the second pigging operation, BKB Gas Field, Salda Gas Field and Meghna Gas Field have been supplying dry gas (BGFCL 2007).
- Sufficient capacity heater are being used at ICS Feni and CGS Faujderhat after second pigging operation (GTCL 2007).
- So from the third pigging operation, very negligible amount of condensate and sludge are recovered .

CHAPTER 5: CONCLUSIONS & RECOMMENDATION

The following conclusions and recommendation are drawn from the findings presented in the previous chapters.

5.1 Conclusions.

- From the first pigging operation, 7,11,000 litres of condensate were recovered because of insufficient capacity Glycol Dehydration Plant at Bakhrabad Gas Field and 25% capacity of BKB-CHT pipeline was used before first pigging in 1990.
- From the second pigging operation, 3,87,000 litres of condensate and 2690 cft sludge were recovered because of partially processed gas (0.315 barrel condensate/MMSCF gas) was supplied from BKB Gas Field.
- From the third pigging operation, very small amount of condensate and sludge recovered for the following reasons:
  - After the second pigging operation, BKB Gas Field process plant are being operated in sufficient capacity.Thus the gas quality is better, has less condensate fractions.
  - In 1997, Ashuganj- Bakhrabad 30ĕ pipeline was commissioned. So since 1997, BKB-CHT pipeline have been being operated in actual capacity range.
  - Since 1997, most of the gas feed to BKB-CHT pipeline from AB pipeline and this gas was coming from Titas, Habiganj, Rashidpur, Kailashtila and Jalabad Gas Field. This gas had to traveled long distance and second time filter at Ashuganj Manifold Station before feed to BKB-CHT pipeline.
  - Since 1997, average 225-250 mmscfd gas was supplied through the BKB-CHT pipeline (GTCL 2007). So condensate and Sludge could not be accumulated inside the pipeline and were collected at ICS feni and CGS Faujderhat .

5.2 RECOMMENDATIONS

- Service Condition should be informed of the pig manufacturing company. As for examle:Medium: Sweet Natural Gas, Accumulated Condensate, Water and Sludge (rust, sand etc.) at the bottom of pipeline. Temperature: 60^0 F-130^0F
- Pig speed calculation should be more accurate and it requires more analysis.
- More careful monitoring is needed so that no leakage happened at different off takes and stations.
- Proper timing of closing and opening the valves of different off takes.
- More accurate control of upstream and down stream flow and pressure is essential during on stream pigging operation .
- It requires intelligent pigging of the pipeline for checking the ovality, erosion, leakage and any damage of the pipeline before on stream pigging.

REFERENCES

TD Williamson India Ltd (2010): The Types of Pigs December 15, 2010 from URL : http:// www.tdwindia.com

Girard India Ltd (2010): The Types of Pigs, December 10, 2010 from URL : http:// www.girardindia.com

D.R.Shannon Company (2010) : The Art of Pigging, Retrieved 2010 from URL : http:// www.d.r.shannon company.com

Polly Pigs (2010): The Types of Pigs, Retrieved , 2010 from URL : http:// www.pollypig.com

Mandrel Pigs (2010): The Types of Pigs, Retrieved, 2010 from URL : http:// www.pigunlimited.com

Gas Transmission Company Ltd (2007): Pigging Peport on Bakhrabad-Chittagong Pipeline, 2007.

Gas Transmission Company Ltd (2007): GTCL Monthly Progress Report, 2007.

Bakhrabad System Ltd (1990): Pigging Peport on Bakhrabad-Chittagong Pipeline, 1990.

Bakhrabad System Ltd (1994): Pigging Peport on Bakhrabad-Chittagong Pipeline, 1994.

Bakhrabad System Ltd (2007): BGSL Monthly Progress Report, 2007.

Bangladesh Gas Field Company Ltd (1994): Gas Analysis Data from Bakhrabad Gas Field , 1994.

Bakhrabad System Ltd (2010): BGSL Major Projects Completedt, Retrieved 2010 from . URL : http:// www.bgsl.org.bd.com/Major_Projects.

ERE Stanford (2010) : Condensate Formation Inside the Gas Pipeline, Retrieved 2010 from URL : http:// www.ere stanford.edu.com

Menon, Engr. Shashi : Gas Pipeline Gas Pipeline Hydraulics.

Ge Jianzhi and Rasheed, Mahmood A. (2009): Hydrate Formation and Prevention in Gas Condensate Pipeline, Retrieved 2009 from URL : http:// www.onepetro.org.com

Kennedy, J.L. (1993): Oil and Gas Pipeline Fundamentals, Penn Well Publishing Company, Oklahoma.

.

APPENDIX ï A

OVERVIEW OF THE PIGGING TECHNOLOGY AND PRACTICE:

- **Introduction**

A pig is defined as "A device that moves through the inside of a pipeline for the purpose of cleaning, dimensioning, or inspecting"(Girard India 2010). For many years on stream pigging was considered a necessary evil. After construction, most companies would not pig on a regular basis for cleaning and testing. As the years passed and the capacities of the lines increased,the efficiency of the lines decreased. The lines were pigged to increase the efficiency. As pipelines get older we would see increased corrosion. It is because of water accumulation in the line, paraffin accumulation on the walls, or other reasons. This happens for lack of operational pigging. We begin pigging the line to clean it or batch inhibitors, etc.

- **Reasons of Pigging a Pipeline**

There are various reasons to pig a pipe-line. After the pipeline is built, it will be necessary to run pigs to remove any debris left in the line from new construction; items such as lunch boxes, tools, welding rods, dead animals trapped in the line, etc. Pigging will also remove mill scale or welding icicles in the line. The owner may also require a pig to verify the ovality of the pipeline. This will require a gauging pig and sometimes a geometry pig. After the pipeline has been cleaned, the next phase is acceptance testing where pigs are used for filling the line with water for hydrostatic testing, de-watering (removing the water after testing), and drying. If it is a liquid line, a pig is used to fill the line with a product during the commissioning and start up of the line.

When the pipeline is in service, it will be necessary to pig the line to maintain line efficiency and aid in the control of corrosion. It is necessary to remove the liquids in wet gas systems, remove accumulated water in product pipelines, and paraffin removal and control in crude oil pipelines. Pigs are also used to batch inhibitors. As time passes special cleaning applications may arise. Pre-Inspection pigging before running an ILI (In Line Inspection) tool will not only require the pipe be clean but a dummy pig be run to assure the ILI tool will go through the line. Under certain conditions pipelines may require chemical cleaning or a train of gel pigs may be used for certain cleaning conditions. Lines are sometimes abandoned and require cleaning before moth balling the ine. Other applications include running a Geometry Pig to determine if there are any dents

or buckles in the line. To determine the amount of corrosion or metal loss in the pipeline, an ILI (In Line Inspection) tool is used. Pipelines that handle multiple products such as various grades of gasoline, heating oils, and jet fuels, often use a pig or sphere to separate these products. Pigs are often run to remove any water that has accumulated in the low spots of the pipeline and reduce corrosion. The running of pigs in dual diameter lines always poses a challenge.

- **Types of Pigs**

Pigs can be divided into three general categories:

1. The conventional or utility pig for "on stream" or routine pigging,
2. The geometry pigs for inspection, and
3. The ILI (In Line Inspection) tools for metal loss and corrosion (Girard India 2010).

- The Conventional or utility pigs
    1. Cleaning Pigs and
    2. Sealing pigs

- **Cleaning pigs**

Cleaning pigs are used to remove accumulated solids and debris from the walls of the pipeline. This is normally paraffin in crude oil pipelines. When inhibitors are used in a gas pipeline, the solvents in the inhibitors evaporate, forming a gunk on the pipe walls which can be removed by cleaning pigs. Cleaning pigs are also used in conjunction with chemical treating of the lines to disturb the corrosion sites and remove water, microbes, corrosion products, and food for microbes. Cleaning pigs are normally equipped with brushes or blades to do the cleaning.

Cleaning pigs are designed to remove solids or accumulated debris in the pipeline. This increases the efficiency and lowers the operating cost. They have wire brushes to scrape the walls of the pipe to remove the solids. Pigs 14" and smaller normally use rotary wire wheel brushes. These brushes are easy to replace and inexpensive. Special rotary brushes are used on some larger pigs. Larger pigs have wear compensating brushes. These brushes can be individually replaced as needed and are mounted on either leaf springs,

cantilever springs, or coil springs. The springs push the brushes against the pipe wall. As the wire brushes wear, the force of the spring keeps it in contact with the pipe wall compensating for the brush wear.

There are many different brush materials available. The standard brushes are made of fine or coarse carbon steel wire. For pipelines with internal coatings, Prostran is the material of choice. Some service requires a stainless steel brush. Special brush designs such as the pit cleaning brush are also available. When soft deposits of paraffin, mud, etc., need to be removed, the urethane blade is an excellent choice. The blade design is interchangeable with the brushes.

Bypass ports are installed in the nose of the pig or on the body. These ports are used to control fluid bypass. If the ports are on the body of the pig, the flow will also flow through the brushes and keep them clean. As the fluid passes through the ports on the nose of the pig, it helps keep the debris in front of the pig stirred up and moving. Plugs are used to regulate the bypass.

The sealing elements are either elastomer cups or discs. They are used as a combination cleaning and sealing element to remove soft deposits. Cups are of standard or conical design. Specialty cups are available for some applications. The cup and disc material is normally manufactured from a polyurethane material which gives outstanding abrasion and tear resistance but is limited in temperature range. Neoprene, nitrile, EPDM, and Viton are available for higher temperature applications (Girard India Ltd, 2010).

Fig-A.1: Cleanining Pig

- **Sealing pigs**

Sealing pigs are used during hydrostatic testing of pipelines to fill the line with water and then de-water the line. Removing condensate and water in wet gas systems, water from product pipelines or separating dissimilar products in a products pipeline, are other applications.

Sealing pigs can be spheres, solid cast polyurethane pigs, or mandrel type pigs with sealing cups or discs. These categories can be further broken down into four different types of pigs:

1. Polly-Pigs (foam),
2. Mandrel,
3. Solid Cast, and
4. Spheres.

- **Polly-Pigs (Foam)**

Foam pigs, better known as Polly-Pigs, are manufactured from open cell polyurethane foam. The foam is of various densities ranging from light density (2 lbs/ft3), medium density (5-8 lbs/ft3), to heavy density (9-10 lbs/ft3). Although normally found in a bullet shape, they can have concave ends, flat ends, or bullet noses on both ends. The Polly-Pig can be bare foam or coated with a 90-durometer polyurethane material. The coated pigs may have a spiral coating of polyurethane, various brush materials or silicon carbide coating. If the pig is of bare foam, it will have the base coated. The standard Polly-Pig length is twice the diameter. Some advantages of Polly-Pigs are that they are compressible, expandable, light weight, and flexible. Polly-pigs will travel through multiple diameter pipelines, go around mitered bends, and short radius 90º bends. They will make abrupt turns in tees so laterals can be cleaned. They will also go through valves with as little as 65% opening. Polly-pigs are also inexpensive (Girard India 2010).

Fig.-A.2: Polly-Pigs (Foam)

The disadvantages of Polly-Pigs are that they are a one time use product, shorter length of runs, and high concentrations of some acids will shorten life. Polly-pigs are used for line proving (proving a pig will pass through the line), drying and wiping, removal of thick soft deposits, condensate removal in wet gas pipelines and pigging multiple diameter lines. Polly-pigs coated with a wire brush or silicon carbide are used for scraping and mild abrasion of the pipeline.

- **Mandrel (Steel Shaft) Pigs**

Mandrel pigs have a metal body (steel or aluminum) and are equipped with seals (scraper cups or discs) to provide the differential pressure to propel the pig in the pipeline. For cleaning the line the pig is equipped with wire brushes or polyurethane blades. One advantage of the mandrel pig is that it can be either a cleaning pig, sealing pig or a combination of both. The seals and brushes can be replaced to make the pig reusable. Cleaning pigs are designed for heavy scraping and can be equipped with wire brushes or polyurethane blades. These pigs are designed for long runs. Bypass holes in the nose of the pig control the speed or act as jet ports to keep debris suspended in front of the pig.

There are also disadvantages to the mandrel pig; the cost of redressing the pig is high, and larger pigs require special handling equipment to load and unload the pig. Occasionally the wire brush bristles will break off and get into instrumentation and other unwanted places. Smaller size mandrel pigs will not negotiate 1.5D bends (Girard India 2010).

Fig.-A.3: Mandrel (Steel Shaft) Pigs

Fig.-A.4: Mandrel (Steel Shaft) Pigs

- **Solid Cast Pigs**

Solid cast pigs are of various designs and are usually made of polyurethane; however, neoprene, nitrile, Viton, and other rubber elastomers are available in smaller size pigs. They are considered sealing pigs although some solid cast pigs are available with wrap around brushes and can be used for cleaning purposes. The solid cast pig is available in the cup, disc, or a combination cup / disc design. Most of the pigs are of one piece construction but several manufacturers have all urethane pigs with replaceable sealing elements. Because of the cost to redress a mandrel pig, (material and labor), and to transport them, many companies use the solid cast pig up through 14" or 16". Some solid cast designs are available in sizes up to 36".

Solid cast pigs are extremely effective in removing liquids from product pipelines, removing condensate and water from wet gas systems, and controlling paraffin build-up in crude oil stems (TD Williamson India 2010).

Fig.-A.5 :Solid Cast Pigs

- **Spheres**

Spheres have been used for many years as a sealing pig. There are four basic types of spheres; inflatable, solid, foam, & soluble. The soluble sphere in usually used in crude oil pipelines and contains a microcrystalline wax and amorphous polyethylene which act as a paraffin inhibitor. Although the sphere will normally dissolve in a few hours, the dissolving rate is a function of fluid temperature, fluid movement, friction, and absorbability of the crude. If the line has never been pigged, it is a good idea to run the soluble pig. If it hangs up in the line, it will not obstruct the flow.

Fig.-A.6: Spare Pigs

The inflatable sphere is manufactured of various elastomers (polyurethane, neoprene, nitrile and Vitron) depending on the application. It has a hollow center with filling valves which are used to inflate the sphere with liquid. Spheres are filled with water, or water and glycol and inflated to the desired size. Spheres should never be inflated with air. Depending on the application and material, the sphere is inflated 1%-2% over the pipe inside diameter. As the sphere wears from ser-vice, it is resized, extending its life. In small sizes the sphere can be manufactured solid, eliminating the need to inflate it. The solid sphere does not have the life of an inflatable sphere because it cannot be resized. Spheres can also be manufactured from open cell polyurethane foam.

They can be coated with a polyurethane material to give better wear. For cleaning purposes they can have wire brushes on the surface. The advantages of the foam sphere are that they are light weight, economical, and do not need to be inflated. Spheres in general are easy to handle, will negotiate short radius 90's, irregular turns and bends. They will go from smaller lateral lines to larger main lines and are easier to automate than other styles of pigs. Spheres are commonly used to remove liquids from wet gas systems, water from product pipelines, batching dissimilar products, meter prover service, paraffin control in crude oil pipelines, and hydrostatic testing and de-watering after pipeline rehabilitation or new construction. Special design considerations for the pipeline should be considered when using spheres. They should never be run in lines that do not have special flow tees installed (Girard India 2010).

- **Batching Pigs**

Batching pigs are used to separate dissimilar fluids such as various grades of gasoline, heating oils, etc., in multiple product pipelines. These pigs are unidirectional if they have scraper cups and bidirectional if equipped with discs.

- **Displacement Pigs**

Displacement pigs displace one fluid with another. They can be bidirectional or unidirectional in design. They are used in the testing and commissioning phase of the pipeline, i.e., hydrostatic testing, line fills and de-watering, etc. Line evacuation and abandonment is another application for the displacement pig.

- **Gauging Pigs**

Gauging pigs are used after constructing the pipeline to determine if there are any obstructions in the pipeline. It assures that the ovality of the line is within accepted tolerance. The gauging plate may be mounted on the front or rear of the pig and is made of a mild steel or aluminum. The plate may be slotted or solid. The outside diameter of the plate is 90-95% of the pipe's inside diameter (TD Williamson India 2010).

Fig: A.7: Aluminium Gauging Plate

- **Profile Pig**

A profile pig is a gauging pig with multiple gauging plates, usually three plates. One plate is mounted on the front, one in the middle, and one on the rear of the pig. It is normally used before running an ILI (In Line Inspection) tool to assure the tool's passage around bends and through the pipeline.

- **Dual Diameter Pigs:**

There are many miles of dual diameter pipelines crossing the country side. The lines are normally two pipe sizes different, i.e., 4" x 6", 8" x 10", etc. The mandrel pig is usually

fitted with solid discs for the smaller line and slotted discs for the larger line. If it's a cleaning pig, the brushes will support it in the line and keep the pig centered.

.

Fig:A.8: DDP Dual Diameter Pig

- **Detector pig**

Occasionally pigs will get stuck in a line. The location of the stuck pig can be found by using a detector pig with a transmitter in its body. The transmitter will emit a signal so it can be located with a receiver. After the pig is located, the line can be dug up and the pig removed. Transmitters will normally mount into a mandrel, solid cast, or Polly-Pig.

- **Specialty Pigs:**

Many applications require special pigs. Manufacturers in the pigging industry have made special pigs for many applications. A pinwheel pig which uses steel pins with hardened tips was developed to remove wax and scale from a pipeline. A magnetic cleaning pig was developed to pick up ferrous debris left in the pipeline.

- **GEOMETRY PIGS**

A geometry / caliper pig is a configuration pig designed to record conditions, such as dents, wrinkles, ovality, bend radius and angle, and occasionally indications of significant internal corrosion by making measurements of the inside surface of the pipe (Girard India 2010).

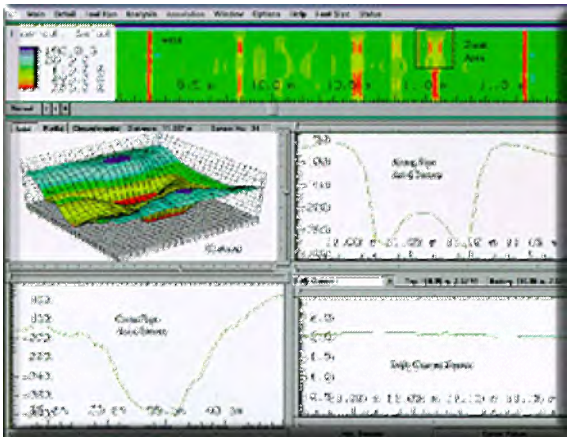


Fig.-A.9 : Geometry Pigs

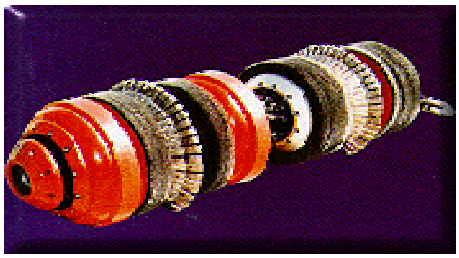


Fig.-A.10 : Geometry Pigs

- **IN LINE INSPECTION TOOLS (ILI) / SMART PIGS**

In Line Inspection provides information on the condition of the pipe and/or its contents. With few exceptions, the In Line Inspection Tool itself is simply the tool which gathers the data, which is then analysed by the engineers and technicians to determine and report on the condition of the line.

Fig.-A.11 : In Line Inspection Tools.

- **MFL INSPECTION TOOL(Intelligent pigs)**

Although the two most common requirements are for geometry/diameter measurement and for metal-loss/corrosion devices, the information which can be provided by these intelligent pigs covers a much wider range of inspection and troubleshooting needs which include:

- measurements;
- Curvature monitoring;
- Pipeline profile;
- Temperature/pressure recording;
- Bend measurement;
- Metal-loss/corrosion detection;
- Photographic inspection;
- Crack detection;
- Wax deposition measurement;
- Leak detection;

- Product sampling, and;
- Mapping.

(Girard India 2010).

Fig.-A.12: Intelligent pigs

- **PLUGS**

A plug is a specialist pig that can be used to isolate a section of pipeline at pressure while some remedial work is undertaken. The plugs can withstand pressures up to 200 bars typically. The plug works by gripping into the line pipe and then having a separate sealing system. Lower pressure techniques include High Friction pigs, which provide a barrier for depressurised systems (Girard India 2010).

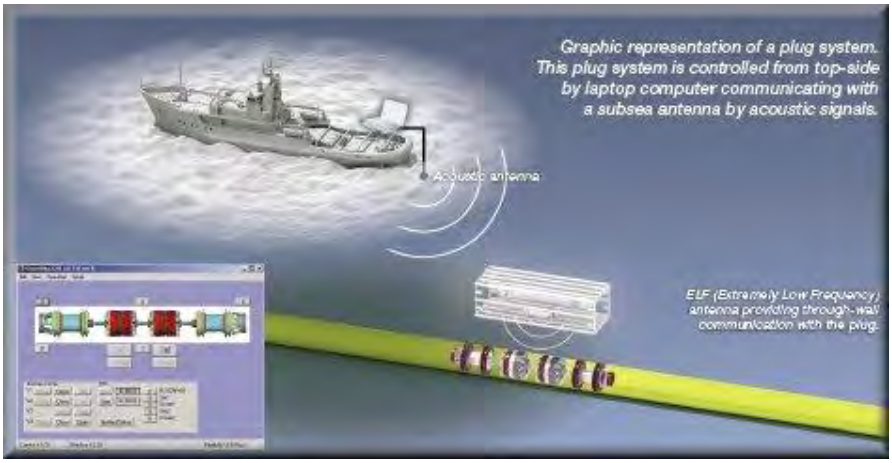


Fig.-A.13: PLUGS

- **GEL PIGS**

Gel pigs are a series of gelled liquid systems which have been developed for use in pipeline operations, either during initial commissioning, or as a part of a continuing maintenance program. Most pipeline gels are water-based, but a range of chemicals, solvents, and even acids can be gelled. Some chemicals can be gelled as the bulk liquid and others only diluted in a carrier. Gelled diesel is commonly used as a carrier of corrosion inhibitor in gas lines. There are four main types of gel that are used in pipeline applications:

1. Batching, or separator gel
2. Debris pickup gel
3. Hydrocarbon gel

- **Dehydrating gel**

As a liquid, although highly viscous, the gel can be pumped through any line which will accept liquids. Gel pigs can be used alone (in liquid lines), in place of batching pigs, or in conjunction with various types of conventional pigs. When used with conventional pigs, gelled pigs can improve overall performance while almost eliminating the risk of sticking a pig. Gel pigs do not wear out in service like conventional pigs. They can, however, be susceptible to dilution and gas cutting. Care must be taken, therefore, when designing a pig train that incorporates gel pigs to minimize fluid bypass of the pigs, and to place a conventional pig at the back of the train when displacing with gas.

Fig.-A.14: Gel Pigs

The principle pipeline applications for gel pigs are as follows

1. Product separation
2. Debris removal
3. Line filling/hydrotesting
4. Dewatering and drying
5. Condensate removal from gas lines
6. Inhibitor and biocide laydown
7. Special chemical treatment
8. Removal of stuck pigs

Specially formulated gels have also been used to seal gate valves during hydrostatic testing. Gels have been developed with a controlled gellation time and a controlled viscosity for temporary pipeline isolation purposes (Girard India 2010).

- **All-Urethane Pipeline Pigs**

Fig.-A.15: All-Urethane Pipeline Pigs

Characteristics:

- Made of the highest quality polyurethane elastomer available.
- One-piece solid polyurethane construction; no assembly necessary.
- Engineered for longer wear and abrasion resistance.
- Versatile.
- Can be run in LPG, crude oil, natural gas, saltwater and product lines.
- Excellent for liquid removal.
- Various durometers available for specific application

Fig.-A.16: The Turbo-MagnumÊ pig

- **The Turbo-Magnum™ pig :**

The Turbo-MagnumÊ pig is available for 2" through 30" pipe. The unique cup design allows smooth transition with full wall seal through tees, check valves and full opening valves. Bolt on, replaceable wire brushes are available when more aggressive cleaning is required. Effective in removing liquids from wet gas systems and liquid pipelines. Also used to control paraffin build up in crude oil lines, separation of refined products, pipeline commissioning and product evacuation.

Fig.-A.17: The Turbo-Flex® pig

- **The Turbo-Flex® pig:**

The Turbo-Flex® pig is available for 2" through 36" pipe. Designed with 5 sealing discs and a rear cup, it is extremely effective in removing liquids in wet gas systems and liquid lines. Its superior sealing capabilities make it ideal for product batching, line displacement, and product evacuation. Used to control paraffin buildup in crude oil lines.

Fig.-A.18:The Turbo-PlusÊ pig

- **The Turbo-Plus™ pig:**

The Turbo-PlusÊ pig is available for 3", 4", and 6" pipe. Ideal for use in plant and industrial applications. The conical cup design allows it to pass through out-of-round pipe with as much as 20% I.D. variation. Ideal for use in pipe with varying wall thickness. Used to evacuate product from process piping in food, cosmetic, and other related industries.

- **Solid Urethane, Bidirectional Displacement Pigs design Criteria**

  Model TBBD

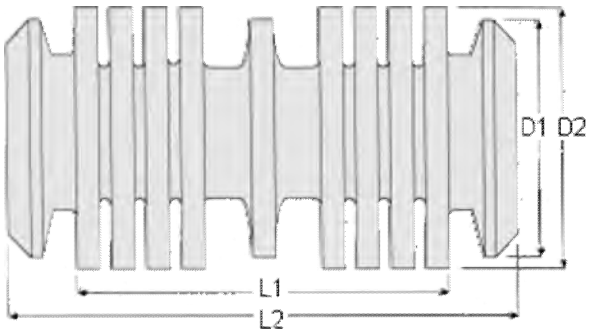


Fig.-A.19: Solid Urethane, Bi-directional Displacement Pigs (Model ï TBBD)

Table-A.1: Solid Urethane, Bidirectional Displacement Pigs Design Criteria (Model-TBBD**)**

Pipe Size	Dimensions				Weight	Material
	D1	D2	L1	L2		
2"	2.00"	2.15"	2.70"	3.90"	0.5lb	Red Urethane 70 Shore A
3"	3.00"	3.18"	3.70"	5.60"	1.0lb	Red Urethane 70 Shore A
4"	4.00"	4.20"	5.25"	7.50"	2.5lb	Red Urethane 70 Shore A
6"	6.00"	6.31"	7.40"	10.75"	9.0lb	Red Urethane 70 Shore A
8"	8.00"	8.30"	10.40"	16.00"	20.5lb	Red Urethane 70 Shore A

- **Model TTP**

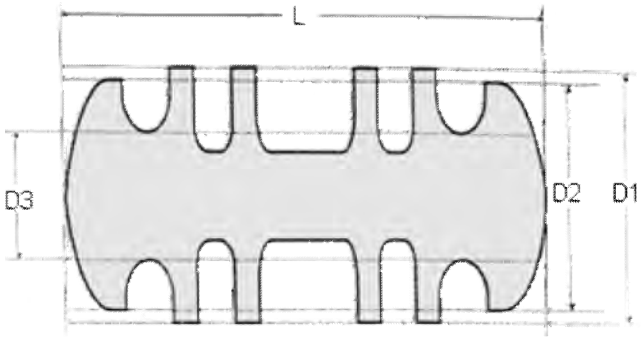


Fig.-A.20: Solid Urethane, Bi-directional Displacement Pigs (Model ï TTP)

Table-A.2: Solid Urethane, Bidirectional Displacement Pigs

Design Criteria (Model-TTP)

Pipe Size	Dimensions			
	L	D1	D2	D3
2"	4"	2.00	1.85"	1.03"
3"	5 11/16"	3.00	2.87"	1.49"
4"	6 15/16"	4.00	3.81"	1.75"

- **The Criteria for Pig used**

The type of pig to be used and its optimum configuration for a particular task in a particular pipeline should be determined based upon several criteria, which include:

1. The purpose
2. Type, location, and volume of the substance to be removed or displaced in conventional pigging applications,
3. Type of information to be gathered from an intelligent pig run,
4. Objectives and goals for the pig run.
5. The line contents
6. The contents of the line while pigging,
7. Available vs. required driving pressure,
8. Velocity of the pig.
9. Characteristics of the pipeline
10. The minimum and maximum internal line sizes,
11. Maximum distance pig must travel,
12. Minimum bend radius, and bend angles,
13. Additional features such as valve types, branch connections, and the elevation profile (Girard India 2010).

- **PIG TRAPS/LAUNCHERS/RECEIVERS**

Pig traps are used for inserting pigs into a pipeline then launching, receiving, and finally removing them without flow interruption. Pig traps are not generally proprietary products and are usually made to a specification drawn up by the user. However, pig trap closures are proprietary products and form a critically important part of a pigging system. Safety is a major consideration in the selection of a closure. All closures must have a built-in safety lock which prevents them being opened while the trap is pressurised.

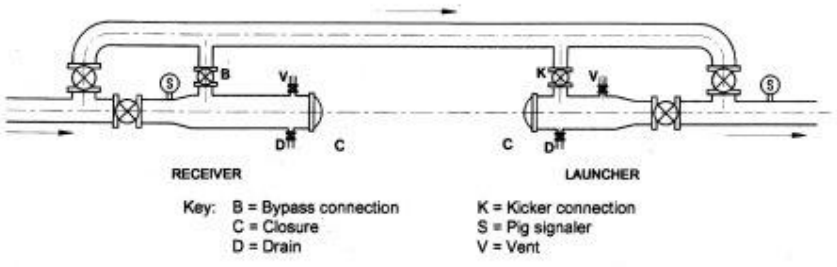


Fig.-A.21: Pig Launchers/Receivers

- **Pigging Method**

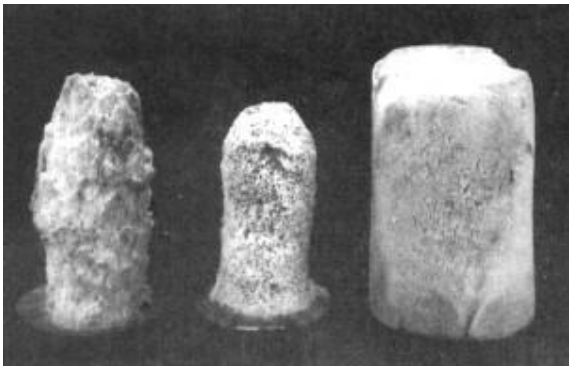


Fig.-A.22: Soft Foam after pigging

The above photograph illustrates how the soft foam is worn away to indicate the true-opening in the pipeline. The pigs on the left were the first ones run and indicate a severely restricted pipe. The pig on the right was the last pig run after cleaning and indicates a clean pipe.

Pigs run through a scaled 8" water line. Left two pigs: medium hardness type RBS. Right two pigs: soft type YBS.

Pigs run through a 6" line. Left pig: type RBS. Right two pigs: type YBS. Polyurethane coating at base shows original diameter.

Fig.-A.23: RBS & YBS Pigs after Pigging

The following general pigging guidelines, tailored toward badly scaled water lines, are applicable to other types of scaled lines as well. The pigs may be propelled using water, air, nitrogen, or sometimes the product in the line.

1. Isolate the section to be cleaned from the system so that pigs don't get lost.

2. Check to make sure that all in-line valves are full port and are fully opened.

3. Turn on the water to double-check the direction of flow, to be sure the water exits at the correct exit location, and to observe the flow rate.

4. Run a full size swab through the line to sweep out loose material and to gauge the true opening in the pipe. Hard scale will wear away the soft foam and the diameter or true opening may be more closely determined (see photo above). Many times it is recommended to run another swab through the section to remove additional loose scale.

5. Run a criss-cross pig just slightly larger than the true opening to begin the cleaning process. It may be necessary to run a full size swab behind the criss-cross pig to improve the seal and allow the criss-cross pig to continue its travel. Continue this process until a pig is discharged from the line in reusable condition.

6. On unlined ductile iron, cast iron, or carbon steel pipes, run a criss-cross wire brush pig of the same size as the previous pigs. Again a full size swab may be required to obtain a better seal. Use only criss-cross pigs on lined pipe, PE or PVC pipe.

7. Increase the size of the pigs in small increments (1/4" to 1/2") depending on the hardness of the scale. Continue to run swabs behind the pigs as necessary.

8. Run two full size pigs (criss-cross or wire brush) once the full I.D. has been attained.

9. Run a full size swab to sweep out loose debris and compare its condition to the first swab which was run, as illustrated by the above photo.

10. Flush the section until the flow is clear of all debris.

11. Shut off the flow and drain all lateral lines into the main line.

12. After completing the drain down, flush the main line one last time.
(Girard India 2010).

- **Pigging for Pipeline Efficiency**

The purpose of operational pigging is to obtain and maintain efficiency of the pipeline to be pigged. The pipeline's efficiency depends on two things: first, it must operate continuously, and second, the required throughput must be obtained at the lowest operating cost.Pipelines are pigged for many reasons. In crude oil pipelines, wax removal or control is important to maintain line efficiency. Liquid removal in wet gas pipelines and removal of debris in the pipe are also important. After determining the cause of the reduced pipeline efficiency and selecting the desired pig, a pigging program can be established. The effectiveness of the pigging program can be evaluated by how much debris is in the receiving trap, or by monitoring the discoloration of the liquid that accumulates in the receiving trap (Girard India 2010).

- **Pre-Run Inspection**

1. The pig must be in good condition if it is to do the job it was selected to do. If the pig has been run before, it should be inspected to assure it would run again without stopping in the pipeline.

2. Measure the outside diameter of the pig's sealing surface with a special diameter tape or, using a regular tape, measure the circumference of the pig's sealing surface and divide the measurement by 3.1416. This diameter must be larger than the inside pipe diameter to maintain a good seal.

3. Inspect the sealing surfaces to assure there are no cuts, tears, punctures or other damage which will affect the pig's ability to run in the pipeline.

4. The unrestrained diameter of brush pigs should also be measured to assure that the brushes will maintain contact with the pipe wall during the complete run. When using brush type mandrel cleaning pigs, the brushes should be inspected for corrosion or breakage. Every precaution should be taken to prevent these brushes from breaking in the pipeline.

5. Loose bristles can damage valves, instrumentation, and other pipeline equipment. All components of brush type mandrel pigs should be checked to be certain that they are tight and in good condition.

- **Pig Launching & Receiving**

Pig launchers are used to launch the pig into the pipeline, and pig receivers are used to receive the pigs after they have made a successful run. The design of these pig traps will depend on the type of pig to be run and pipeline design conditions. These designs are not covered here.

Provisions in the station design should include handling equipment for pigs 20" and larger. Caution should be taken for liquid spillage from the pig traps.

- **Pig Launching & Receiving Procedures**

Pig launchers are used to launch the pig into the pipeline, and **pig receivers** are used to receive the pigs after they have made a successful run. The choice of these pig traps will depend on the type of pig to be run and pipeline design conditions. Provisions in the station design should include handling equipment for pigs 20" and larger. Caution should be taken for liquid spillage from the pig traps (Girard India 2010).

- **Typical Pig Launching Procedures**

The operational sequence described below is for general information only. It is not intended, nor should it be used, to train pigging system operators. Operating procedures will vary from one pipeline company to another. The following pig launching procedures can be used as a guideline for developing operating procedures.

Since company policies vary regarding whether the pig launcher is left on stream or isolated from the pipeline after the pig is launched, the operator should verify that the trap is isolated from the pipeline and depressurized before commencing any part of the launch procedure.

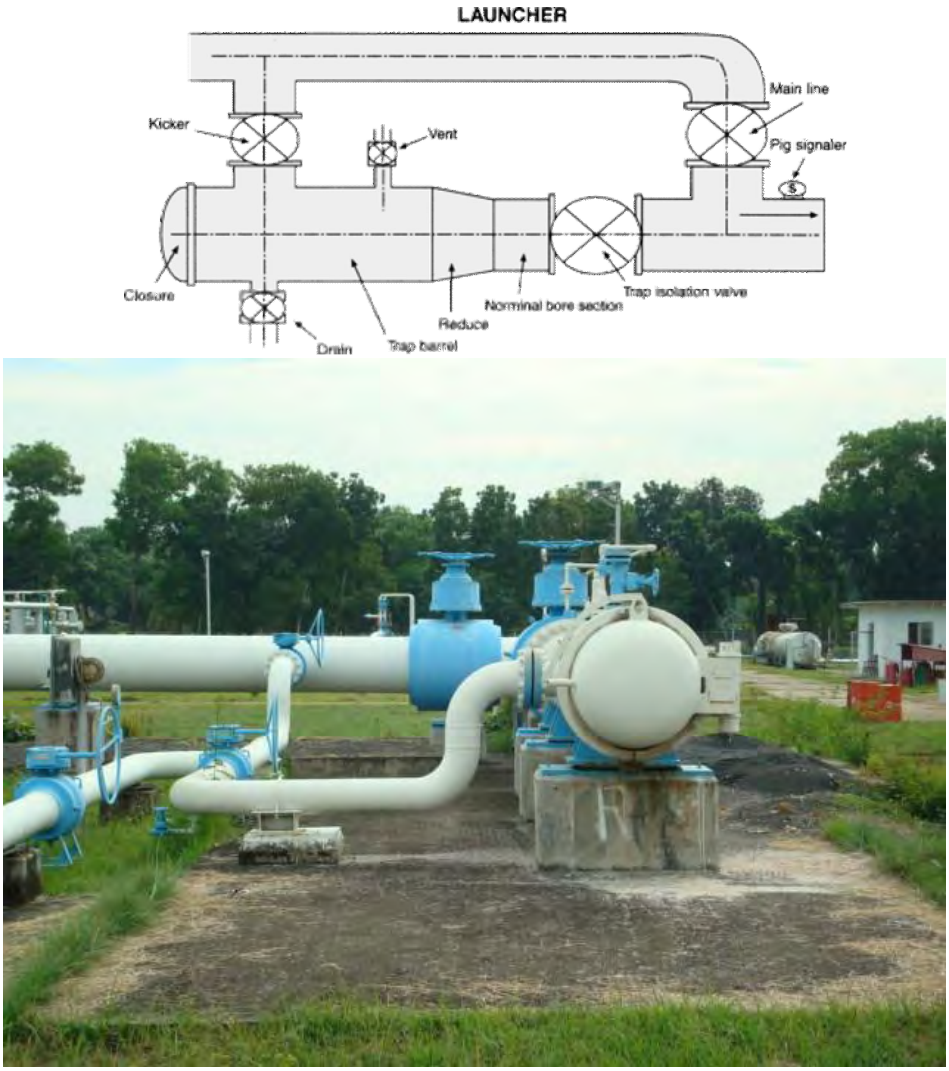


Fig.-A.24: Typical Pig Launcher

1. Make sure that the isolation valve and the kicker valves are closed.

2. In liquid systems, open the drain valve and allow air to displace the liquid by opening the vent valve. In natural gas systems, open the vent and vent the launcher to atmospheric pressure.

3. When the pig launcher is completely drained (0 psi), with the vent and drain valves still open; open the trap (closure) door.
4. Install the pig with the nose firmly in contact with the reducer between the barrel and the nominal bore section of the launcher.

5. Clean the closure seal and other sealing surfaces lubricate if necessary, and close and secure the closure door.
6. Close the drain valve. Slowly fill the trap by gradually opening the kicker valve and venting through the vent valve.
7. When filling is complete, close the vent valve to allow pressure to equalize across the isolation valve.
8. Open the isolation valve. The pig is ready for launching.
9. Partially close the main line valve. This will increase the flow through the kicker valve and behind the pig. Continue to close the main line valve until the pig leaves the trap into the main line as indicated by the pig signaler.
10. After the pig leaves the trap and enters the main line, fully open the main line valve. Close the isolation valve and the kicker valve.

The pig launching is complete (Girard India 2010).

- **Typical Pig Receiving Procedures**

The operational sequence described below is for general information only. It is not intended, nor should it be used, to train pigging system operators. Operating procedures will vary from one Pipeline Company to another. The following pig receiving procedures can be used as a guideline for developing operating procedures.

Since company policies vary regarding whether the pig receiver is left on stream or isolated from the pipeline, the operator should verify whether there is any internal pressure in the receiving trap before starting any part of the receiving procedures.

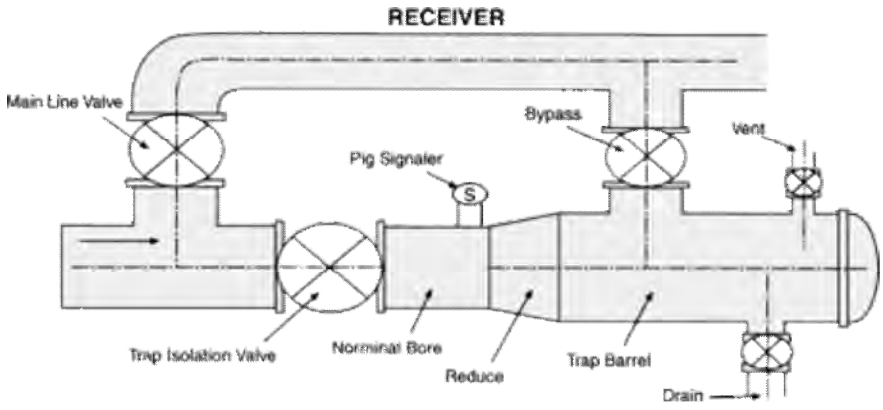


Fig.-A.25: Typical Pig Receiver

1. Make sure the receiver is pressurized.
2. Fully open the bypass valve.
3. Fully open the isolation valve and partially close the main line valve.
4. Monitor the pig signaler for pig arrival.
5. Close the isolation valve and bypass valve.
6. Open the drain valve and the vent valve.
7. Check the pressure gauge on the receiver to assure the trap is depressurized(0 psi).

8. Open the trap closure and remove the pig from the receiver. Clean the closure seal and other sealing surfaces, lubricate if necessary, and close and secure the trap (closure) door (Girard India 2010).

- **Standard Pig Launcher / Receiver**

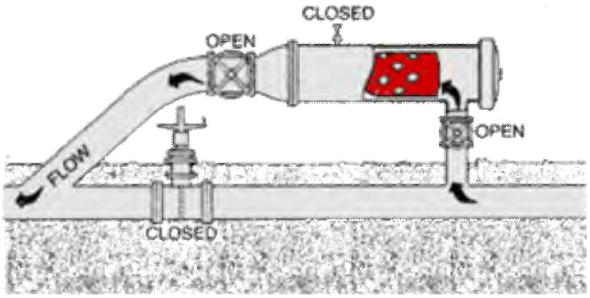


Fig.-A.26: Conventional Pig Launching

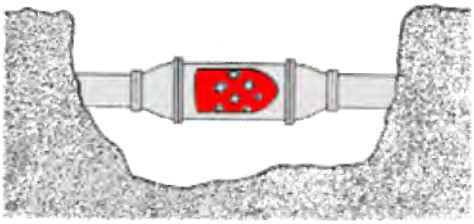


Fig.-A.27:Launching Pig in Water Main Section

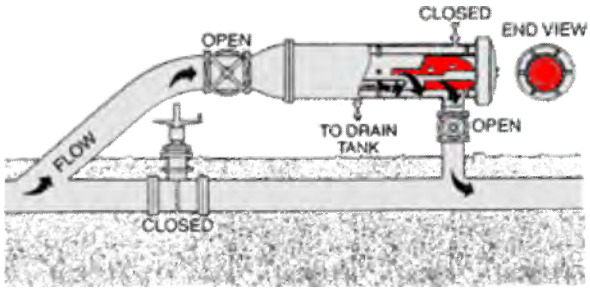


Fig.-A.28:Trapping Pig with Slotted Tray

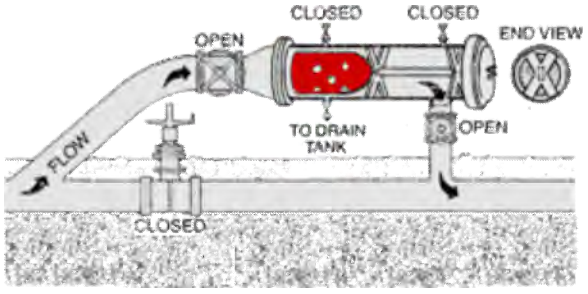


Fig.-A.29:Conventional Pig Trapping

- **Pig Tracking Equipment**

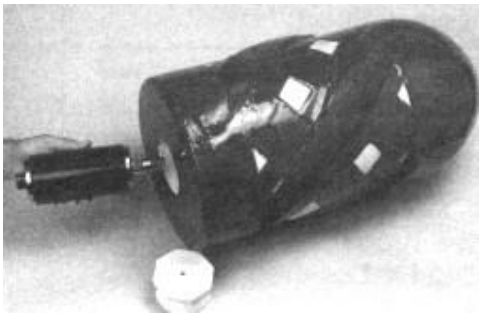


Fig.-A.30: Pig Tracking Equipment

The SPY Pig Tracker is a reliable and simplified way of locating and/or tracking pigs that are used in pipelines today. It can also be used as a temporary or non-intrusive pig signaler. The SPY Pig Tracker is available in three transmitter models:

- **PT 107 Transmitter.** Designed for 4" through 6" pipe with 3D or greater bends. Designed for use ONLY with a foam (Polly-Pig) cavity or solid cast urethane pig.
- **PT 275 Transmitter.** Designed for 8" though 12" pipe with 1 1/2 D or greater bends.
- **PT 750 Transmitter.** Designed for 12" and larger pipe with 1 1/2 D bends (TD Williamson India 2010).

- **Mounting**

The PT 275 and PT 750 transmitters can be mounted in a steel mandrel pig body, foam pigs, or be towed behind a pig using spacing or wear discs. A mounting plate adaptor is required for proper mounting of the transmitter. When properly installed, the battery section of the transmitter is enclosed in the pig body and the electronics section of the transmitter is exposed. When towed behind a pig, it is recommended that the transmitter be installed in a medium or high density Polly-Pig with criss-cross type spirals of polyurethane coating. For mounting in a cavity or mandrel the minimum hole diameter is:

Table-A.3: Minimum Hole Diameter

PT 107	1 1/2"
PT 275	3 3/8"
PT 750	3 1/2"

- **Operation**

For normal tracking or pig signaler operation the wand is kept parallel to the pipe. For pinpointing the pig, the wand is held perpendicular or at 90º to the pipe or transmitter. The depth (distance to the transmitter) can be determined by triangulation. The receiver will occasionally pick up some outside interference that can be recognized with a minimum amount of operating experience. Common causes of outside interference are:

- Automotive electronic ignitions
- Keying two-way radios
- Large belt buckles or key rings
- Some electronic watches
- Large electrical transmission equipment

Table-A.4: Transmitter Battery Size

PT 107	One 3V Lithium battery. Maximum signal strength is 60+ hours.
PT 275	Four "AA" batteries. Maximum signal strength is 200+ hours.
PT 750	Eight "C" batteries. Maximum signal strength is 500+ hours.
PTR (Receiver)	Two 9 volt batteries. 50 hours of continuous operation.

Table-A.5: Transmitter Signal Strength

Model	Signal Strength of Pick-Up Range	
	Underground	Above Ground (Free Air)
PT 107	8 Feet	20-25 Feet
PT 275	15 Feet	65-70 Feet
PT 750	25-30 Feet	100 Feet

(Girard India 2010)

- **Withstanding operating pressures of the transmitters**

Table-A.6: Transmitter Withstanding Pressure

PT 107	1000 PSI
PT 275	2000 PSI
PT 750	3000 PSI

- **System Specifications**

Table-A.7: System Specifications

System	Size (Inches)	Batteries	Hours of Signal
Model 2 System For 4" to 6" Pipelines Includes: PT 107 Transmitter, receiver (PTR), pick-up wand, shoulder strap, wrench, batteries, and durable shipping case.	Length: 6 1/2" Diameter 1 1/4"	1 ea. 3V Lithium	60
Model 4 System For 8" to 12" Pipelines Includes: PT 275 Transmitter, receiver (PTR), pick-up wand, shoulder strap, wrench, batteries, and durable shipping case.	Length: 9 1/2" Diameter: 3"	4 ea. "AA" Type	200
Model 12 System For 12" & Larger Pipelines Includes: PT 750 Transmitter, receiver (PTR),pick-up wand, shoulder strap, wrench, batteries,and durable shipping case.	Length: 16" Diameter: 3 1/8"	8 ea. "C" Type	500

(Girard India 2010)

- **Recommended Procedures for Using Transmiter Pig**

It is important to identify and locate trouble spots in a pipeline. This can be accomplished by running a pig with an electronic transmitter. A few precautions should be followed prior to introducing the transmitter pig into the line.

A. Always make sure the line has flow capabilities. This is easily accomplished by running a YBS (2 Ib/ft^3 density swab) to prove the line. Unless the line is severely restricted, the YBS should come out at the discharge end of the line. If the problem is construction debris, the debris could restrict the swab from traveling the full length of the pipeline. If this happens, put the transmitter pig into the pipeline to locate the stuck pig.

B. If the pipeline in question has never been pigged, or has only been pigged intermittently, Girard recommends using the progressive pigging method to clean the pipeline.

C. If the pipeline has been pigged on a routine basis, a YBS should still be run first. This will determine if any changes have occurred in the pipeline which would cause a problem (TD Williamson India 2010).

- **Dealing with a "Stuck" Pig**

  - **Introduction**

The goals of "pigging" a pipeline include not only running pigs to remove a product or to clean the line, but to do the work without sticking the pig. Getting the pig stuck rarely happens in a pipeline which is pigged routinely, but can happen when pigging a pipeline which has been neglected or never pigged before. It's good practice to run a low density (2 lb/ft^3) foam pig in any "suspect" pipeline and examine the foam pig for wear patterns, tears, gouges, etc. The pigging project should be continued only after feeling comfortable that the line is piggable. Girard's "Progressive Pigging" guidelines should be reviewed prior to beginning a first-time pigging project. If a pig becomes stuck, it is important to identify the cause. Retrieving the pig is the first priority. Usually one of two conditions

exist when a pig is stuck: fluid bypasses around the pig, or there is a complete blockage of the flow.

- **Troubleshooting Pigs Which Have No Bypass**

A. Increase the line pressure, but do not exceed safe limits of the pipeline.

B. Remove pressure from the line and vent or drain toward the launcher. Removing pressure allows the pig to relax to its original shape and may cause it to back up in the pipeline. Allow pres-sure to dissipate. After 15-30 minutes, re-pressure the line in an attempt to drive the pig through the restriction. Repeat two to three times.

C. Consider ways to back the pig out of the line, returning it to the pig launcher. This requires pressuring from the opposite end of the pipeline.

D. In a potable water line when pigging with a foam pig, super-chlorinate (3000 to 5000 ppm) in a slug form to dissolve the pig. The line must be thoroughly flushed and tested after super chlorination.

- **Cups & Discs, Replacement Parts for Steel Mandrel Pipeline Pigs**

Fig.-A.31: Cups & Discs, Replacement Parts

1. Polyurethane Conical Cups
2 .Polyurethane Scraper Cups
3. Polyurethane Scraper Discs
4. Type "A" Polyurethane Scraper Cups
5. Polyurethane Guide / Sealing / Spacer Discs for Bidirectional Pigs

- **Design criteria of Polyurethane Conical Cups, Replacement Parts for Steel Mandrel Pipeline Pigs**

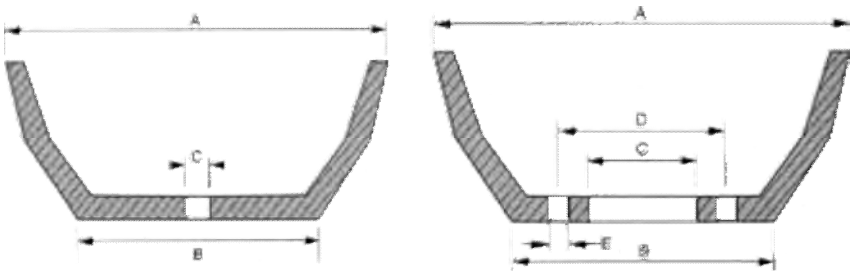


Fig.-A.32: Polyurethane Conical Cups

1. Made of liquid cast polyurethane.
2. High tear strength.
3. Outstanding cut and abrasion resistance.
4. Size to fit most pig bodies.
5. More flexible than scraper cups for ease in traversing out-of-round pipe.

Table-A.8: Design Criteria of Polyurethane Conical Cups

Size	A	B	C	D	E	
	Trailing Edge OD	Leading Edge OD	Center Hole	Bolt Circle	Bolt # - Size	Approx. Weight
4"	4 5/16"	2 7/16"	9/16"	n/a	n/a	0.4 lbs.
5"	5 1/16"	3 1/4"	11/16"	n/a	n/a	0.8 lbs.
6"	6 3/8"	4"	1 1/16"	n/a	n/a	1.2 lbs.
8"	8 1/2"	6"	11/16"	Na	n/a	2.2 lbs.
10"	10 1/2"	7 1/2"	1 1/16"	n/a	n/a	3.5 lbs.
11"	11"	8"	11/16"	n/a	n/a	4.2 lbs.
12" HW	11 13/16"	8 3/4"	1 1/16"	ri/a	n/a	5.0 lbs.
12"	12 7/16"	8 3/4"	1 1/16"	n/a	n/a	6.0 lbs.
14"	13 15/16"	9 3/4"	1 1/16"	n/a	n/a	7.0 lbs.
14 1/2"	14 ½"	9 3/4"	1 1/16"	n/a	n/a	8.0 lbs.
16"	16"	11"	6 3/8"	81/2"	8 - 9/16"	9.0 lbs.
16 1/2"	16 ½"	11"	6 3/8"	81/2"	8 - 9/16"	10.0 lbs.
18"	18"	12 7/8"	8 3/8"	101/2"	12 - 9/16"	12.0 lbs.
20"	20"	12 7/8"	8 3/8"	101/2"	12 - 9/16"	15.0 lbs.
22"	22"	15 1/4"	10 3/8"	13"	14 - 9/16"	20.0 lbs.
22 1/2"	22 ½"	15 1/4"	10 3/8"	13"	14 - 9/16"	23.0 lbs.
24"	24"	15 1/4"	10 3/8"	13"	14 - 9/16"	27.0 lbs.
26"	26"	18"	12 3/8"	15"	16 - 9/16"	34.0 lbs.
28"	28 ¼"	18"	12 3/8"	15"	16 - 9/16"	40.0 lbs.
30"	30"	20 1/4"	15 3/8"	18"	18 - 9/16"	48.0 lbs.
32"	32"	20 1/4"	15 3/8"	18"	18 - 9/16"	54.0 lbs.
34"	34"	22 1/8"	17 3/8"	20"	22 - 9/16"	78.0 lbs.
36"	36"	22 1/8"	17 3/8"	20"	22 - 9/16"	88.0 lbs.
38"	38"	26"	20 7/8"	24"	24 - 5/8"	100.0 lbs.
40"	40"	26 1/2"	20 7/8"	24"	24 - 5/8"	120.0 lbs.
42"	42"	26 1/2"	20 7/8"	24"	24 - 5/8"	135.0 lbs.

(Girard India 2010)

- **Design Criteria of Polyurethane Scraper Cups, Replacement Parts for Steel Mandrel Pipeline Pigs:**

1. Made of liquid cast polyurethane.
2. High tear strength.
3. Outstanding cut and abrasion resistance.
4. Center hole and bolt circle can be modified to fit most pig bodies.
5. Various durometers to fit different applications

6. Made of liquid cast polyurethane.
7. High tear strength.
8. Outstanding cut and abrasion resistance.
9. Center hole and bolt circle can be modified to fit most pig bodies.
10. Various durometers to fit different applications.

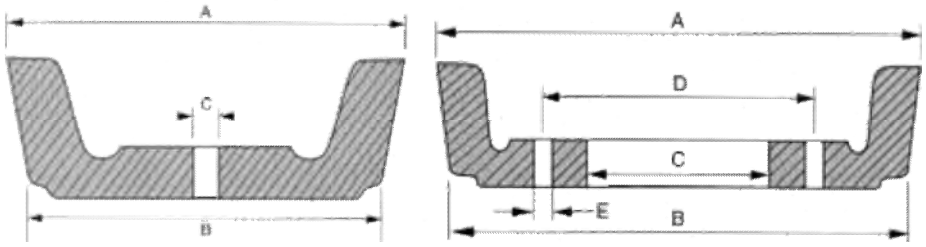


Fig.-A.33: Polyurethane Scraper Cups

Table-A.9: Design Criteria of Polyurethane Scraper Cups

Size	A	B	C	D	E	Approx. Weight
	Trailing Edge OD	Leading Edge OD	Center Hole	Bolt Circle	Bolt # - Size	
2"	2 ¼"	1 1/2"	3/8"	n/a	n/a	0.1 lbs
3"	3 ¼"	2 3/4"	9/16"	n/a	n/a	0.2 lbs
4"	4 ¼"	3 3/4"	9/16"	n/a	n/a	0.3 lbs
4" TW	4 ½"	3 3/4"	9/16"	n/a	n/a	0.4 lbs
6"	6 5/16"	5 1/2"	1 1/16"	n/a	n/a	1.0 lbs
6" TW	6 ½"	5 1/2"	1 1/16"	n/a	n/a	1.1 lbs
8"	8 3/8"	7 5/8"	1 1/16"	n/a	n/a	2.2 lbs
8" TW	8 5/8"	7 5/8"	1 1/16"	n/a	n/a	2.4 lbs
10"	10 3/8"	9 3/8"	1 1/16"	n/a	n/a	3.5 lbs
10" TW	10 5/8"	9 5/8"	1 1/16"	n/a	n/a	3.7 lbs
12"	12 3/8"	11 1/2"	1 1/16"	n/a	n/a	5.0 lbs

12" TW	12 5/8"	11 5/8"	1 1/16"	n/a	n/a	5.3 lbs
14"	14"	13"	1 1/16"	n/a	n/a	7.0 lbs
16"	16"	14 7/8"	8 1/8"	11"	8 - 9/16"	9.0 lbs
18"	18 1/8"	17"	11"	12 3/4"	8 - 9/16"	12.0 lbs
20"	20 1/8"	18 3/4"	10 5/8"	13 1/2"	12 - 9/16"	15.0 lbs
22"	22"	20 3/4"	10 5/8"	13 1/2"	12 - 9/16"	18.0 lbs
24"	24"	22 3/4"	13 3/4"	16 1/2"	14 - 9/16"	22.0 lbs
26"	26"	24 1/4"	13 3/4"	16 1/2"	14 - 9/16"	28.0 lbs
28"	28"	26 1/4"	16 1/4"	19 1/2"	16 - 9/16"	35.0 lbs
30"	30 1/4"	28 3/4"	16 1/4"	19 1/2"	16 - 9/16"	45.0 lbs
32"	32 1/4"	30 1/2"	16 1/4"	19 1/2"	16 - 9/16"	60.0 lbs
36"	36"	34"	22"	25"	22 - 9/16"	58.0 lbs
40"	40 1/4"	37 1/2"	22 1/4"	26'	24 - 9/16"	80.0 lbs
42"	42 1/4"	39 1/2"	24"	30"	24 - 9/16"	85.0 lbs
46"	46"	44"	32"	36"	24 - 9/16"	90.0 lbs
48"	48 1/4"	46"	32"	36	24 - 9/16"	120.0 lbs
54"	54"	51"	40"	44"	36 - 5/8"	135.0 lbs

(Girard India 2010)

- **Design Criteria of Polyurethane Scraper Discs, Replacement Parts for Steel Mandrel Pipeline Pigs:**

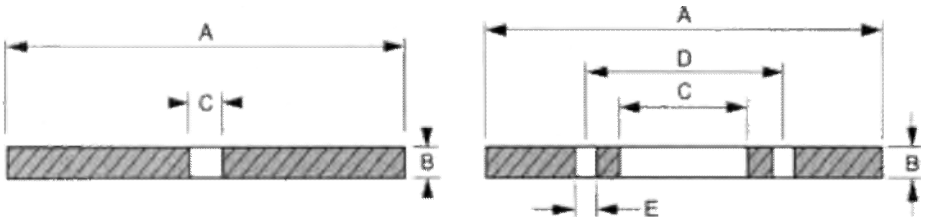


Fig.-A.34: Polyurethane Scraper Discs

1. Made of liquid cast polyurethane.
2. Outstanding cut and abrasion resistance.
3. Center hole and bolt circle can be modified to fit ALL pig bodies.
4. High tear strength.
5. Disc OD can be sized to fit any pipeline ID.
6. Custom disc thickness available.

Table: A.10: Design Criteria of Polyurethane Scraper Discs

Size	A	B	C	D	E	Approx. Weight
	O.D.	Thickness	Ctr. Hole	Bolt Circle	Bolt# - Size	
2"	2 1/4"	1/4"	7/16"	n/a	n/a	0.05 lbs
3"	3 1/4"	1/4"	9/16"	n/a	n/a	0.10 lbs
4"	4 1/4"	3/8"	9/16"	n/a	n/a	0.25 lbs
6"	6 3/8"	5/8"	1 1/16"	n/a	n/a	0.90 lbs
6" TW	6 5/8"	5/8"	1 1/16"	n/a	n/a	1.00 lbs
8"	8 1/4"	11/16"	1 1/16"	n/a	n/a	1.70 lbs
8"TW	8 5/8"	11/16"	11/16"	n/a	n/a	1.80 lbs
10"	10 5/16"	3/4"	1 1/16"	n/a	n/a	2.80 lbs
10"TW	10 5/8"	3/4"	1 1/16"	n/a	n/a	3.00 lbs
12"	12 3/8"	7/8"	1 1/16"	n/a	n/a	4.70 lbs
12"TW	12 5/8"	7/8"	1 1/16"	n/a	n/a	4.90 lbs

14"	13 5/8"	1"	1 1/16"	n/a	n/a	6.50 lbs
14" TW	14"	1"	1 1/16"	n/a	n/a	6.70 lbs
16"	15 3/4"	1 1/16"	8 1/2"	11"	8 - 9/16"	7.00 lbs
16" CC	15 3/4"	1 1/16"	6 3/4"	8 1/2"	8 - 9/16"	7.80 lbs
18"	17 3/4"	1 1/8"	10 3/4"	12 3/4"	8 - 9/16"	7.90 lbs
18" CC	17 3/4"	1 1/8"	8 1/2"	10 1/2"	12 - 9/16"	9.50 lbs
18/16"	17 3/4"	1 1/8"	8 1/2"	11"	8 - 9/16"	9.50 lbs
20"	19 3/4"	1 3/8"	11"	13 1/2"	12 - 9/16"	13.00 lbs
20" CC	19 3/4"	1 3/8"	8 1/2"	10 1/2"	12 - 9/16"	15.30 lbs
22"	21 3/4"	1 3/8"	11"	13 1/2"	12 - 9/16"	16.80 lbs
22" CC	21 3/4"	1 3/8"	10 1/2"	13"	14 - 9/16"	17.25 lbs
24"	23 3/4"	1 1/2"	14 1/4"	16 1/2"	14 - 9/16"	19.00 lbs
24" CC	23 3/4"	1 1/2"	10 1/2"	13"	14 - 9/16"	23.50 lbs
26"	25 3/4"	1 1/2"	14 1/4"	16 1/2"	14 - 9/16"	24.25 lbs
26" CC	25 3/4"	1 1/2"	12 1/2"	15"	16 - 9/16"	27.00 lbs
28"	27 3/4"	1 1/2"	16 1/2"	191/2"	16 - 9/16"	26.75 lbs
28" CC	27 3/4"	1 1/2"	12 1/2"	15"	16 - 9/16"	32.00 lbs
30"	29 3/4"	1 3/4"	16 1/2"	19 1/2"	16 - 9/16"	37.25 lbs
30" CC	29 3/4"	1 3/4"	15 1/2"	18"	18 - 9/16"	39.00 lbs
32"	31 3/4"	1 3/4"	16 1/2"	19 1/2"	16 - 9/16"	40.50 lbs
32" CC	31 3/4"	1 3/4"	15 1/2"	18"	18 - 9/16"	46.50 lbs
34"	33 3/4"	1 7/8"	22 1/4"	25"	22 - 9/16"	43.00 lbs
34" CC	33 3/4"	1 7/8"	17 1/2"	20"	22 - 9/16"	54.00 lbs
36"	35 3/4"	2"	22 1/4"	25"	22 - 9/16"	55.00 lbs
36" CC	35 3/4"	2"	17 1/2"	20"	22 - 9/16"	67.00 lbs
40"	39 3/4"	2"	22 1/2"	26"	24 - 5/8"	74.00 lbs
40" CC	39 3/4"	2"	21"	24"	24 - 5/8"	79.00 lbs
42"	41 3/4"	2"	25"	30"	24 - 5/8"	77.00 lbs

42" CC	41 3/4"	2"	21"	24"	24 - 5/8"	90.00 lbs
48"	47 3/4"	2"	32"	36"	24 - 5/8"	87.00 lbs
48" CC	47 3/4"	2"	25"	28"	28 - 5/8"	114.50 lbs

(Girard India 2010)

- **Design Criteria of Polyurethane Guide / Sealing / Spacer Discs for Bidirectional Pigs, Replacement Parts for Steel Mandrel Pipeline Pigs:**

1. Made of liquid cast polyurethane.
2. Outstanding cut and abrasion resistance.
3. Center hole and bolt circle can be modified to fit ALL pig bodies.
4. High tear strength.
5. Disc OD can be sized to fit any pipeline ID.
6. Custom disc thickness available.
7. Sizes 4" - 14" OD

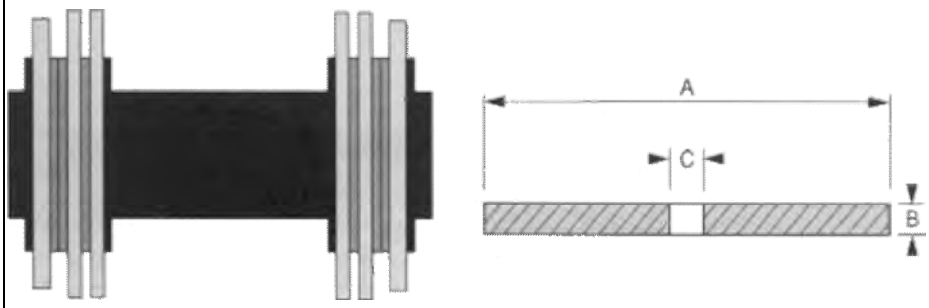


Fig.-A.35: Polyurethane Guide / Sealing / Spacer Discs

Table-A.11: Design Criteria of Polyurethane Guide / Sealing / Spacer Discs

Size	Type	A	B	C	Approx. Weight
		OD	Thickness	Center Hole	
4"	Guide Disc	4.0"	3/8"	9/16"	0.2 lbs
	Sealing Disc	4 3/8"	1/4"	9/16"	0.2 lbs
	Spacer Disc	2.0"	1/4"	9/16"	0.1 lbs
6"	Guide Disc	6.0"	5/8"	1 1/16"	0.8 lbs
	Sealing Disc	6 5/8"	3/8"	1 1/16"	0.6 lbs

	Spacer Disc	3.0"	1/2"	1 1/16"	0.2 lbs
8"	Guide Disc	8.0"	5/8"	1 1/16"	1.4 lbs
	Sealing Disc	8 5/8"	1/2"	1 1/16"	1.3 lbs
	Spacer Disc	4.0"	1/2"	1 1/16"	0.3 lbs
10"	Guide Disc	10.0"	3/4"	1 1/16"	2.6 lbs
	Sealing Disc	10 3/4"	5/8"	1 1/16"	2.5 lbs
	Spacer Disc	6.0"	5/8"	1 1/16"	0.8 lbs
12"	Guide Disc	12.0"	1.0"	1 1/16"	5.0 lbs
	Sealing Disc	12 3/4"	5/8"	1 1/16"	3.5 lbs
	Spacer Disc	8.0"	5/8"	1 1/16"	1.4 lbs
14"	Guide Disc	13 1/4"	1.0"	1 1/16"	6.0 lbs
	Sealing Disc	14.0"	5/8"	1 1/16"	4.2 lbs
	Spacer Disc	10.0"	5/8"	1 1/16"	2.2 lbs

(Girard India 2010)

- **Pig Valve for Pig Launching & Receiving**

Fig.-A.36: The Pig Valve

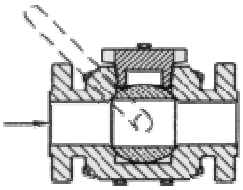
A true double-block and bleed valve that also allows pipeline pigs to be inserted or removed safely and conveniently (TD Williamson India 2010).

- **Send or Receive Pigs with a Quality Pig Valve**

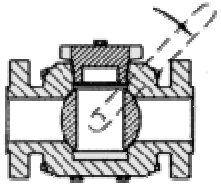
1. Pig Valves give you a double block & bleed valve that can send or receive pigs.
2. Safe, efficient, cost effective means for pigging.
3. Capable of sending and receiving "Bullet", "Scraper" and "Spherical" type pigs.
4. Trunnion mounted ball for extended seat life and ease of operation (all size ranges).
5. Environmentally superior to Pig "Ts" and Traps.
6. Standard temperature range is -50°F (-46°C) to +250°F (+121°C).
7. Main components manufactured from A350-LF2.
8. Built for both sweet and sour services.
9. Designed in accordance with ANSI, API, MSS and NACE requirements.
10. Covered by CRN #OC2161.2.
11. Patents applied for and granted.

- **Typical Pig Launching & Receiving Sequences**

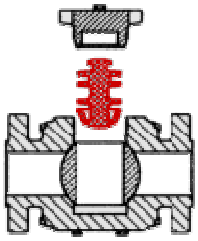
Pig Launching - Clockwise to Close



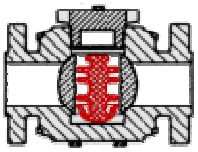
Step 1
Open position. Through conduit flow - no pockets to trap wax or debris.



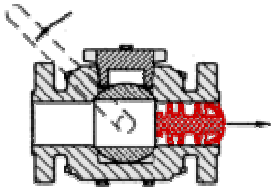
Step 2
Close valve. Upstream and downstream is sealed off. Vent body cavity pressure.



Step 3
Remove entry plug. Insert pig into valve ball cavity.

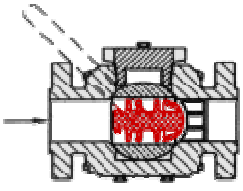


Step 4
Screw entry plug into place. Close vent valve.

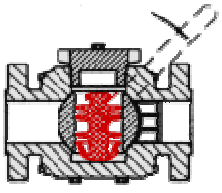


Step 5
Open valve. Flowline pressure moves the pig downstream.

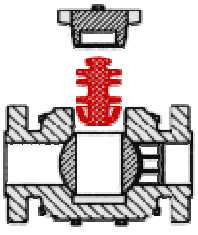
Pig Receiving - Clockwise to Close
When used as a pig receiver, the tailpiece stopper is used to receive the pig.



Step 1



Step 2

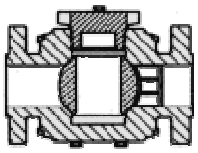


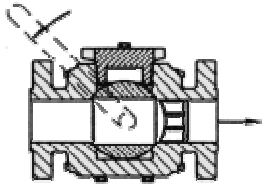
Step 3

Open position. Through conduit flow - stopper in valve cavity arrests pig.

Close valve. Upstream and downstream is sealed off. Vent body cavity pressure.

Remove entry plug. Remove pig from valve ball cavity.





Step 4
Screw entry plug into place. Close vent valve.

Step 5
Open valve. Flow brings the next pig along to be trapped.

6" Pig Launching Valve being installed with bypass loop.

4" Pig Receiving Valve with gear operator and Hi-T Pigalert pig detector.

Fig.-A.37: 6" & 4" Pig Launching Valve

- **Multi-Pig Launchers**

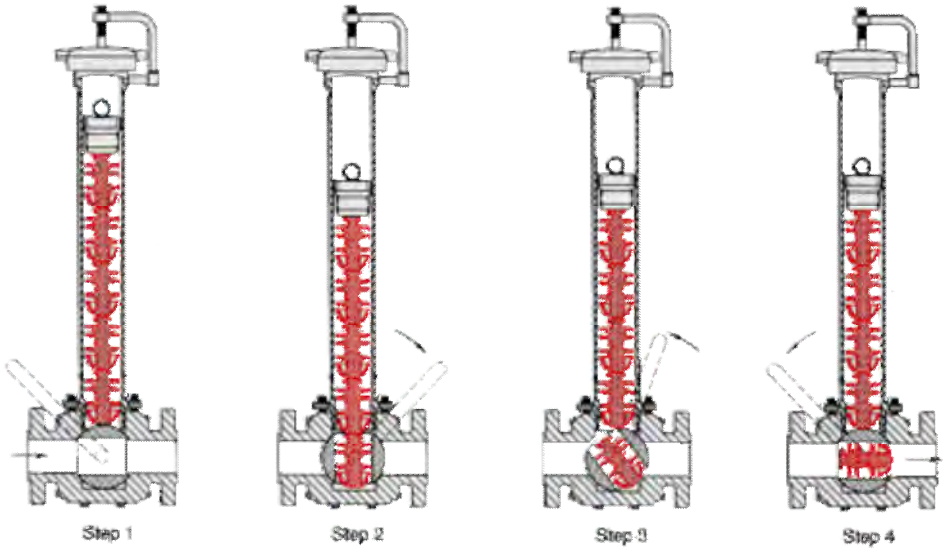


Fig.-A.38: Multi-Pig Launchers

Multi pig launchers and automated pig valve actuators are available for pig valves (Girard India 2010).

Appendix-B

Third Pigging Data Table

BKB-CTG on stream pigging from 12 Non 8:00 AM to 13 Nov 8:00 AM 2007

Monitoring report, BKB RMS Monitoring Team no.1

Table B.1:

Date	Time (hrs)	Pressure Inlet (Psig)	RMS Flow (mmscfd)	12″ Valve opening (%)	**Remarks**
12 Nov 07	8:30	800	85.00	100	**Pig Kicked at 08:30 AM from BKB end**
	9:00	792	85.00	100	
	10:00	788	85.50	100	
	10:34	787	78.40	100	Pig crossed at 10:34 AM from Kutumbopur
	11:00	783	82.98	100	
	12:00	781	69.55	100	
	13:00	776	74.91	100	
	14:00	773	73.33	100	
	14:28	773	72.80	100	Pig crossed at 14:28 PM from Bijra Offtake
	15:00	773	78.13	100	
	15:15	773	78.10	100	Pig crossed at 15:15 PM from Laksam TBS
	15:23	773	78.10	100	Pig crossed at 15:23 PM from MLV-4
	16:00	773	91.83	100	
	17:00	773	99.74	100	
	18:00	771	99.96	100	
	18:32	768	101.99	100	Pig crossed at 18:32 PM from MLV-5
	18:48	768	101.99	100	
	19:00	766	106.08	100	
	20:00	760	104.86	100	
	20:12	760	105.00	100	Pig received at 20:12 PM at ICS Feni
	21:00	756	108.00	100	
	21:20	755	106.00	100	Pig kicked at 21:20 PM from ICS Feni
	22:00	754	108.63	100	
	22:31	754	109.97	100	Pig crossed at 22:31 PM from Kalidas River East MLV-9
	23:00	755	112.20	100	

	23:27	758	108.40	100	Pig crossed at 23:27 PM from Muhuri river East MLV-11
13 Nov 07	00:00	762	101.80	100	
	00:05	762	101.80	100	Pig crossed at 00:05 AM from Feni river East MLV-12
	00:55	761	77.00	50	12″ Valve opening decreased by 50% to maintain flow 80 mmscfd as per instruction of GM(ESD),GTCL
	01:00	762	81.09	50	
	02:00	760	77.59	50	
	02:20	759	74.14	50	Pig crossed at 02:20 AM from Mitachara Offtake.
	03:00	758	79.50	50	
	04:00	763	82.92	50	
	05:00	769	84.98	50	
	06:00	774	83.39	50	
	06:35	774	84.32	50	Pig crossed at 06:35AM,13 Nov 07 from Sitakunda.
	07:00	774	83.28	50	
	08:00	772	79.00	50	
	08:30	770	77.23	50	
	09:00	770	77.23	50	
	10:00	767	75.15	50	
	10:55	763	79.59	48	12″ Valve opening slightly adjusted to maintain flow 80 mmscfd as per instruction of GM (ESD), GTCL.
	11:00	762	78.14	48	
	11:21	762	101.60	55	12″ Valve opening slightly adjusted to maintain flow 100 mmscfd as per instruction of GM (ESD), GTCL.
	11:30	770	98.65	55	
	11:32	769	98.65	55	Pig crossed at 11:32 AM,13 Nov 07 from MLV-14, Silimpur.
	11:40	769	84.00	51	
	12:00	769	77.88	51	
	12:15	755	78.00	51	Pig arrived at CGS Chittagong.
	13:00	775	79.00	51	
	13:10	747	104.00	58	12″ Valve opening slightly adjusted to maintain flow 100 mmscfd as per instruction of GM (ESD), GTCL.
	14:00	759	106.37	58	

(GTCL Pigging Report 2007).

BKB-CTG on stream pigging from 12 Non 8:00 AM to 13 Nov 14:00 PM 2007 , CGS-Faujderhat Monitoring Team no.1

Table B.2:

Date	Time (hrs)	Pressure Inlet (Psig)	RMS Flow (mmscfd)	**Remarks**
12 Nov 07	8:00	733	87.00	
	8:30	731	86.00	**Pig Kicked at 08:30 AM from BKB end**
	9:00	728	87.00	
	9:30	726	86.00	
	10:00	723	85.00	
	10:30	721	85.00	Pig crossed at 10:34 AM from Kutumbopur
	11:00	729	50.00	
	11:30	735	62.	
	12:00	727	83	
	12:30	716	81	
	13:00	718	81.00	
	13:30	715	81.00	
	14:00	713	81.00	
	14:30	711	82.00	Pig crossed at 2:28 PM from Bijra Offtake
	15:00	709	80.00	
	15:30	707	80.00	Pig crossed at 3:15 PM from Laksam TBS
	16:00	714	50.00	Pig crossed at 3:23 PM from MLV-4
	16:30	718	51.00	
	17:00	721	50.00	
	17:30	708	87.00	
	18:00	687	125.00	
	18:30	672	147.00	Pig crossed at 6:32 PM from MLV-5
	19:00	673	103.00	
	19:30	673	104.00	
	20:00	663	129.00	
	20:30	660	102.00	Pig received at 8:12 PM at ICS Feni
	21:00	662	102.00	
13 Nov 07	21:30	661	102.00	Pig kicked at 9:20 PM from ICS Feni
	22:00	661	101.00	
	22:30	661	101.00	Pig crossed at 10:31 PM from Kalidas River East MLV-9
	23:00	684	34.00	
	23:30	701	27.00	Pig crossed at 11:27 PM from Muhuri river East MLV-11
	24:00	706	55.00	Pig crossed at 12:05 AM from Feni river East MLV-12

	01:00	721	48.00	
	01:30	716	65.00	
	02:00	711	82.60	
	02:30	713	58.79	Pig crossed at 02:20 AM from Mitachara Offtake.
	03:00	716	58.55	
	03:30	718	59.21	
	04:00	721	59.00	
	04:30	723	59.82	
	05:00	726	60.00	
	05:30	729	60.55	
	06:00	732	61.00	
	06:30	734	60.55	Pig crossed at 06:35AM,13 Nov 07 from Sitakunda.
	07:00	735	60.55	
	07:30	735	60.00	
	08:00	735	61.00	.
	08:30	732	60.00	
	09:00	732	60.00	
	09:30	730	59.00	
	10.00	729	72.00	
	10:30	722	72.00	
	11:00	719	185.00	
	11:30	676	61.00	Pig crossed at 11:32 AM,13 Nov 07 from MLV-14, Silimpur
	12:00	705	71.00	
	12:30	706	84.00	Pig arrived at CGS Chittagong.
	13:00	699	84.00	
	13:30	691	105.000	
	14:00	679	119.00	

(GTCL Pigging Report 2007).

Monitoring Points, Pig position, pig speed, crossing time, Reaching time at Monitoring Points:

Table B.3:

Monitoring Points	Distance from BKB Gas Field	Speed of the pig and time taken to cross	Reaching Time	Operations
BKB Gas Field	0.00 miles	Speed: 0.00 miles/hr Time:0:00 hrs	8:30 am	▪ Pig launch by 800 psi pressure and 85 MMSCFD flow. ▪ Feni Gas field was remain shut down. ▪ Off take valve of Kutumbopur was closed. ▪ Gas supply to adjacent area as well as relavent power station and bulk consumer of Kutumbopur TBS was remained off.
MLV-2, Comilla Off take, Kutumbopur TBS	Kutumbopur 9.56 miles	Speed: 4.66 miles/hr Time taken: 02 hrs 03 minutes.	10:33 am	▪ Off take valve of Chandpur (Bijra) and Laksam TBS were closed. ▪ Gas supply to adjacent area as well as relavent industry from Bijra Off take and Laksam TBS was remained off.
Chandpur Off take, Comilla ï Chandpur road crossing	Bijra 27.19 miles	Speed: 4.56 miles/hr Time taken: 05 hrs 58	2:28 pm	▪ After crossing Chandpur off take, off take valve of Kutumbopur TBS were

		minutes.		opened.
MLV-3, Laksam TBS	Perul 31.01 miles	Speed: 4.59 miles/hr Time taken: 06 hrs 45 minutes.	3:15 pm	▪ After crossing Laksam TBS , off take valve of Feni TBS was closed. ▪ Gas supply to adjacent area as well as relavent industry and power station from Feni TBS was remained off.
MLV-4, Beside Laksam Rail Line	Laksam 31.36 miles	Speed: 4.57 miles/hr Time taken: 06 hrs 52 minutes.	3:22 pm	▪ Gas supply to adjacent area as well as relavent industry and power station from Feni TBS and Laksam TBS was remain off.
MLV-5,	Jamurail Comilla 45.58 miles	Speed: 4.54 miles/hr Time taken: 10 hrs 02 minutes.	6:32 pm	▪ Off take valve of Feni TBS was still remain off. ▪ Gas supply to adjacent area as well as relavent industry and power station from Feni TBS was remained off.
MLV-7	Dakatia River 46.51 miles	Speed: 4.52 miles/hr Time taken: 10 hrs 18 minutes.	6:48 pm	▪ Off take valve of Laksam TBS was opened. ▪ Off take valve of Feni TBS was still remain off. ▪ Gas supply to adjacent area as well as relavent industry and power station from Feni

				TBS was remained off.
Feni ICS	Feni 54.8 miles	Speed: 4.68 miles/hr Time taken: 11 hrs 42 minutes.	6:48 pm	▪ After reaching the pig at Feni ICS, gas was supplied to Main Line during about one hour.

(GTCL Pigging Report 2007).

Monitoring points, distance from ICS Feni, pig speed and reaching time at monitoring points:

Table B.4:

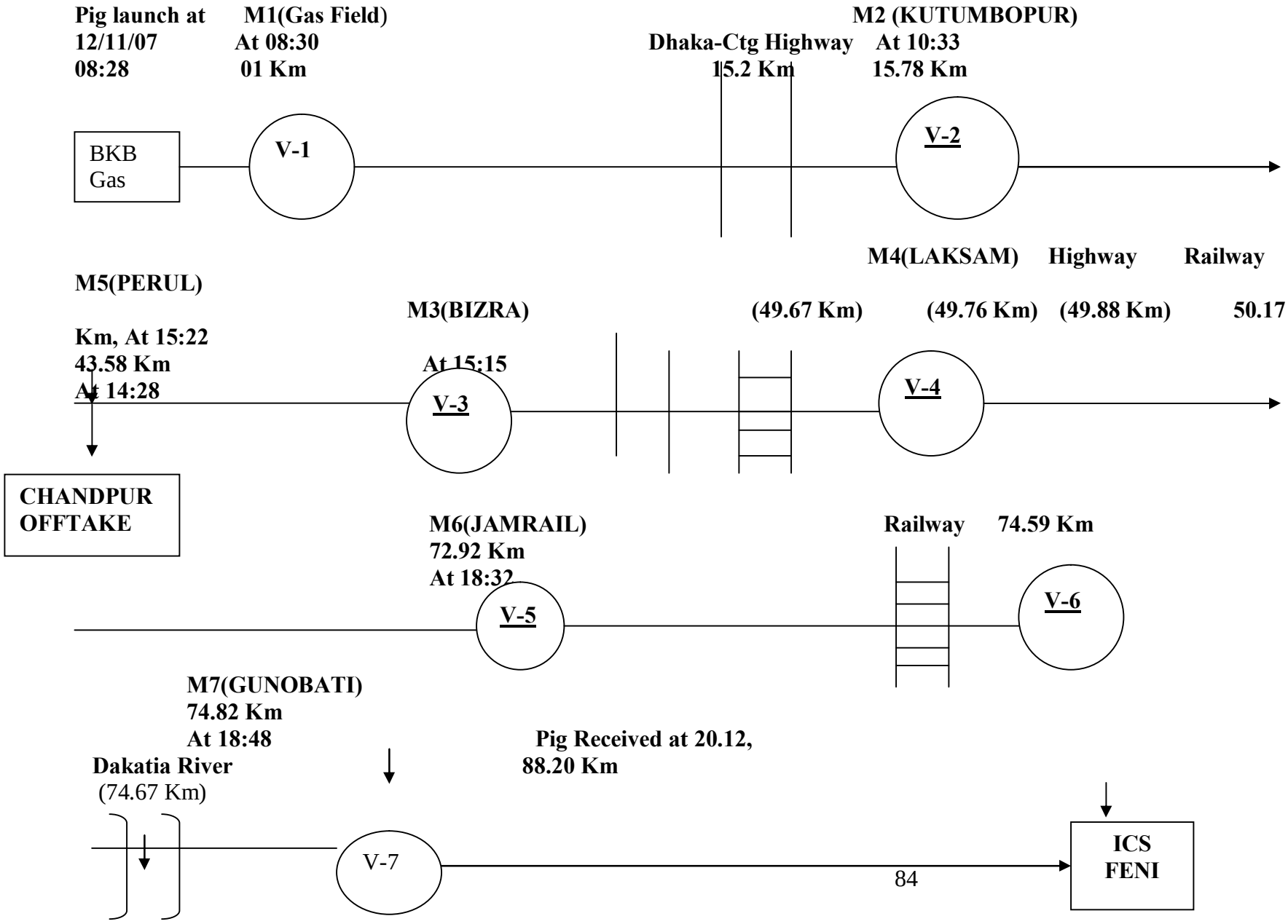
Monitoring Points	Distance from ICS Feni	Speed of the pig and time taken to cross	Reaching Time	Operations
ICS Feni	Feni 0.00 miles	Speed: 0.00 miles/hr Time:0.00 hrs	9:20 pm	▪ Feni Gas Field was remained shut down. ▪ Pig was launch by 755 psi pressure and 106 MMSCFD flow. ▪ Off take valve of feni ICS was closed. ▪ Gas supply to adjacent area as well as relavent power station and bulk consumer of Feni TBS was remained off.
MLV-9	East bank of Kalidasï Paharika river, 9.77 miles	Speed: 5.72 miles/hr Time taken: 01 hrs 11 minutes.	10:33 am	▪ Off take valve of Mithchara TBS was closed. ▪ Gas supply to adjacent area as well as relavent industry from Mithchara TBS was remained off.
MLV-11	East bank of Muhuri	Speed: 5.59 miles/hr	11:27 pm	▪ Off take valve of Mithchara TBS was closed.

	river, 11.84 miles	Time taken: 02 hrs 07 minutes.		▪ Gas supply to adjacent area as well as relavent industry from Mithchara TBS was remained off. ▪ After crossing Mithchara TBS, off take valve of Feni TBS was opened to supply gas to adjacent area.
MLV-12	East bank of Feni river, 13.14 miles	Speed: 4.87 miles/hr Time taken: 02 hrs 45 minutes.	12:05 at mid night date: 13.11.2007	▪ Off take valve of Mithchara TBS was closed. ▪ Gas supply to adjacent area as well as relavent industry from Mithchara TBS was remained off.
Mirsarai Off take	Mithachara , 21.34 miles	Speed: 4.27 miles/hr Time taken: 05 hrs 00 minutes.	2:20am	▪ Off take valve of Mithchara TBS was closed. ▪ Gas supply to adjacent area as well as relavent industry from Mithchara TBS was remained off. ▪ Off take valve of Barabkunda TBS was closed.
MLV-13	Shitakunda 30.45 miles	Speed: 3.29 miles/hr Time taken: 09 hrs 15 minutes.	6:15 am	▪ Offtake valve of Mthchara TBS was opened. ▪ Off take valve of Barabkunda TBS was closed. ▪ Gas supply to adjacent area as well as relavent industry and power station from Mithachara and Barabkunda TBS was remained off.
Barabkunda TBS	Barabku-nda 37.58	Speed: 3.60miles/hr	7:45am (morning)	▪ Off take valve of Barabkunda TBS was remain

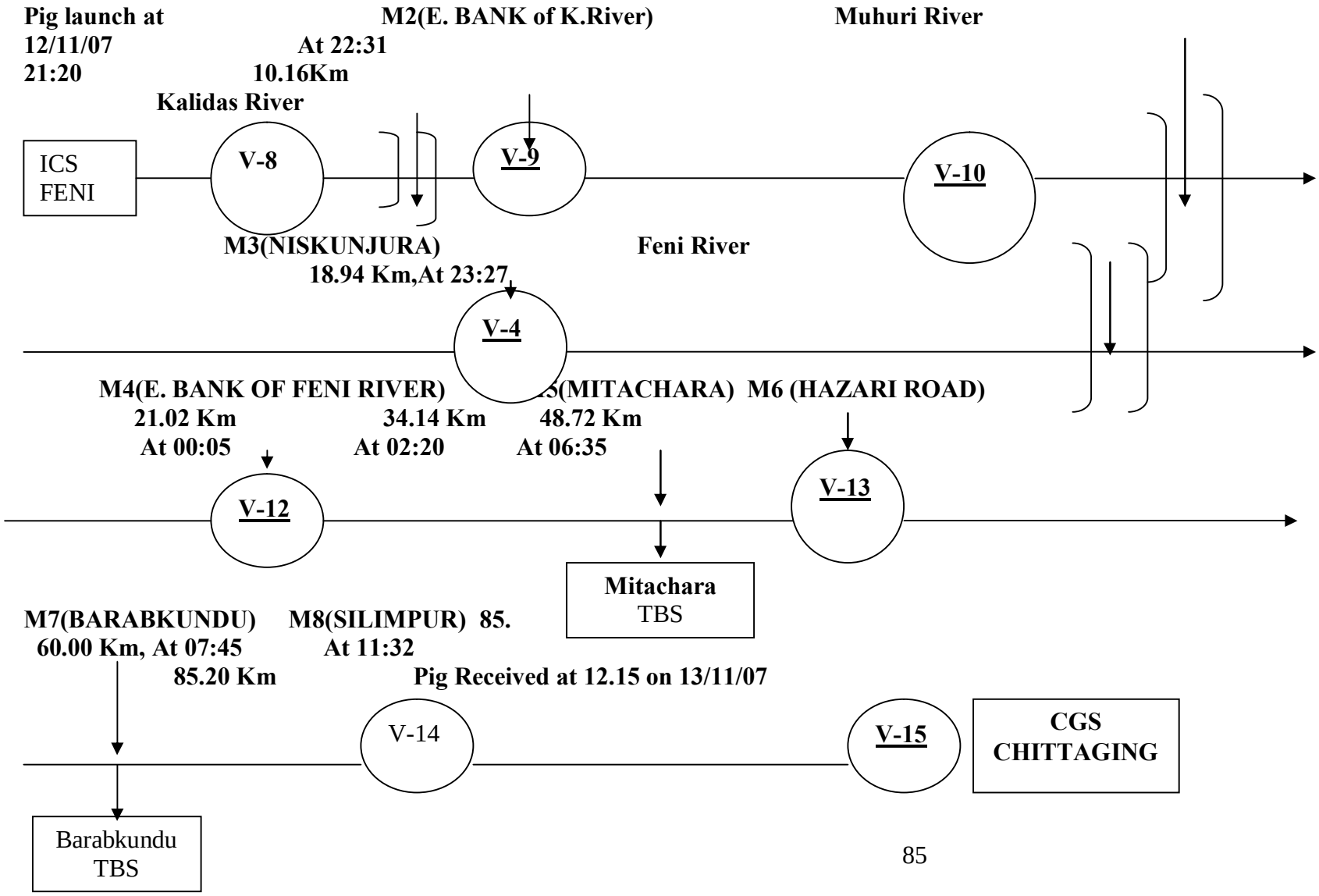
	miles	Time taken: 10 hrs 25 minutes.		closed. ▪ Gas supply to adjacent area as well as relavent industry and power station from Barabkunda TBS was remained off.
MLV-14	Silimpur, Faujderhat 53.25 miles	Speed: 3.75 miles/hr Time taken: 14 hrs 12 minutes.	11:32 am	▪ Off take valve of Barabkunda TBS was remained closed. ▪ Gas supply to adjacent area as well as relavent industry and power station from Barabkunda TBS was remained off. ▪ After crossing Barabkunda, the inlet valve of CGS Chittagong was closed and gas was supplied to BGSL system through kicker line and by- pass line.
CGS Chittagong	Chittagong 53.65 miles	Speed: 3.60 miles/hr Time taken: 14 hrs 55 minutes.	12:15 pm date:13.11. 2007	▪ After reaching the pig at CGS Chittagong, the off take valve of Barabkunda TBS was opened to supply gas.

(GTCL Pigging Report 2007).

APPENDIX -C


Pig launch at
12/11/07
08:28
M1(Gas Field)
At 08:30
01 Km
M2 (KUTUMBOPUR)
Dhaka-Ctg Highway
15.2 Km
At 10:33
15.78 Km
BKB
Gas
V-1
V-2
M4(LAKSAM)
Highway
Railway
M5(PERUL)
M3(BIZRA)
(49.67 Km)
(49.76 Km)
(49.88 Km)
50.17
Km, At 15:22
43.58 Km
At 14:28
At 15:15
V-3
V-4
CHANDPUR
OFFTAKE
M6(JAMRAIL)
72.92 Km
At 18:32
Railway
74.59 Km
V-5
V-6
M7(GUNOBATI)
74.82 Km
At 18:48
Pig Received at 20.12,
88.20 Km
Dakatia River
(74.67 Km)
V-7
ICS
FENI

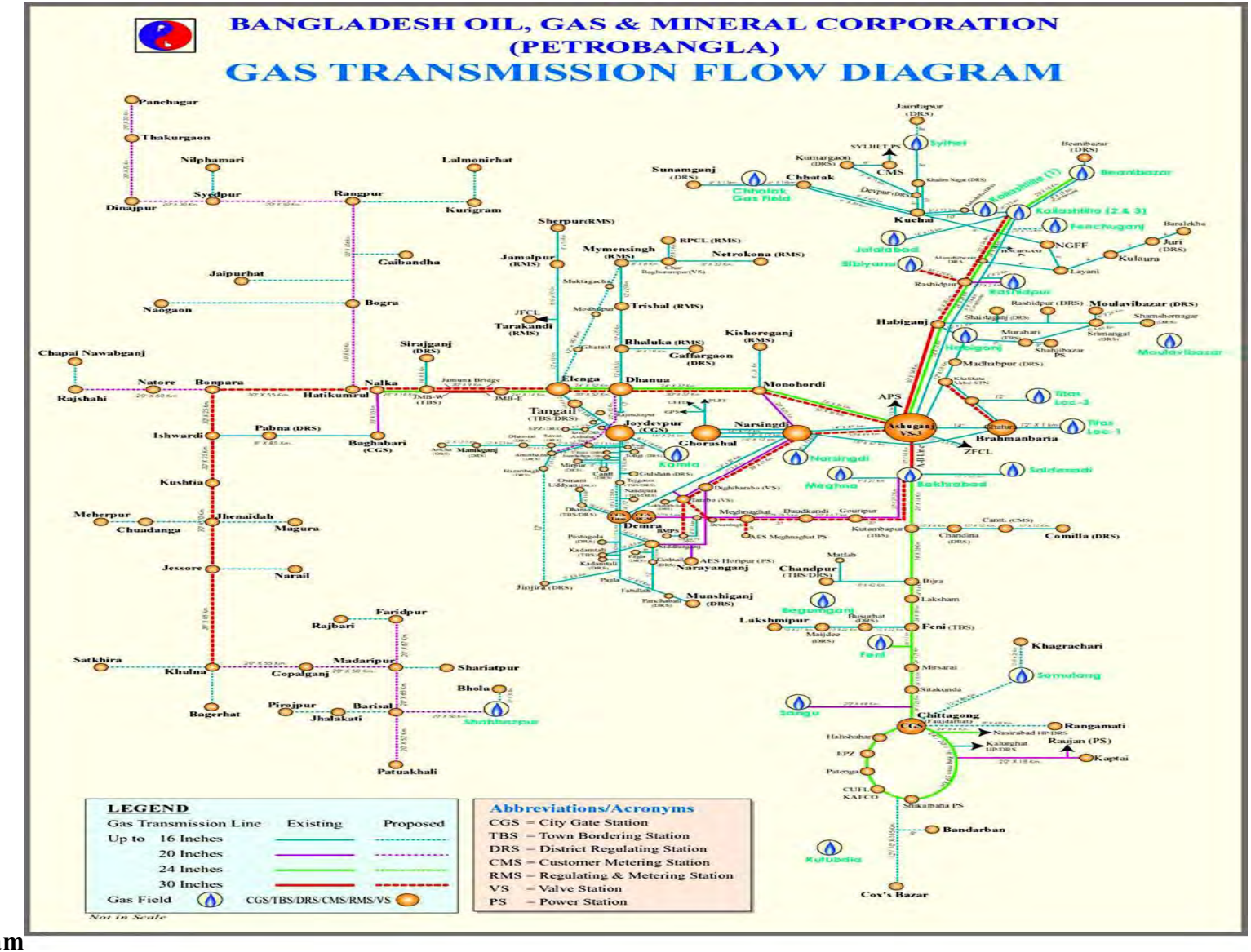
FigB.1: Line Diagram of BKB-Chittagong High Pressure GasA Transmission Pipeline
(BKB-ICS Feni Portion) Monitoring Points



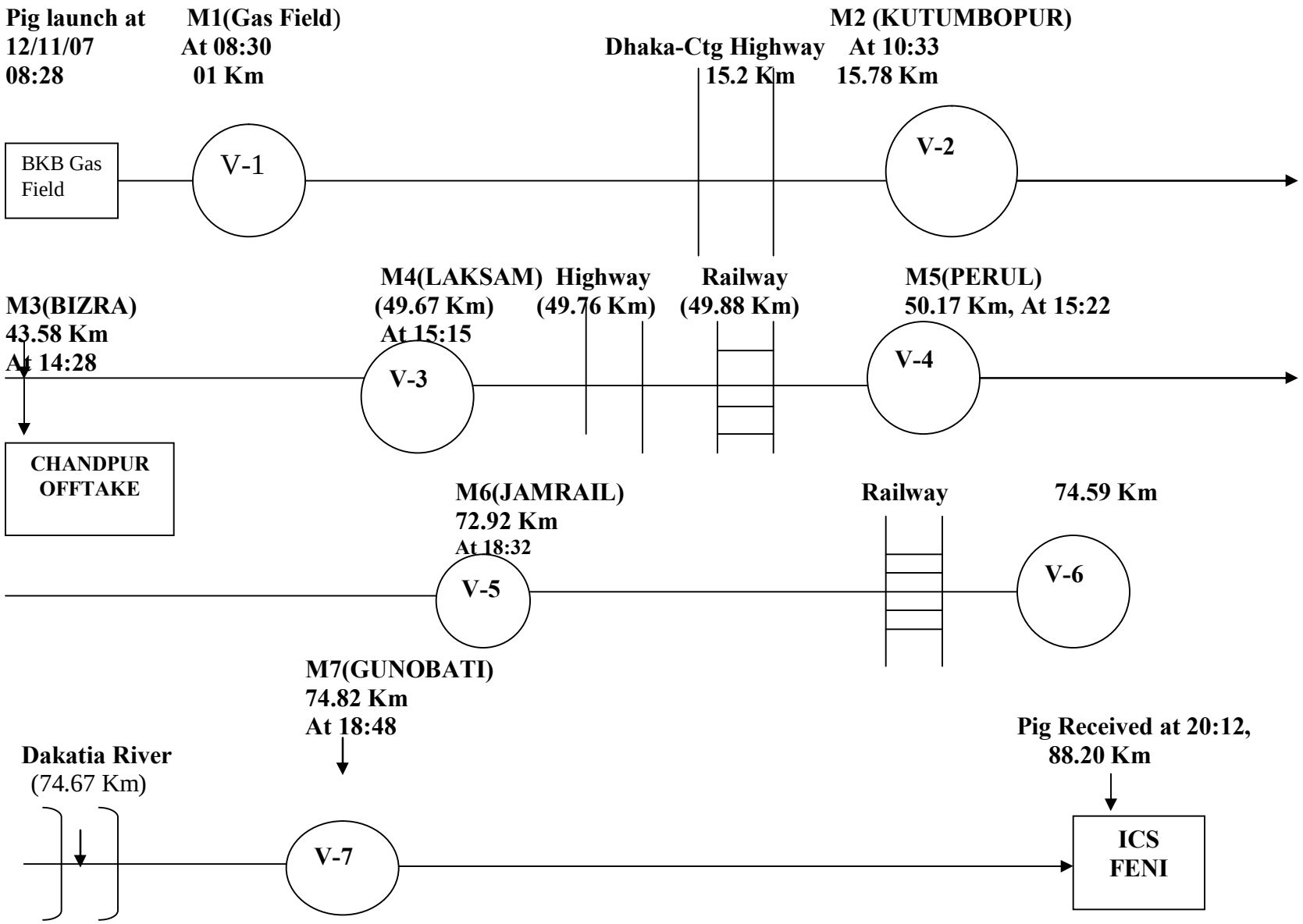
FigB.2: Line Diagram of BKB-Chittagong High Pressure GasA Transmission Pipeline
(ICS Feni-CGS Chittagong Portion) Monitoring Points
'V' Stands for Main Line Valve Station

Fig.B.3: A Pig Receiver of NS 24″ Pipeline

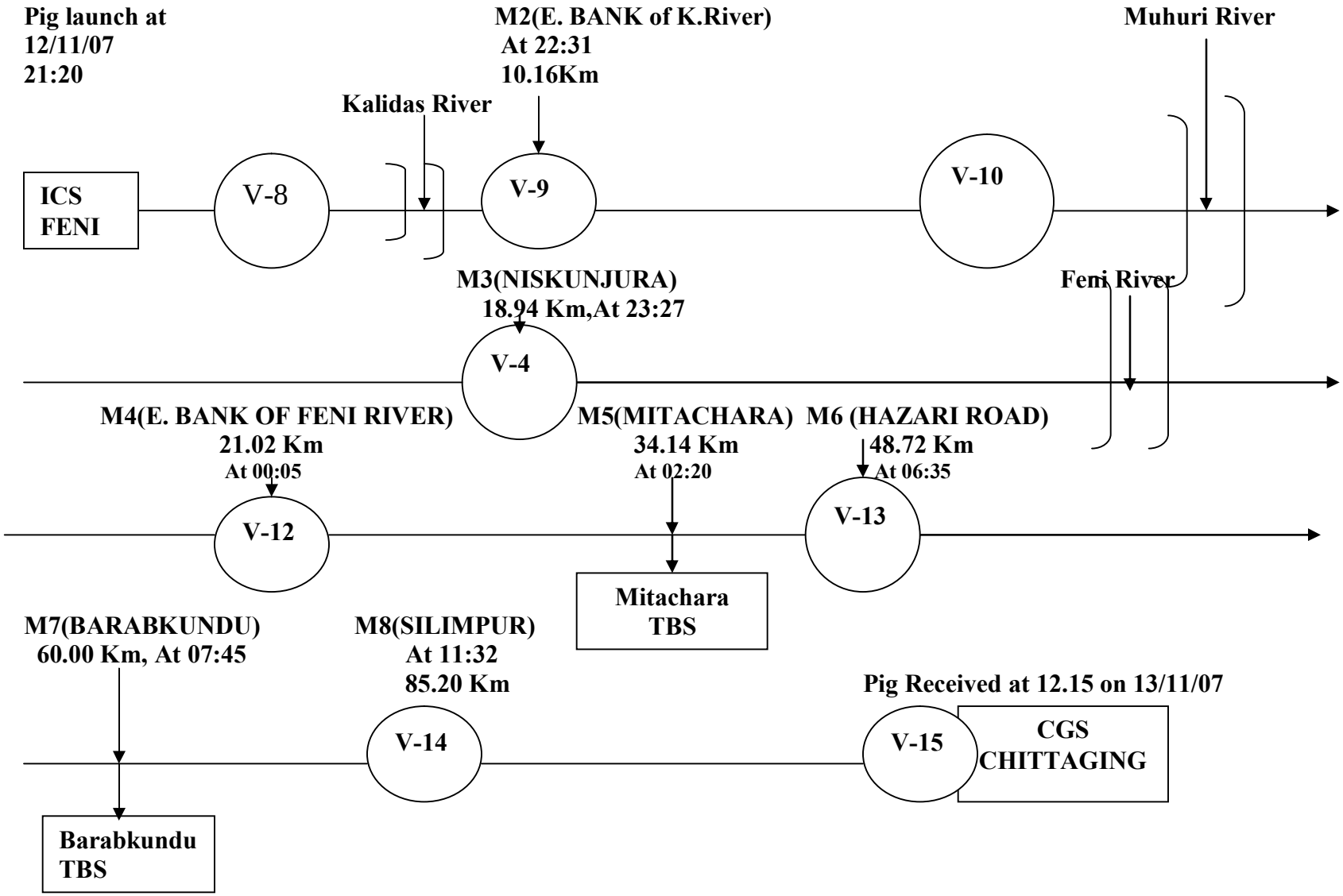
Fig. B4: Gas Transmission Flow


BANGLADESH OIL, GAS & MINERAL CORPORATION
(PETROBANGLA)
GAS TRANSMISSION FLOW DIAGRAM
Panchagar
Thakurgaon
Nilphamari
Lalmonirhat
Syedpur
Rangpur
Dinajpur
Kurigram
Gaibandha
Jaipurhat
Bogra
Naogaon
Chapai Nawabganj
Sirajganj (DRS)
Natore
Bonpara
Nalka
Hatikumrul
Rajshahi
Ishwardi
Pabna (DRS)
Baghabari (CGS)
Kushtia
Meherpur
Chuadanga
Jhenaidah
Magura
Jessore
Narail
Satkhira
Khulna
Gopalganj
Madaripur
Shariatpur
Bagerhat
Pirojpur
Barisal
Jhalakati
Bhola
Shahbazpur
Faridpur
Rajbari
Patuakhali
Sherpur(RMS)
Jamalpur (RMS)
Mymensingh (RMS)
RPCL (RMS)
Netrokona (RMS)
Trishal (RMS)
JFCL
Tarakandi (RMS)
Bhaluka (RMS)
Gaffargaon (DRS)
Kishoreganj (RMS)
Elenga
Dhanua
Monohordi
Tangail (TBS-DRS)
Joydevpur (CGS)
Narsingdi
Ghorashal
Kamta
Demra
Narayanganj
Munshiganj (DRS)
Jinjira (DRS)
Sunamganj (DRS)
Chhatak
Chhatak Gas Field
Kumargaon (DRS)
SYLHET PS
CMS
Sylhet
Beanibazar (DRS)
Beanibazar
Kailashtilla (1)
Kailashtilla (2 & 3)
Fenchuganj
Baralekha
Juri (DRS)
Kulaura
NGFF
Layani
Kuchai
Jalalabad
Bibiyana
Rashidpur
Rashidpur (DRS)
Habiganj
Shaistaganj (DRS)
Murahari (TBS)
Shahjibazar PS
Moulavibazar (DRS)
Shamshernagar (DRS)
Srimangal (DRS)
Moulavibazar
Madhabpur (DRS)
Titas Loc.-3
Titas Loc.-1
Brahmanbaria
ZFCL
Ashuganj VS-1
APS
Meghna
Bakhrabad
Salda River
Daudkandi
Gouripur
Kutumbapur (TBS)
Cantt. (CMS)
Chandina (DRS)
Comilla (DRS)
AES Meghnaghat PS
AES Horigpur (PS)
Matlab
Chandpur (TBS-DRS)
Bijra
Laksham
Feni (TBS)
Lakshmipur
Feni
Khagrachari
Sonalang
Mirsarai
Sitakunda
Sonju
Chittagong
Fouzdarhat
CGS
Nasirabad HP/DRS
Kaloorghat HP/DRS
Rangamati
Raojan (PS)
Kaptai
Halishahar
EPZ
Patenga
CUFL
KAFCO
Shikalbaha PS
Bandarban
Kutubdia
Cox's Bazar
LEGEND
Gas Transmission Line
Existing
Proposed
Up to 16 Inches
20 Inches
24 Inches
30 Inches
Gas Field
CGS/TBS/DRS/CMS/RMS/VS
Not to Scale
Abbreviations/Acronyms
CGS = City Gate Station
TBS = Town Bordering Station
DRS = District Regulating Station
CMS = Customer Metering Station
RMS = Regulating & Metering Station
VS = Valve Station
PS = Power Station

Diagram



FigC1: Line Diagram of BKB-Chittagong High Pressure Gas Transmission Pipeline
(BKB-ICS Feni Portion) Monitoring Points



FigC2: Line Diagram of BKB-Chittagong High Pressure Gas Transmission Pipeline
(ICS Feni-CGS Chittagong Portion) Monitoring Points
'V' Stands for Main Line Valve Station

Fig.B3: A Pig launcher of Ashuganj-Bakhrabad 30″ Pipeline

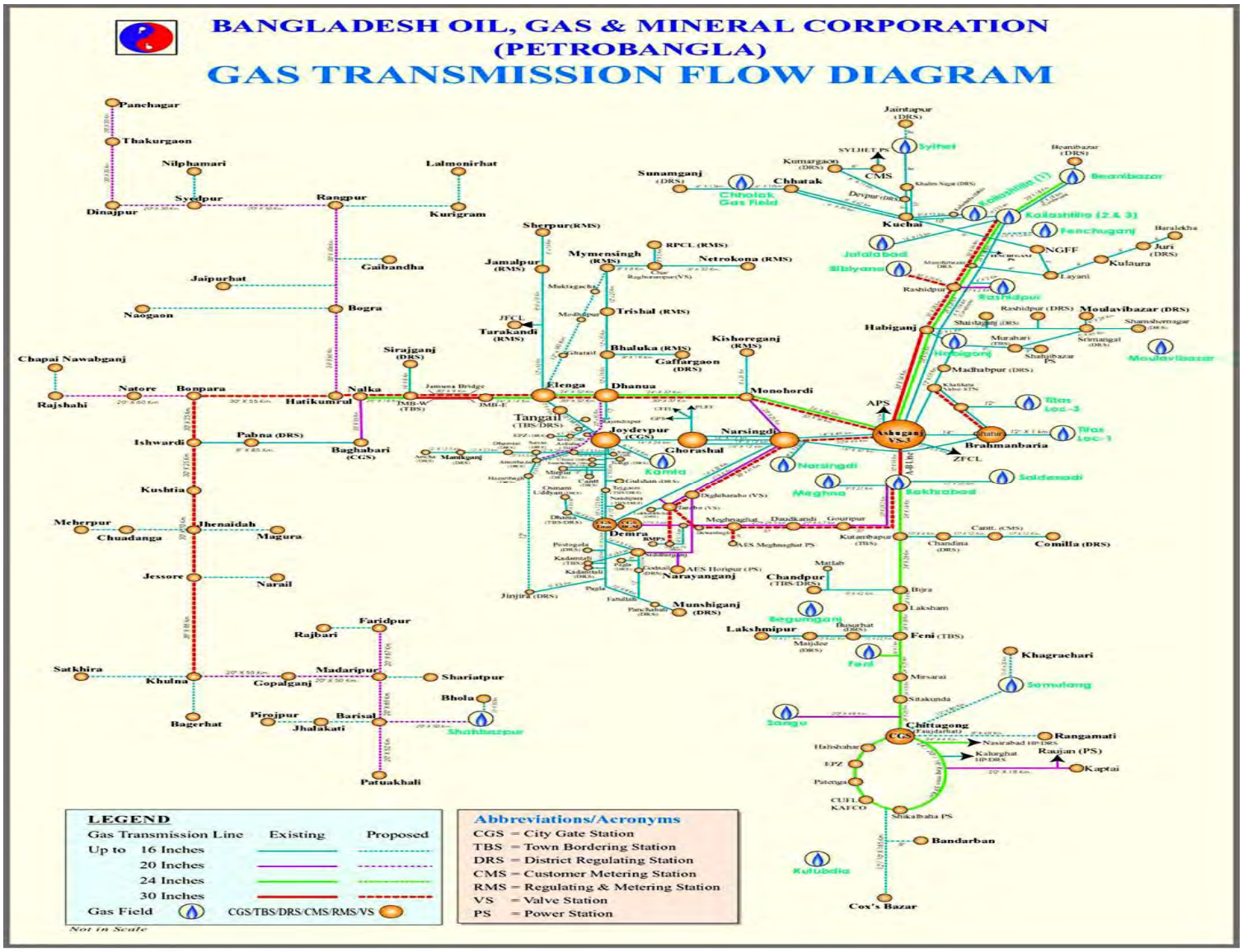


Fig. B4: Gas Transmission Flow Diagram