A Dissertation Report

On

"Reliable operation & maintenance of pump station in a Cross Country Pipeline with new Operation & Control Philosophy (OPCP)" – A Case Study

Submitted by :

Chitra Mohan Borah

Enrolment No. R020115007

MBA (OIL & GAS)

Submitted to :

Dr. Tarun Dhingra

Assistant Dean-Research &

Senior Associate Professor & Head

Department of Strategic Management

University of Petroleum & Energy Studies

A Dissertation Report submitted in partial fulfillment of the requirements for MBA (OIL & GAS)

DECLARATION

I hereby declare that this project titled **"Reliable operation & maintenance of pump station in a Cross Country Pipeline with new Operation & Control Philosophy (OPCP)" – A Case Study** submitted by me to the University of Petroleum and Energy Studies, Dehra Dun for partial fulfillment of pre-requisites for completion of 2nd (final) semester under MBA (Oil & Gas Management), is a bona fide work carried out by me under the guidance of Sri Samir Kumar Das DGM(PLP). This has not been submitted to any university or institution for the award of any degree, diploma/certificate or published any time before.

Place : Duliajan
Date: 01-08-2016

Signature

(Chitra Mohan Borah)
Enrolment No. RO20115007
MBA(Oil &Gas Management)

Guide's Signature
Guide's Name: Dr. Tarun Dhingra, Sr. Associate Professor
University of Petroleum & Energy Studies

CERTIFICATE

This is to certify that "Reliable operation & maintenance of pump station in a Cross Country Pipeline with new Operation & Control Philosophy (OPCP)" – A Case Study being submitted by Chitra Mohan Borah , Enrollment No.:R020115007, for partial fulfilment of the degree of "MBA (Oil & Gas Management)" is a record of bonfide research work carried out by him. He has worked under my supervision and has fulfilled the requirements for the submission of this report.

Guide's Signature
Guide's Name: Dr. Tarun Dhingra
Sr. Associate Professor
University of Petroleum & Energy Studies

ACKNOWLEDGEMENT

I sincerely express my gratitude to OIL Management & L&D department for giving me the opportunity to pursue MBA (Oil and Gas). I express my sincere thanks to my External and Internal Guide for giving me the necessary guidance and suggestions for completing this project. My sincere thanks to all executives and employees of OIL Pipeline department. Sincere thanks to the colleagues and Executives of MBA (O&G) batch and other departments who helped me to in providing the necessary data/information for completion this project.

My sincere thanks to all my class mates of MBA (Oil & Gas) from OIL for their support and encouragement.

Chitra Mohan Borah
Chief Engineer (PL-Mech)
OIL INDIA LIMITED
MBA(Oil &Gas Management)
Enrolment No. RO20115007

TABLE OF CONTENTS

LIST OF ABBRIVIATIONS

SL. No.	ABBRIVIATION	MEANING
01	APPS	APPS Application Software
02	DFR	Detailed Feasibility Report
03	EPMC	Engg. Procrument and Construction Management
04	ESD	Emergency Shut Down
05	FSD	Fire Shut Down
06	LSS	Low Signal Selector
07	SMCS	Supervisory Monitoring and Control System
08	LALL	Level Alarm Low Low
09	MLP	Main Line Pump
10	MOV	Motor Operated Valve
11	PAHH	Pressure Alarm High High
12	PALL	Pressure Alarm Low Low
13	PIC	Pressure Indicator Controller
14	PLC	Programmable Logic Control
15	PV	Pressure Control Valve
16	PS	Pumping Station
17	RTU	Remote Telemetry Unit
18	SIC	Speed Indicator Controller
19	SCADA	Supervisory Control and Data Acquisition System
20	TAHH	Temperature Alarm High High
21	VFD	Variable Frequency Drive
22	OPCP	Operation and Control Philosophy
23	UGPS	Up-gradation of Pump Station

LIST OF FIGURES

LIST OF TABLES

CHAPTER – 1: INTRODUCTION

1.1 Industry Profile :

The oil and gas sector is among the six core industries in India and plays a major role in influencing decision making for all the other important sections of the economy.

India's economic growth is closely related to energy demand ; therefore the need for oil and gas is projected to grow more, thereby making the sector quite conducive for investment.

The Government of India has adopted several policies to fulfill the increasing demand. The government has allowed 100 per cent foreign direct investment (FDI) in many segments of the sector, including natural gas, petroleum products, and refineries, among others. Today, it attracts both domestic and foreign investment, as attested by the presence of Reliance Industries Ltd (RIL) and Cairn India. About this industry :

- The oil and gas industry ranks amongst India's six core industries.
- India was the fourth largest consumer of crude oil and petroleum products in the world in 2014, after the United States, China and Japan.
- Oil imports constitute about 78.6% of India's total domestic oil consumption in 2014-15.
- Oil and gas contributes about 35.5% to primary energy consumption.
- During 2014, natural gas constituted about 7.1% of the energy mix.
- India had 47 Trillion cubic feet of proven natural gas reserves at the beginning of 2014. Approximately 34% of total reserves are located onshore, while 66% are offshore.
- India has 215.066 MMTPA of refining capacity, making it the second largest refiner in Asia after China. Private joint venture companies own about 44% of total capacity.
- India increasingly relies on imported LNG; the country was the fourth-largest LNG importer in 2014 and accounted for 5.7% of global imports.

1.2 Company Profile :

Oil India Private Limited (OIL) was incorporated in 1959 as a rupee company with 2/3rd by BOC (Burmah Oil Company) of U.K. & 1/3rd by Govt. of India. In 1961 the Govt. of India & BOC transformed OIL in to a joint venture (JV) company with equal partnership. In 1981, OIL became a wholly-owned Government of India enterprise. Today, OIL is a premier Indian national oil company engaged in the business of exploration, development and production of crude oil and natural gas, transportation of crude oil, petroleum and production of LPG. At present, the Government of India is the promoter of the company, holding 68.43 per cent of OIL's total issued and paid-up capital. The balance 31.57 per cent of the equity capital is held by the public and others including corporate bodies, mutual funds, banks, FIIs(Foreign Institutional Investors) , resident individuals, etc.

The prime objectives of OIL are Exploration , Exploitation , Production & Transportation of crude oil and natural gas. Oil India Limited is now a fully Government owned company under Ministry of P&NG, Govt. of India. It is the 2nd largest PSU in the upstream sector of Petroleum Industry in India. At present OIL supplies crude oil to four refineries viz: Digboi, Numaligary, Guwahati and Bongaigaon. Also it transports imported crude oil to Bongaigaon Refinery from Barauni, which comes via PHBPL (Paradip Haldia Barauni Pipeline) of IOCL.

OIL also has participating interest in NELP exploration blocks in Mahanadi Offshore, Mumbai Deepwater, Krishna Godavari Deepwater, etc. as well as various overseas projects in Libya, Gabon, USA, Nigeria, Venezuela, Mozambique and Sudan.

1.2.1 OIL's PIPELINE :

Transportation of oil to refineries is being bestowed to its Pipe Line Department which is rendering its service through cross country pipelines since 1962. It began on 26th of March, 1962. On that day, the first batch of crude oil transported by OIL INDIA PIPELINE from Independent India's first oil field in Naharkatia and Moran was delivered to the country's first public sector refinery at Noonmati, Guwahati Assam. Pipeline department transport crude oil from injecting places from OIL & ONGC fields to refineries.

Pipeline department has got 1157.58 KM long Trunk Pipeline for crude oil transportation. From PS1 to PS5, 401.35 Kms length of 16" OD steel pipe were imported from U.K.& completed in March 1962.

From PS5 To Barauni Terminal(BT) covering 756.23 KMs PL of 14" OD was supplied by Hindustan Steel Limited , Rourkela and this sector was completed in February 1963.

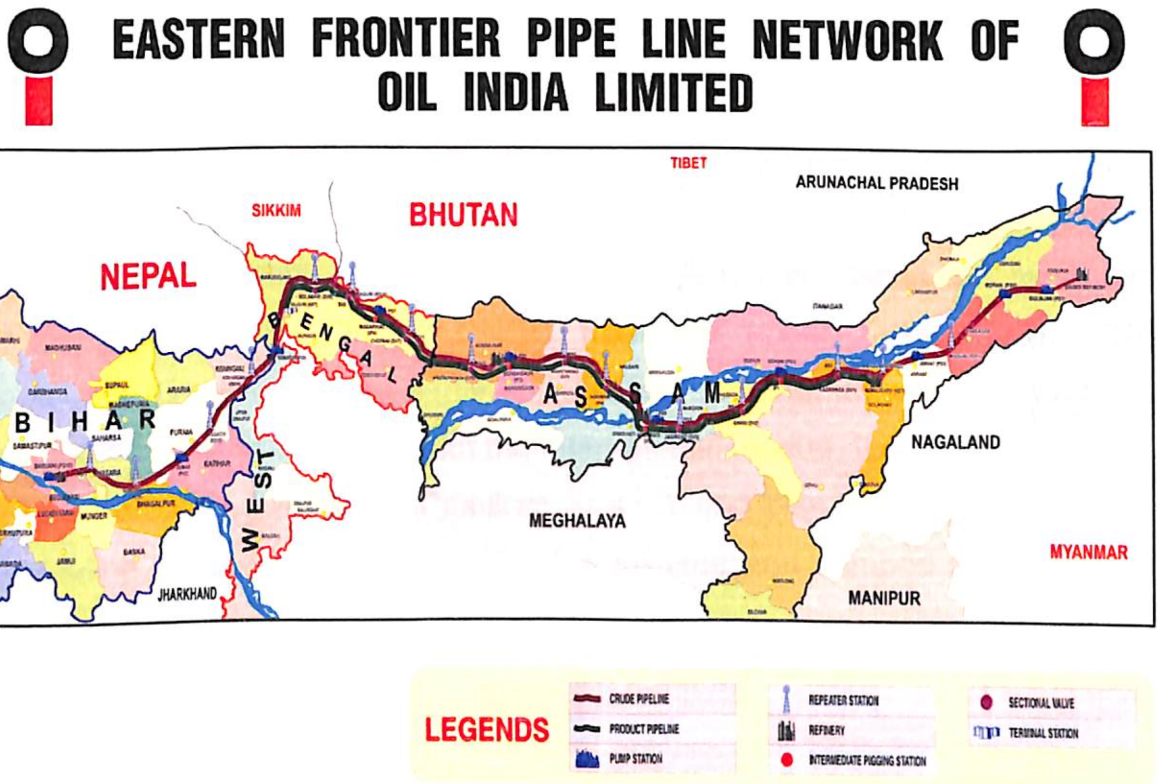


Figure – 1.2.1. Crude oil pipeline network

The pipeline is generally kept buried in a 18.3 mtr (60 ft.) width stretch of land , called Right of Way (RoW) owned by Oil India Ltd, at an average depth of 1,2 mtr (4 ft) and has over ground installations and specialized features like Pump Stations, Repeater Stations, River crossings etc.

With the commissioning of Numaligarh Refinery Assam, OIL has upgraded its existing technology to transport imported crude oil using the same pipeline by means of reverse pumping from Barauni (BTPS) to PS6.

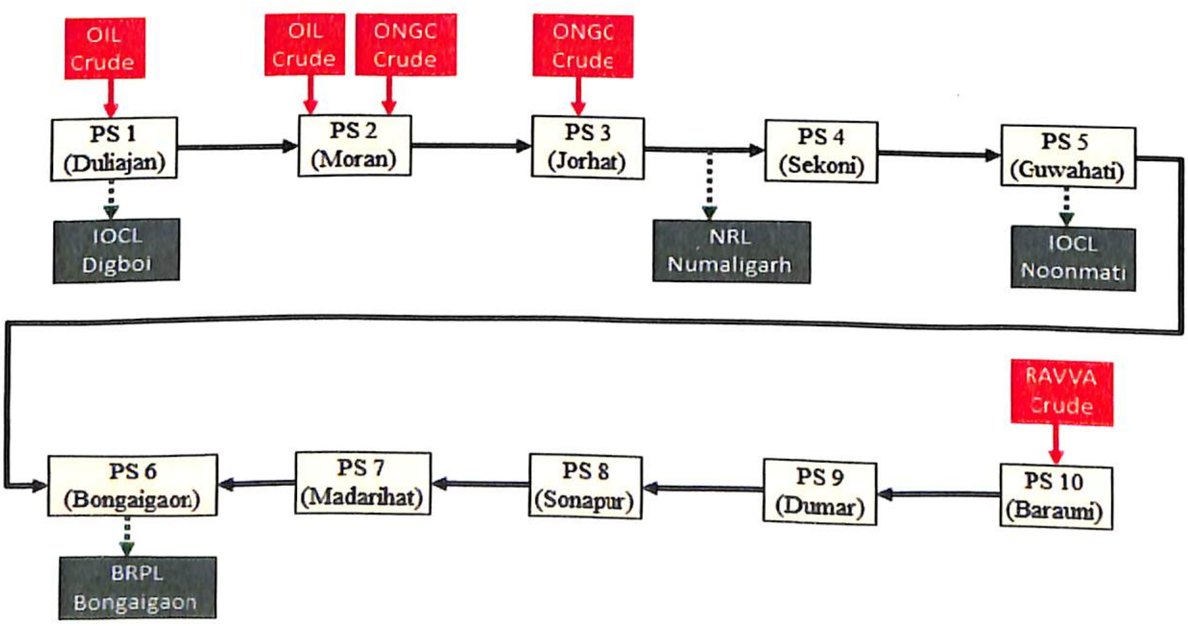
	Refineries	YoC	Company	Capacity (MMTPA
1	Digboi Refinery	1901	IOCL	0.65
3	Guwahati Refinery	1962	IOCL	1.00
4	BRPL	1974	IOCL	2.70
2	Numaligar Refinery	2000	BPCL, OIL & Govt of Assam	3.00

Crude oil produced by OIL in various upper Assam and Arunachal Pradesh fields is injected in OIL pipeline at PS1(Duliajan) and PS2(Moran).

ONGC crude oil produced in various north-eastern fields is also injected in OIL pipeline at PS2(Moran) and PS3(Jorhat).

Refined petroleum is transported from Numaligarh Refinery to Siliguri Marketing Terminal by an another pipeline, called NSPL.

Three refineries (Digboi, Numaligarh & Bongaigaon) are being fed by Assam's crude oil produced by OIL & ONGC from the upper Assam fields. BRPL (Bongaigaon, Assam) is being partly supplied by crude oil from Assam and major part is by the imported crude oil from the international market. It comes to Barauni by PHBPL(Paradip-Haldia-Barauni Pipeline) of IOCL and then transported to BRPL by OIL's pipeline. In pump stations crude oil is injected and pumped to the refineries through pipelines.



Balance Tank Philosophy – Auto/Manual concept

Figure : 1.3.1 : Block diagram of OIL's crude oil pipeline

CHAPTER - 2: OBJECTIVES

2.1 Rationale of the study :

Profits for enhancing shareholders wealth and sustainable growth within the framework of the laws of land are the basic objectives of most of the organizations or companies doing business. Minimization of cost of operation and maintenance (O&M) with reliable & safe operation is an important aspect of profit maximization.

Effective operation and maintenance of machineries and process systems increase productivity and safety by reducing the cost of quality operation / production and decreasing the impacts of potential hazards.

Firstly, human resources are the key resources which can change the philosophy of operation and maintenance to add value to the system. Thus the job analysis and job specification define the required competence and skills for efficient operation and maintenance of the new OPCP. It has to be compared with the available stock of the skills & competence and the required competence level. Competence mapping, TNA (Training Need Analysis) , Impart Training , Fresh recruitment, Development of skills, Effective PMS etc. are some tools for improving the compatibility between the requirement and availability of skills which attracts strategic management decisions.

Secondly, effective machineries with efficient technologies are the back bond behind many successful business organizations.

OIL being an Energy company of the country, its prime purpose is to produce oil & gas and supply to the customers as desired without disturbing the supply chain. So its resources like man and machineries need continuous change and improvements for reliable and efficient operation.

2.2 Motivation for the research :

The existing machineries of the Pump Stations are vintage of sixty's. It became an operational necessity and call of the hour to replace the age old surface equipments in line with the latest statutory standards for safety and efficiency of operation.

Pumping machineries are being changed with technology upgradation. The existing practiced IC engine driven reciprocating pumps will be replaced by centrifugal pumps driven by VFD(Variable Frequency Drive) controlled HT motors. The operation is on 24x7 and round the year. Due to change in technology and Operation & Control Philosophy(OPCP), the modus operandi of pump station will change. It requires new pragmatic adaptation to be incorporated for reliable & cost effective operation. Moreover, maintenance philosophy will also to be designed to align it with the new technology & objectives of operation.

2.3. Management Problem :

What are the benefits the organization will derive by replacing the existing pumping machineries with new machineries and upgraded technologies.

2.4 Research Problem :

Reliability of operation and cost effectiveness of the new replaced technology by rotary machineries with tight line pumping in comparision to existing reciprocating machineries with Balance Tank pumping.

2.5 Objectives :

To study the suitability of the inducted technology in line with reliable operation and cost effective maintenance philosophy and techno commercial analysis. Also to to study the comparative advantages of the new technology.

CHAPTER – 3 : LITERATURE REVIEW

3.1 Review of literatures :

Instead of re-inventing the wheel, one must refer to the previous researches done in the similar area. This helps in - clarity of concepts, restricts duplication of research, exposes the gap between established knowledge and the present situation.

Basically we have gone through the literatures as mentioned in the review of literatures to gather some knowledge on the subject of research. Main topics are related under the domain of pipeline technology, pumping technology , monitoring and controlling systems in oil & gas sectors. Inference

S. N.	Title	Author	Inference
1	Centrifugal pumps: Basic concepts of operations and maintenance and trouble shooting PART-I Literature Review\1.centrifugalpumps O &M&Trouble shooting.pdf	Mukesh Sahdev	Operation & maintenance and trouble shooting techniques of Centrifugal pumps for reliable operation. Design errors, poor operation & poor maintenance
2	Pipeline pumps- Efficiency & Reliability Literature Review\2.PL pumps Transmountain pipeline.pdf	Harindra Samarasekera	The energy consumed by pumps represent a major portion of operation costs in the pipeline industry, especially if the pipelines are very long.
3	Understand the Basics of Centrifugal Pump Operation Literature Review\3.Basics of Centrifugal Pump operation.pdf	Kimberly Fernandez, Bernadette Pyzdrowski, Drew W. Schiller and Michael B. Smith,	Centrifugal pumps are the most common type of kinetic pump, and are used most often in applications with moderate-to-high flow.
4	Types of Maintenance Programs Literature Review\4.types of maintenance.pdf	O&M Best Practices Guide, Release 3.0	Past and current maintenance practices in both the private and government sectors would imply that maintenance is the actions associated with equipment repair

			after it is broken or before it is broken being identified by monitoring.
5	New Development in Centrifugal Pumps for Optimum Cavitation Performance Literature Review\5.Development in Centrifugal Pumps.pdf	Moufak A. Zaher Head of Research, Faculty of Applied Skills, Unitec Institute of Technology, Auckland, New Zealand	It describes how the rotational motion ahead of the impeller , created by partial bleeding from delivery side to the suction has allowed the adoption of increased operating discharge pressure without high NPSH requirement.
6	Operation & Maintenance - Best Practices A Guide to Achieving Operational Efficiency Literature Review\6.O&M Best Practices.pdf	G. P. Sullivan R. Pugh A. P. Melendez W. D. Hunt Pacific Northwest National Laboratory, U.S. Department of Energy	For reliable and efficient operation of the pumping system the best and suitable methodologies adopted in different organizations.
7	Oil and Gas Pipelines in India Literature Review\7.O&G pipelines in India.pdf	This report is published by India Infrastructure Research, a division of India Infrastructure Publishing Private Limited, for providing information on the infrastructure sectors.	Oil & Gas pipelines, Policy & Regulations, Project Economics, crude oil pipelines etc.
8	Pipeline Transportation of Oil & Gas – Past, Present & Future Literature Review\8. Session 5 P J Sarma.pdf	Pulak Jyoti Sarma Chief Engineer(Pipeline Maintenance) Oil India Limited Pipeline Department Guwahati	History of pipelines, its development, advantages and future prospects
9	Pump Maintenance - Repair Literature Review\9.Trombly - Pump Status.pdf	Brian Trombly Mo Droppers Cummins Bridgeway, Gaylord, Mi	Basic parts of Centrifugal pumps, Installation & reliability, preventive maintenance, trouble shooting , cavitation etc.
10	"Vision 2030" Natural Gas Infrastructure in India Literature Review\10. Natural	Report by Industry Group For Petroleum & Natural Gas Regulatory Board	

	Gas Infrastructure In India.pdf		
11	Indian Petroleum and Natural Gas Statistics Literature Review\11. Indian Petroleum & Natural Gas Statistics.pdf	Govt. Journals	**It** " presents comprehensive statistics on various aspects of Indian Petroleum & Natural Gas Industries, covering the exploration, production, refining, marketing activities etc. of Oil sector.
12	OIL Industry - in brief Literature Review\12. OIL Industry - in brief.docx	Govt. Journal	Oil & Gas sectors in Indioa, Market Size, Investment, Govt. Initiatives, Road ahead for Oil & Gas Sector.
13	Improving Operational Safety in Oil Pipelines Literature Review\13. Schraml.pdf	6th Pipeline Technology Conference 2011	Safe operation of pipeline in various conditions
14	Tight-line pumping Literature Review\14.Tight-Line Pumping.docx	By Dr. Bradley Hull John Carroll University	Batch pumping through pipelines, Pipeline hubs, Common carriers concept.
15	VFD : Variable Frequency Drive : Literature Review\01. VFD.docx;Literature Review\02. VFD.docx	by Christopher Jaszczolt, Yaskawa America, Inc	VFD motors , its operation & advantages, Efficiency in VFD pumps etc.
16	CBM –Conditioned Based MaintenanceLiterature Review\03 Conditioned Based Maintenance(CBM).docx	Article from Internet	Condition based maintenance (CBM) is a maintenance strategy that monitors the actual condition of the asset to decide what maintenance needs to be done. CBM dictates that maintenance should only be performed when certain indicators show signs of decreasing performance or upcoming failure.

Table : 3.1.1 – Review of Literatures

CHAPTER - 4: RESEARCH METHODOLOGY

4.1 Research Approach :

The case study is taken under the descriptive research analysis covering the existing and the new system of pumping technology with change in surface machineries. Cost benefit analysis has already been done in the DFR stage. Now the emphasis is to analyse the practical reliabilty in operation and maintenance of the new system.

Literature study and analytical research are my major learning methods, which play an important role in this report. Analytical research involves analyzing existing facts and information.

In addition, the report is more persuasive and practical based on the study of real case. I also use Internet-searching engine, which is a fast approach to get wanted answers of this time.

- Data will be from company, manuals, other documents, newspapers, magazines and internet.
- Sources of data will be primary as well as secondary.

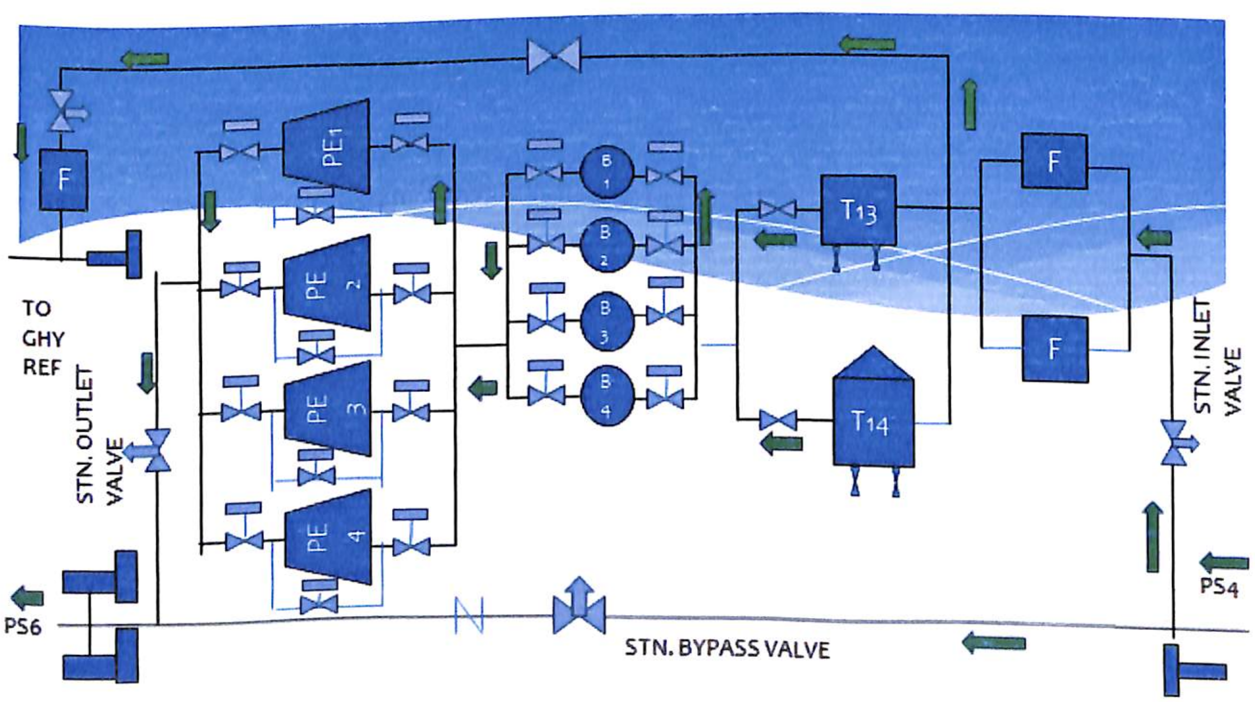


Figure 4.1– LAYOUT OF A PUMP STATION

4.2 : Many equipments in the existing Pump Station:

There are so many auxiliary equipments in the existing system of pumping that need individual attention, otherwise the main line pumping suffers. In the existing pumping system a pump station possess mainly the following machineries:

a) Mainline pumps : Reciprocation Pumps
b) Prime Movers : IC engines run on dual fuel (HSD / crude oil)
c) Auxiliary machineries & equipments : Air Compressors, Fuel Transfer pumps, Cooling Pumps, Radiator fans, Booster Pumps, Balance Tanks, Fuel Tanks, Radiator banks, strainers etc.

View of Pump Station

ALDRICH PUMP

BALANCE TANK

BOOSTER PUMP

Figure 4 .2 – View of Pump Station

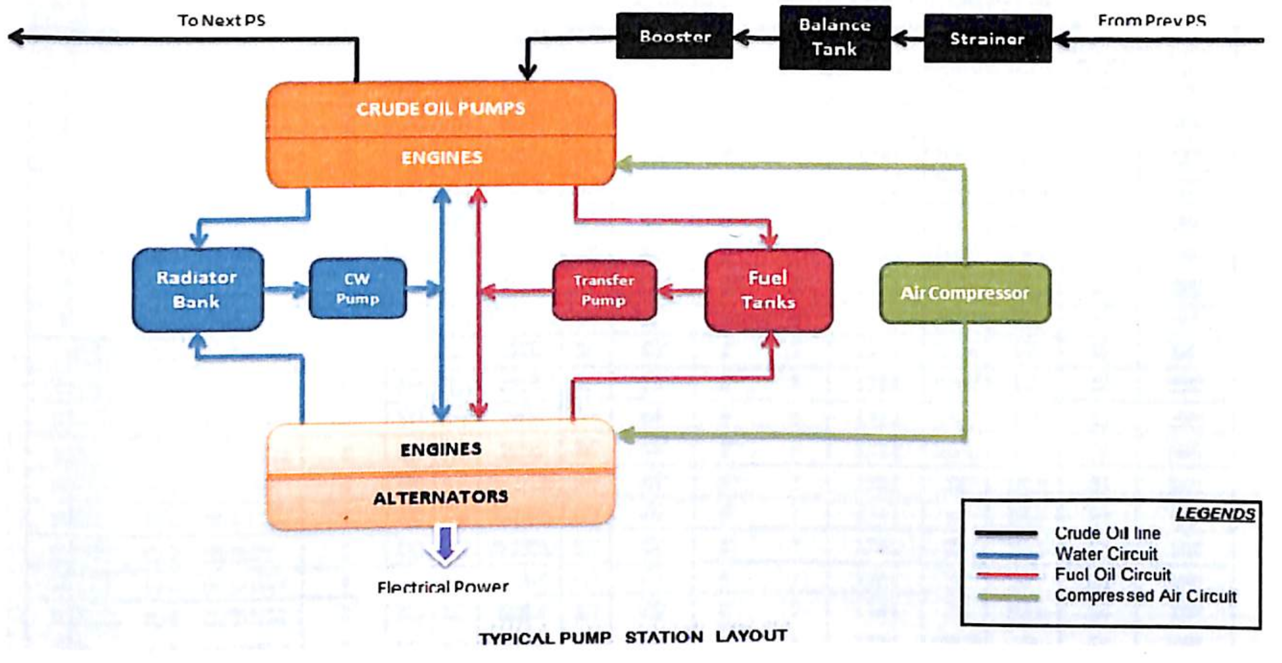


Figure 4 .3– Schemetic diagram of an existing Pump Station

Sl.	Stn	Pumping Units	Engine Sl. No.	No. of Cylinders	BHP	RPM	Pump Sl. No.	Type	Plunger Dia	Stroke Length	No. of Plunger	Engine to Pump Gear Ratio	Max Pump RPM	Through Put Kls/Hr	Max Pressure Kg/cm^2	YoC
1	PS-1	PU-1	K4/41747/B	3	155	346	19174	5/5	3½"	5"	5	1:1	346	81.2	55	1962
2		PU-2	K4/41747/A	3	155	346	19173	5/5	3½"	5"	5	1:1	346	81.2	55	1962
3		PU-3	K4/41747/A	8	615	460	19170	6/7	5¼"	6"	7	1.74:1	254.37	245.6	63	1962
4		PU-4	K4/41747/B	8	615	460	19171	6/7	5¼"	6"	7	1.74:1	254.37	245.6	63	1962
5		PU-5	K4/41747/C	8	615	460	19172	6/7	5¼"	6"	7	1.74:1	254.37	245.6	63	1962
6	PS-2	PU-1	K4/41752/A	5	413	500	19183	6/5	5¼"	6"	5	2.02:1	247.52	158.2	67	1962
7		PU-2	K4/41752/B	5	413	500	19184	6/5	5¼"	6"	5	2.02:1	247.52	158.2	67	1962
8		PU-3	D4/91222	8	615	460	73-22127	6/7	4 5/8"	6"	7	1.74:1	264.37	184	67	1975
9	PS-3	PU-1	K4/41757/D	6	517	522	19178	6/7	4½"	6"	5	1.72:1	303.49	135	88	1962
10		PU-2	K4/41757/C	6	517	522	19177	6/7	4½"	6"	5	1.72:1	303.49	135	88	1962
11		PU-3	K4/41757/B	6	517	522	19176	6/7	4½"	6"	5	1.72:1	303.49	135	88	1962
12		PU-4	K4/41757/A	6	517	522	19175	6/7	4½"	6"	5	1.72:1	303.49	135	88	1962
13		PU-5	D4/91242	8	690	522	73-22129	6/7	4½"	6"	7	1.74:1	300	185.9	88	1975
14		PU-6	D4/96958/A	8	690	522	76-22523	6/7	4½"	6"	7	1.74:1	300	185.9	88	1979
15		PU-7	D5/59178	8	690	522	83-23580	6/7	4½"	6"	7	1.74:1	300	185.9	88	1986
16		PU-8	D6/50121-1	8	690	522	6445-K	6/7	4½"	6"	7	1.74:1	300	185.9	88	1997
17		PU-9	D6/50121-2	8	690	522	6446-K	6/7	4½"	6"	7	1.74:1	300	185.9	88	1997
18	PS-4	PU-1	K4/41762/A	6	517	522	19179	6/7	4½"	6"	5	1.72:1	303.49	135	88	1962
19		PU-2	K4/41762/B	6	517	522	19180	6/7	4½"	6"	5	1.72:1	303.49	135	88	1962
20		PU-3	K4/41762/C	6	517	522	19181	6/7	4½"	6"	5	1.72:1	303.49	135	88	1962
21		PU-4	K4/41762/D	6	517	522	19182	6/7	4½"	6"	5	1.72:1	303.49	135	88	1962
22		PU-5	D4/91262	8	690	522	73-225130	6/7	4½"	6"	7	1.74:1	300	185.9	88	1975
23		PU-6	D4/96958/B	8	690	522	76-22524	6/7	4½"	6"	7	1.74:1	300	185.9	88	1978
24		PU-7	D5/59191	8	690	522	83-23580	6/7	4½"	6"	7	1.74:1	300	185.9	88	1986
25	PS-5	PU-1	K4/41767/A	8	690	522	19185	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
26		PU-2	K4/41767/B	8	690	522	19186	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
27		PU-3	K4/41767/C	8	690	522	19187	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
28		PU-4	D4/91282	8	690	522	73-22128	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1975
29	PS-6	PU-1	K4/41772/A	8	690	522	19191	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
30		PU-2	K4/41772/B	8	690	522	19192	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
31		PU-3	K4/41772/C	8	690	522	19193	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
32	PS-7	PU-1	K4/41777/A	8	690	522	19419	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
33		PU-2	K4/41777/B	8	690	522	19420	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
34		PU-3	K4/41777/C	8	690	522	19421	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
35		PU-4	D4/96500/B	8	690	522	75-22450	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1978
36	PS-8	PU-1	K4/41782/A	8	690	522	19194	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
37		PU-2	K4/41782/B	8	690	522	19195	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
38		PU-3	K4/41782/C	8	690	522	19196	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
39		PU-4	D4/96500/C	8	690	522	75-22451	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1978
40	PS-9	PU-1	K4/41787/A	8	690	522	19197	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
41		PU-2	K4/41787/B	8	690	522	19198	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
42		PU-3	K4/41787/C	8	690	522	19199	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1962
43		PU-4	D4/96500/D	8	690	522	72-22653	6/7	4 1/8"	6"	7	1.74:1	300	154.7	101	1978
44	PS-10	PU-1	D5/59204	8	690	522	83-23575	6/7	4 5/8"	6"	7	1.74:1	300	154.7	101	1986
45		PU-2	D5/59165	8	690	522	83-23576	6/7	4 5/8"	6"	7	1.74:1	300	154.7	101	1986
46		PU-3	D5/59230	8	690	522	83-23578	6/7	4 5/8"	6"	7	1.74:1	300	154.7	101	1986
47		PU-4	D5/59152	8	690	522	75-22450	6/7	4 5/8"	6"	7	1.74:1	300	154.7	101	1978
48	TPS	PU-1	D4/9658	8	690	522	76-22525	6/7	4 1/8"	6"	7	1.74:1	300	154.7	63	1978
49		PU-2	D5/59152	8	690	522	83-23581	6/7	4 1/8"	6"	7	1.74:1	300	154.7	63	1986
50		PU-3	D6/50121-3	8	690	522	6447-K	6/7	4 1/8"	6"	7	1.74:1	300	154.7	63	1986

Table 4(a) : List of Pump Units in the existing system

Pump Tag	001-PA-CF-103A/B	002-PA-CF-103A/B	004-PA-CF-101A/B	005-PA-CF-101A/B	008-PA-CF-101A/B	010-PA-CF-102A/B
Location	PS1 DULIAJAN (MAINLINE)	PS2 MORAN	PS4 SEKONI	PS5 GUWAHATI	PS8 SONAPUR	PS10 BARAUNI
Purchase Order	7906398/SGG, DT. 03.01.2014	7906398/SGG dated 03.01.2014	7906398/SGG dated 03.01.2014	7906398/SGG dated 03.01.2014	7906398/SGG dated 03.01.2014	7906398/SGG dated 03.01.2014
Unit Price (INR)	35659334.00	24197444.00	24986948.50	23640954.00	36512788.00	36683788.00
Make	SULZER PUMPS	SULZER PUMPS	SULZER PUMPS	SULZER PUMPS	SULZER PUMPS	SULZER PUMPS
Pump Model	GSG150-360 /5 STAGES API 610, BB5, Double casing	GSG100-300 / 6+1D STAGES API 610, BB5, Double casing	GSG150-360 / 3+2D STAGES API 610, BB5, Double casing	GSG100-300 / 3+2D STAGES API 610, BB5, Double casing	GSG150-360 / 6 STAGES API 610, BB5, Double casing	GSG150-360 / 6 STAGES API 610, BB5, Double casing
Serial no.	521137 521138	521141 521142	521143 521144	521145 521146	521147 521148	521149 521150
Diff. Head (m)	861	744	415	344	1032	1070
Suc. Pr. [kg/cm2(g)] Norm/Max	2.0/10.5	2.0/10.5	2.0/61	5/10/1956	2/10/38	2/10.5
Disch. Pr. [kg/cm2(g)]	76	63	37	34	84	87
Max. head at rated impeller (m)	1025.6	862.6	495	413	1147.6	1180.9
Flow (m3/hr) Norm/ Rated	290	174/174	328/328	183/183	283/283	283/283
Mandatory Operating Region (m3/hr)	203-348	136.2-233.6	260.1-446	132.4-227	266-456	269.5-462
Allowable Operating Region (m3/hr)	58-348	40-233.6	69-446	40-227	77-456	79-462
No. of stages	5	6 + 1 DUMMY	3 + 2 DUMMY	3 + 2 DUMMY	6	6
Impeller Dia. (mm) Rated/ Max/ Min	349/365/320	302/305/275	349/365/320	299/305/275	354/365/320	357/365/320
Pump Bearing & Lubrication	Antifriction bearing DE: NDE: Splash Lubrication	Antifriction bearing DE: NDE: Splash Lubrication (ISO VG 46)	Antifriction bearing DE: NDE: Splash Lubrication (ISO VG 46)	Antifriction bearing DE: NDE: Splash Lubrication (ISO VG 46)	Antifriction bearing DE: NDE: Splash Lubrication (ISO VG 46)	Antifriction bearing DE: NDE: Splash Lubrication (ISO VG 46)
Pump efficiency	71.80%	69%	74.2	69.9	70.8	71.5
Capacity at BEP (m3/hr)	290	194.7	371.7	189.2	380	385
Rotation (view from	CCW	CCW	CCW	CCW	CCW	CCW
Speed (rpm)	2940	2976	2976	2972	2980	2980
Piping Suc/ Disch	10" 900# RF 6" 600# RF	8" 900# RTJ 4" 900# RTJ	10" 900# RTJ 6" 900# RTJ	8" 600# RF 4" 600# RF	10" 900# RTJ 6" 900# RTJ	10" 900# RTJ 6" 900# RTJ
Mech. Seal	Make: Eagle Burgmann India Pvt	Make: Eagle Burgmann India	Make: Eagle Burgmann India	Make: Eagle Burgmann India Pvt.	Make: Eagle Burgmann India Pvt.	Make: Eagle Burgmann India Pvt.
Coupling	Make: Unique Transmission (India)	Make: Unique Transmission	Make: Unique Transmission	Make: Unique Transmission (India)	Make: Unique Transmission (India)	Make: Unique Transmission (India)
Motor details	Make:Nidec ASI S.p.A. (ANSALDO)	Make:BHEL Frame: 1MJ7632-2	Make:BHEL Frame: 1MJ7632-2	Make:BHEL Frame: 1MJ7560-2	Make:Nidec ASI S.p.A. (ANSALDO)	Make:Nidec ASI S.p.A. (ANSALDO)
Pump suction Strainer	Make: Varall Engineers Flowrate: 291 m3/hr Mesh: 3 mesh x 16 SWG, SS304	Make: Varall Engineers Flowrate: 175 m3/hr Mesh: 3 mesh x 16 SWG, SS304	Make: Varall Engineers Flowrate: 329 m3/hr Mesh: 3 mesh x 16 SWG, SS304	Make: Varall Engineers Flowrate: 329 m3/hr Mesh: 3 mesh x 16 SWG, SS304	Make: Varall Engineers Flowrate: 284 m3/hr Mesh: 3 mesh x 16 SWG, SS304	Make: Varall Engineers Flowrate: 284 m3/hr Mesh: 3 mesh x 16 SWG, SS304

Table 4(b) - Mainline Pump Summery (New System)

Sl. No.	Description	Location	Quantity	SUB TOTAL	UoM	Make
1	Booster Pump	PS1	4	12	NO	KSB
2		PS2	2		NO	
3		PS3	2		NO	
4		PS11	2		NO	
5		PS10	2		NO	
6	RESTART ROCKING PUMP	PS1	3	11	NO	GOMA
7		PS2	1		NO	
8		PS3	2		NO	
9		PS11	1		NO	
10		PS4	2		NO	
11		PS5	2		NO	
12	SLOPE PUMP TRANSFER	PS4	2	10		GOMA
13		PS5	2			
14		PS8	2			
15		PS7	2			
16		PS9	2			
17	SUMP PUMP	PS1	1	13	NO	KIRLOSKAR BROTHERS LTD
18		PS2	1		NO	
19		PS3	1		NO	
20		PS4	1		NO	
21		PS5	1		NO	
22		PS6	1		NO	
23		PS8	1		NO	
24		PS10	1		NO	
25		PS11	1		NO	
26		DIGBOI REF	1		NO	
27		GHY REF	1		NO	
28		NRL	1		NO	
29		BGR	1		NO	
30	FIRE WATER PUMP(MAIN) ENGINE DRIVEN	PS4	3	8	NO	KIRLOSKER BROTHERS LTD
31		PS5	3		NO	
32		PS8	2		NO	
33	FIRE WATER PUMP(JOCKEY) ELECTRIC	PS4	2	6	NO	KIRLOSKER BROTHERS LTD
34		PS5	2		NO	
35		PS8	2		NO	
36	DIESEL TRANSFER PUMP	PS3	2	8	NO	SU-MOTORS
37		PS4	2		NO	
38		PS5	2		NO	
39		PS8	2		NO	
40	BASKET FILTERS	PS1	4	31	NO	Multiple vendor
41		PS2	2		NO	
42		PS3	7		NO	
43		PS4	2		NO	
44		PS5	2		NO	
45		PS6	4		NO	
46		PS8	2		NO	
47		PS10	2		NO	
48		PS11	2		NO	
49		DIGBOI REF	2		NO	
50		NRL	2		NO	
51	CI DOSING PUMPS	PS1	4	18	NO	ACCUDYNE INDUSTRIES
52		PS2	2		NO	
53		PS3	2		NO	
54		PS4	2		NO	
55		PS5	2		NO	
56		PS8	2		NO	
57		PS10	2		NO	
58		PS11	2		NO	
59	SCRAPER TRAPS	PS1	2	24	NO	CONTROL PLUS
60		PS2	2		NO	
61		PS3	2		NO	
62		PS4	2		NO	
63		PS5	3		NO	
64		PS6	4		NO	
65		PS8	2		NO	
66		PS10	1		NO	
67		PS11	1		NO	
68		DIGBOI REF	1		NO	
69		GHY REF	1		NO	
70		NRL	1		NO	
71		BGR	2		NO	

Table – 4 (c) : List of Auxilliary Equipments in the New System

4.3 Improved system design with better automation – a necessity :

In the existing system the operating pressure is the main monitoring parameter for the oil to reach its destination i.e. the next pump station and there was no control in maintaining a minimum pressure inside the pipeline at all elevation in unplanned shutdown of its operation. In such situation the pressure on the highest spot was lower and in some points it may be less than the product vapor pressure for which the product may change phases and slack line flow (i.e. column separation) can happen. The problem has more serious consequences during restarting operation, since there were large volumes filled only by vapor phase. It takes some time after pumping is resumed for the product to start coming out in its destination (that is when the tight line flow happened). During this time, there is no information of pressure decrease, which means that a leak in the pipeline would not be detected until this time had passed.

In the existing technology the measurement of flow, temperature and pressure in each extremity of the pipeline take care of the safety and environmental requirements, considering the available technology.

In the new procedures, there was a greater concern about the safety of the pipelines, and the technology evolution allowed the operational parameters to be measured with lower uncertainties.

4.4 : Regular operation before UGPS/NBPS:

Our endeavour will be to justify the transition to adapt an existing pipeline to the new operating and control philosophy of the company.

In the existing pumping system only the flow rate, temperature and the pressure in each salient locations are measured. In such operations, there was no control of the minimum pressure inside the pipeline. Because of this, there is a possibility of vapor accumulation in the higher points, when operation stops suddenly and the liquid flows from the highest points to the lowest points in that situation. In this situation, there may be a creation of empty space along the pipeline, which was filled by product/oil vapor. Figure 1 represents the situation in which there is no flow and Figure 2 represents the situation in which there is slack line flow.

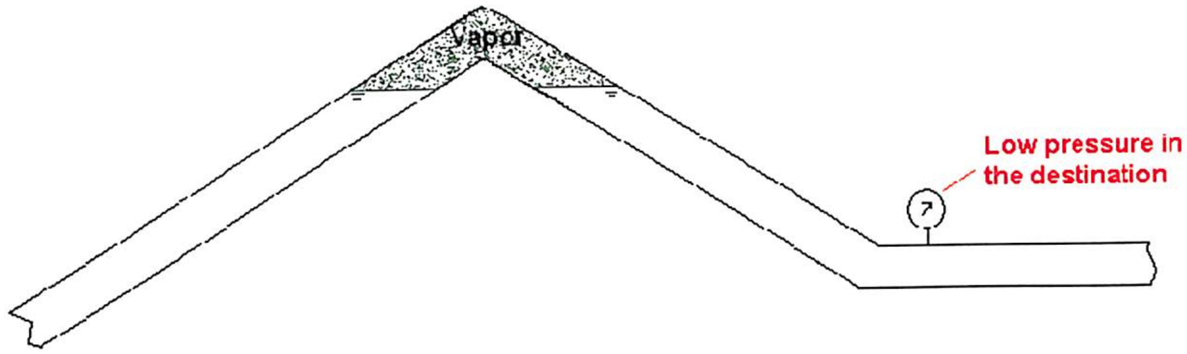


Figure: 4.3.1 – Vapour in the high points of the pipeline (no flow)

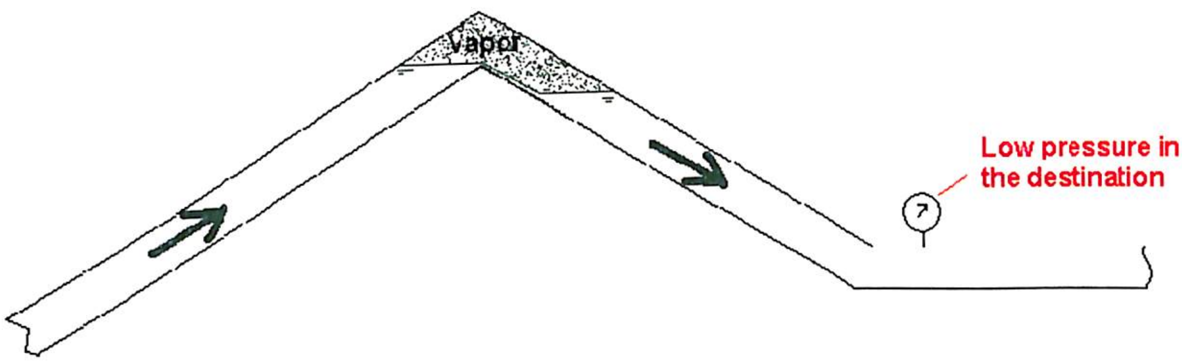


Figure : 4-3-2 – Vapour in the high points of the pipeline (slack line flow)

Because of this situation, when operation resumes every time after unplanned shutdown, part of the vapor starts to get compressed and changed into liquid phase. Before steady flow is achieved, due to this compression, no product arrived to the destination for some time depending on flow rate and there is no information if it is getting compressed or if there is a leak from the pipeline. This problem could only be perceived after the regular time of operation start had passed, and if this occurred, a lot of oil/product would have already escaped.

In order to avoid this possibility, controlled valve philosophy is incorporated in the new upgradation project to improve safety by eliminating the vapor accumulation, maintaining all the fluid inside the pipeline in the liquid phase. Besides the environmental issue, there is also a social matter, since this pipeline passes through populated areas, and a leak in these regions would cause a great disaster to the community. Furthermore, the measurement and the custody transfer of the transported quantities can be more accurate, if there is no vapor phase in the line.

4.5 : New OPCP after the UGPS :

In the new automated OPCP it consists of automating the pumps on upstream end and inserting control valves on its other extremity i.e. downstream end. It aims also to transfer the control of each extremity to a centralized control center (SMCS). This enables the installation of a leak detection system.

In order to solve the problem presented in the previous section, the pipeline should have sufficient pressure in the destination, so that the pressure in the highest points also increased and the value becomes higher than the vapor pressure of the product. It is possible to observe that the flow is steady in the whole line, and that no slack line flow occurs. It requires three dimensions : (a) the measurement system (b) the control system and (c) the pumps automation.

The measurement system, which consists of a flow meter, a density meter, a pressure transmitter and a temperature meter, was the first to be started up. The density and the temperature are used to calculate the flow rate at a standard temperature. In order to monitor leaks from the pipeline, pressure decreases are evaluated.

The control system consists of two control valves that operate alternately, two blocking valves for each control valve and two pressure transmitters, one upstream and the other downstream the control valves. These control valves are used for maintaining a minimum pressure inside the pipeline, so that there is no product vaporization.

The third part, pumps automation, consisted of the elaboration of a new logic for control and operation, and no physical adaptation of the system was needed. All this work aimed the system remote operation from the SMCS.

4.5.1 Operational safety

After the implementation of this project, the pipeline can be centrally controlled by SMCS. The line remain full during the whole operation, even in unplanned shutdown of upstream pump station as represented in Figure 3. It is now ready for implementing the leak detection system. The response in the other extremity of the line to any pressure or flow alteration is immediate and is monitored by the measurement system

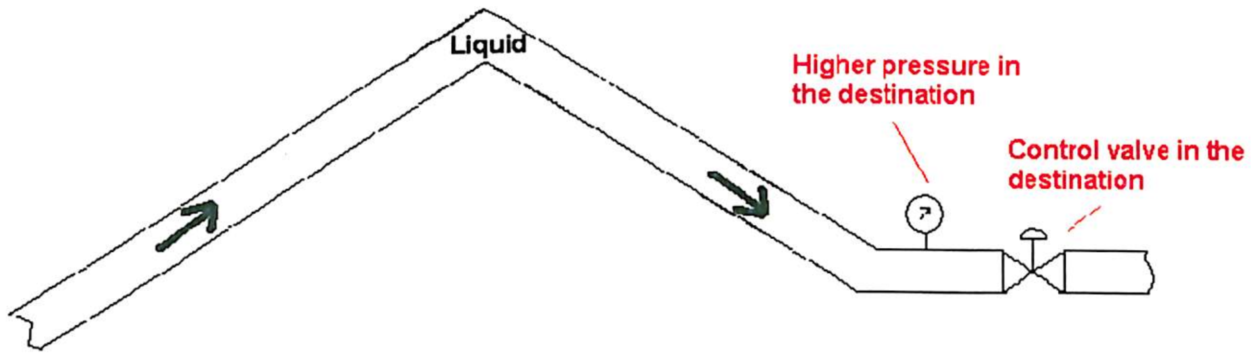


Figure : 4.4.1.1- Pipeline operating with full line

The whole operating and control philosophy will be changed during the new project. These changes consisted in the adaptation of the equipments, with the introduction of the pumps automation and the insertion of control valves in the destination. The operational safety is enhanced by the full pipeline operation, since any disturbance in the process is promptly perceived by the supervisory system (SCADA). This will be improved by the implementation of the leak detection system.

Motor driven pumping with Variable Frequency Drives (VFD) shall provide all the below benefits.

4.5.2 Higher efficiency in energy use by use of VFDs:

Existing Prime movers are dual fuelled 'Allen' Make IC engines of 155-690 BHP, coupled to mainline pumps through reducer gear mechanism. This present system does not allow large variation in flow. Therefore, the new centrifugal pumps with VFD ensure variable flow requirements for satisfying operation needs of NBPL (Naharkatia Barauni Pipeline) system in all conditions. Motors can operate in range from 25 % to 100 % of flow required when coupled with Variable Frequency drives (VFD). VFD's also help in soft start of the Motor hence saving starting current load on power source as well the sudden shocks to pumps & motors. This is major strength of motors as it is envisaged that NBPL shall operate in variable flow regime. Motors with speed variation through VFD's shall draw only necessary power thus increased overall efficiency and reducing net power consumption & OPEX of pump station.

4.5.2.1 What is a VFD and Why should we use VFDs ?

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor.
Frequency (or hertz) is directly related to the motor's speed (RPMs). In other words, the faster the frequency, the faster the RPMs go. If an application does not require an electric motor to run at full speed, the VFD can be used to regulate the frequency and voltage to meet the requirements of the electric motor's load/speed.

By use of VFD we can cut down energy costs by controlling the motor with a variable frequency drive, which is one of the benefits of Variable Frequency Drives. VFDs allow to match the speed of the motor-driven pupms to the load requirement. There is no other method of AC electric motor control that allows to accomplish this benefit.

Electric motor systems are responsible for more than 65% of the power consumption in industry today. Optimizing motor control systems by installing or upgrading to VFDs can reduce energy consumption in the pump station by as much as 70%.

4.5.3 : Extend Equipment Life and Reduce Maintenance

Equipment/Pumps will last longer and will have less downtime due to maintenance when it's controlled by VFDs ensuring optimal motor application speed. Because of the VFDs optimal control of the motor's frequency and voltage, the VFD will offer better protection for motor from problems such as electro thermal overloads, phase protection, under voltage, overvoltage, etc. During starting a load with a VFD it will not subject the motor or driven load to the "instant shock" of across the line starting, but can start smoothly, thereby eliminating belt, gear and bearing wear. It also is an excellent way to reduce and/or eliminate water hammer since we can have smooth acceleration and deceleration cycles.

4.5.4: Reduction in OPEX and maintenance cost – a comparision :

- Load variation range mostly available with engines is approx. 50% to 100% of engine rating for continuous operation against requirement of load variation in the range of 25% to 100% for pumps to achieve variable flow.
- In case engines has to be run below 50% of the rated conditions, depending on specific make, model and ambient conditions, these engines may be required to operate at approx. 80% engine rated load.
- The engines are of standard rating hence higher rating engines than the required pump driver rating shall normally be applied for most of the stations leading to Part load operation of engines for most of the cases resulting in increased fuel consumption and the capital and operating cost on the driver shall be higher than optimum
- Higher maintenance cycle and maintenance cost in existing reciprocating engines because of engines being a reciprocating type machine operating at elevated temperature. Further operation at part load shall increase the maintenance cycle and cost.
- Motors with intended capacity & rating are easily available in market and has replaced engine drives for 80 to 90 % onshore applications.
- Motors can operate in range from 25 % to 100 % of flow required when coupled with Variable Frequency drives (VFD). VFD's also help in soft start of the Motor hence saving starting current load on power source as well the

sudden shocks to pumps & motors. This is major strength of motors as it is envisaged that NBPL shall be operated in variable flow regime.

- Motors with speed variation through VFD's shall draw only necessary power thus increased overall efficiency and reducing net power consumption & OPEX of pump station.
- Motors have less wear & tear and are easier to operate & maintain with virtually no moving parts except armatur. Motors require very few mandatory spares as compared to engines and hence reduction in inventory to large extent.
- The capital cost of motors is 20 % to 50 % is less than the engines depending upon size & ratings.
- Noise level is very low & space requirements are comparatively less.

4.5.5 Optimum capacity utilization :

- Speed range available in existing engines is approx. 70% to 100% of the rated value against pump speed variation requirement from 50% to 100%, in order to achieve the entire operating cases.
- Load variation range mostly available with engines is approx. 50% to 100% of engine rating for continuous operation against requirement of load variation in the range of 25% to 100% for pumps to achieve variable flow.
- In case engines has to be run below 50% of the rated conditions, depending on specific make, model and ambient conditions, these engines may be required to operate at approx. 80% engine rated load.
- The engines are of standard rating hence higher rating engines than the required pump driver rating shall normally be applied for most of the stations leading to :
    - Part load operation of engines for most of the cases resulting in increased fuel consumption.
    - Some of the cases shall become not operable on continuous basis due to restriction specified in above.
    - The capital and operating cost on the driver shall be higher than optimum

- ❖ Noise level of engines is considerably high and normally no acoustic enclosures are provided around engines in mechanical drive application. Hence engines shall be required to keep in closed RCC room for restricting noise outside. This shall be additional capital cost as well as running cost (for room ventilation).
- ❖ Higher maintenance cycle and maintenance cost because of engines being a reciprocating type machine operating at elevated temperature. Further operation at part load shall increase the maintenance cycle and cost.

4.6 : Analysis of Maintenance Methodologies:

Common maintenance methodologies adopted in the industries can be grouped under following types. Out of the discussed the suitable maintenance methodology will be adopted.

4.6.1 Reactive Maintenance (Breakdown or Run-to-Failure Maintenance) :

Basic philosophy –

- ➢ Allow machinery to run to failure.
- ➢ Repair or replace damaged equipment when obvious problems occur.
- ➢ Cost : 18 USD/hp/yr
- ➢ it works well if equipment shutdowns do not affect production and if labor and material costs do not matter.

4.6.2 Preventive Maintenance (Time-Based Maintenance) :

Basic philosophy –

- ➢ Schedule maintenance activities at predetermined time intervals or machine run.
- ➢ Repair or replace damaged equipment before obvious problems occur.
- ➢ Cost: $13/hp/yr
- ➢ The advantages of this approach are that it works well for equipment that does not run continuously, and with personnel who have enough knowledge, skills, and time to perform the preventive maintenance work.

- It aims for sustaining or extending its useful life through controlling degradation to an acceptable level. By simply expending the necessary resources to conduct maintenance activities intended by the equipment designer, equipment life is extended and its reliability is increased.
- While preventive maintenance is not the optimum maintenance program, it does have several advantages over that of a purely reactive program. By performing the preventive maintenance as the equipment designer envisioned, we will extend the life of the equipment closer to design. Preventive maintenance (lubrication, filter change, etc.) will generally run the equipment more efficiently.
- While we will not prevent equipment catastrophic failures, we will decrease the number of failures. Minimizing failures translate into maintenance and capital cost savings.
- Preventive maintenance (lubrication, filter change, etc.) will generally run the equipment more efficiently resulting in OPEX savings.

4.6.3 Predictive Maintenance (Condition-Based Maintenance) :

Basic philosophy –

- Here maintenance is done on need basis on the actual condition of the machine rather than on some preset schedule.
- Cost: $9/hp/yr
- scheduling maintenance activities only if and when mechanical or operational conditions warrant-by periodically monitoring the machinery for excessive vibration, temperature and/or lubrication degradation, or by observing any other unhealthy trends that occur over time.
- When the condition gets to a predetermined unacceptable level, the equipment is shut down to repair or replace damaged components so as to prevent a more costly failure from occurring.
- In other words, "Don't fix what is not broken."

- Advantages of this approach are that it works very well if personnel have adequate knowledge, skills, and time to perform the predictive maintenance work, and that it allows equipment repairs to be scheduled in an orderly fashion.
- It also provides some lead-time to purchase materials for the necessary repairs, reducing the need for a high parts inventory.
- Schedule lube oil change of a engine is an example of preventive maintenance but the quality of oil is not measured. But in preventive maintenance actual deterioration is checked.
- We will be able to minimize inventory and order parts, as required, well ahead of time to support the downstream maintenance needs.

4.6.4 Reliability Centered Maintenance (Pro-Active or Prevention Maintenance)

Basic philosophy

- This philosophy utilizes all of the previously discussed predictive/preventive maintenance techniques, in concert with root cause failure analysis. This not only detects and pinpoints precise problems that occur, but ensures that advanced installation and repair techniques are performed, including potential equipment redesign or modification, thus helping to avoid problems or keep them from occurring
- Utilizes predictive/preventive maintenance techniques with root cause failure analysis to detect and pinpoint the precise problems, combined with advanced installation and repair techniques, including potential equipment redesign or modification to avoid or eliminate problems from occurring.
- One advantage to this approach is that it works extremely well if personnel have the knowledge, skills, and time to perform all of the required activities.
- Furthermore, it allows lead-time to purchase materials for necessary repairs, thus reducing the need for a high parts inventory.

- ➢ Since maintenance work is performed only when it is needed, and extra efforts are put forth to thoroughly investigate the cause of the failure and determine ways to improve machinery reliability, there can be a substantial increase in production capacity.
- ➢ It recognizes that all equipment in a facility is not of equal importance to either the process or facility safety. It recognizes that equipment design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others.
- ➢ Cost: $6/hp/yr
- ➢ RCM is highly reliant on predictive maintenance but also recognizes that maintenance activities on equipment that is inexpensive and unimportant to facility reliability may best be left to a reactive maintenance approach.
- ➢ RCM approach utilizes all available maintenance approaches with the predominant methodology being predictive.
  - <10% Reactive
  - 25% to 35% Preventive
  - 45% to 55% Predictive.

Since RCM encompasses (a) Reactive (b) Preventive & (c) Predictive maintenance and the cost of maintenance is also reasonable so this mode of maintenance may be adopted.

4.7. Analysis of new Operational & Control Philosophy : (OPCP) :

4.7.1 : OPCP FOR MAINLINE PUMPS:

- The mainline pumps at all stations are provided with variable (VFD) speed motors. Speed of the pump shall be controlled to deliver desired flow rate.
- LSIC (Speed Indicator Controller) set point shall be given from SMCS(Supervisory Monitoring & Control System) at Noonmati through SCADA.

- SIC set point can be given from particular station as well from SMCS. In case particular station wants to give the set point of SIC, station shall be taken in Manual mode from Auto Mode.
- Auto/ Manual switch shall be made available at respective stations. The pump speed w.r.t flow shall be set at the speed controller SIC and will be communicated to the pump station for controlling the speed of the pumps.
- In the normal operation this communication will be through SCADA. Meeting of flow requirements using least energy will be the objective of the control scheme.
- In case of signal failure to SIC from SMCS, Alarm shall be generated at Local/SMCS and control shall be transferred to respective station.
- Based upon daily off-take quota from respective up-liftment point, MLP(Main Line Pumps) speed of respective station/downstream stations shall be given through Local Control Room/SMCS which is governed by pump characteristic curve furnished by pump vendor.
- When MLP are operating in Manual mode pump speed shall be set from respective Station and station pressure shall be control by PV/PIC.
- In Auto mode SIC set point shall be automatically taken from suction/discharge PIC through low selector switch which will manipulate speed to control suction/discharge pressure and residual excess pressure will be controlled by PV/PIC (Pressure Control Valve / Pressure Indicator Controller) under split rage control to keep pump discharge pressure within design limit of pipeline.
- Initially pump discharge pressure shall be controlled by SIC but if it fails to do so, PV will control the pressure under split range signal from PIC.
- In case of downstream station shuts down mainline pump shall be bypassed and Station flow rate will reduce as this station will now be pumping crude oil to longer distance.
- The pump discharge pressure will increase as operating point shifts to the left on the performance curve. The booster pumps being fixed speed pumps will deliver higher discharge pressure at lower flow rate and increase suction pressure of MLP. In order to control the discharge pressure the discharge PIC

will give new set point to SIC to reduce the speed to meet new head and speed requirements.

In addition to the above, the Mainline Pumps can also get tripped due to signals related to machine operations like high bearing/winding temperature, vibration, mechanical seal failure, electrical fault etc. The suction pressure controller is set at set pressure ensure sufficient NPSH is available to the pumps at maximum flow rate.

4.7.2 Procedure for taking station inline when it is running in By-Pass mode :

During station by-pass mode of operation station shall experience higher pressure. Mainline pumps should be started at minimum speed in Manual mode so as to limit pump discharge pressure within piping design pressure. Once mainline pumps are inline with other stations it should be taken in auto mode.

4.7.3 : Barauni – Bongaigaon Sector :

At Barauni Station, the crude oil is supplied to mainline pump suction from the storage Tanks (TK- 235 , TK-236 or OIL's Balance Tank) through booster pumps and from there crude oil is transferred to Bongaigaon Refinery via PS-9, PS-8, PS-7 & PS-6.

4.7.3.1 : OPCP for Booster Pumps at Barauni – Flow towards Bongaigaon

Booster pumps will transfer the crude oil from existing line through hook up to mainline suction. The metered flow will be compensated by pressure and temperature in the line and flow computer will receive density data from density cum viscosity meter to calculate mass flow rate. The pumps line up for start up and tripping interlocks are provided.

4.7.3.2 : Operation and control philosophy for the Mainline pumps at Barauni:

The mainline pumps at Barauni Station are controlled by station control sequence. Every pump unit is controlled by unit control logic. The individual unit sequences in turn are linked to the main station control sequence, which also monitors and controls all the critical parameters of the pump station. To start the mainline pumps at Barauni it is required to confirm the following:

1. Barauni Injection Station is ready to inject crude oil. The prerequisite for starting mainline pumps is that the booster pumps are operating.

2. All Station inlet/outlet valves & Sectionalizing Valves are in open position

3. Receipt Terminals are ready to receive crude oil.

These verifications are performed at SMCS using the SCADA information as well as physical field verification and confirmation from respective locations over telephones. After verification of the above, Barauni station can be started. With the actuation of station start up push button, station outlet MOV is brought under open position. Station control sends signal to booster pump unit control for readiness to start the pump.

There are two variable speed motor driven (VFD) Mainline Pumps, (One operating + one standby) for injection in mainline. To start the Mainline Pumps, the Mainline Pump unit start up push button needs to be actuated. This push button actuates interlock for main line and the selected Mainline Pump unit starts & after a time delay, the discharge valve of the selected unit is opened.

The mainline pumps at Barauni station are provided with variable speed motor. Based on the selected case speed of the pump shall be controlled to deliver desired flow rate. SIC set point shall be given from SMCS through SCADA. Flow metering assembly with one working and one stand-by along with Meter proving facility is also being provided at the Mainline pump discharge.

During reverse pumping Station inlet/outlet are closed. And tanks are lined up to receive crude in reverse direction from Naharkatia-Bongaigaon Section through station by-pass line.

4.7.3.3 : Sump Tank & Sump Pump at Barauni Pump Station :

Sump tank has been provided at Barauni Station for collection of the slops from various points such as header drains, equipment drains, TSV relief etc. During crude transportation, the collected slop is pumped into the inlet header upstream of the filters. Sump pump is fitted to the sump tanks for slop transfer. Sump tank is provided with a sump pump, electrical heater, level indicator (with high, low alarm), Temperature controller (with high, high high alarm), and flame arrestor. All these indicators and controls are through PLC (Programmable Logic Control) and SCADA (Supervisory Control and Data Acquisition).

4.7.4 : Corrosion Inhibitor Dosing syatem

Corrosion Inhibitor is required to be injected in the pipeline for internal corrosion protection. For this purpose a Corrosion Inhibitor tank and a set of Corrosion Inhibitor dosing pumps for mainline (One operating + one stand by) have been provided. Corrosion inhibitor is injected at the suction of mainline pumps. Now based on product flow rate Corrosion Inhibitor dosing will be automatically determined & adjusted through VFD to maintain set PPM.

The dosing capacity of these pumps can also be adjusted by manual stroke adjustment of the pumps.

4.7.5 : Emergency / Normal shutdown

Emergency/Normal shutdown of the pipeline, if required, will be done from the SMCS. Any station willing to have normal shutdown will request SMCS for the shutdown of the pipeline. This will be done by the actuation of a single ESD push button in SMCS to take action for the shutdown of the entire pipeline operation. The Emergency shutdown of the entire pipeline can also be taken from each pump station under extreme emergency.

4.7.6: Sequence for normal shutdown of the entire pipeline: Barauni Bongaigaon Section:

1. Close terminal inlet valve at Bongaigaon Receipt Terminal
2. Pressurise the section PS8 – PS6 and stop pumps at Sonapur.
3. Close terminal inlet/ outlet valve at PS-8
4. If PS-8 is running in by-pass mode its by-pass MOVs shall be closed.
5. Pressurise the section PS10 – PS8 and stop pumps at Barauni PS10 , close terminal inlet/ outlet valve at Barauni PS-10.

In emergency shutdown ESD signals are generated corresponding to pump station and pumps are shutdown. Thereafter, the shutdown sequence described above is followed. In case of fire or activation of either total pipeline shutdown or station emergency shutdown, power to all MOVs will be cut off manually after closure of MOVs.

CHAPTER - 5: INDIAN OIL AND GAS INDUSTRY

Government Initiatives :

Some of the major initiatives taken by the Government of India to promote oil and gas sector are:

- In a major drive to enhance the petroleum and hydrocarbon sector, Government of India has introduced initiatives like the Hydrocarbon Exploration Licensing Policy (HELP), Marketing and Pricing freedom for new gas production, grant of extension to the Production Sharing Contracts and assigning the Ratna offshore field award to Oil and Natural Gas Corporation (ONGC) for development.
- Mr Dharmendra Pradhan, Minister of State (Independent Charge) for Petroleum and Natural Gas has released the Hydrocarbon Vision 2030 for North East India, with the objective of leveraging the north-eastern region's hydrocarbon potential, enhance access to clean fuels, improve availability of petroleum products, facilitate economic development and to involve local population in the economic activities in this sector.
- The Government of India plans to incentivise gas production from deep-water, ultra deep-water and high pressure-high temperature areas which are presently not exploited on account of higher cost and risk, and also to augment the investment in nuclear power generation in the next 15 to 20 years.
- The Government of India is in the process of identifying at least 50 potential blocks of 100 sq km and above to be given to companies for bringing private investment in the mineral exploration sector. The Ministry of Petroleum and Natural Gas has put up for comments a draft policy, to opt for revenue-sharing model while auctioning future oil and gas blocks for exploration to private companies, compared to production-sharing mode earlier, in order to make the process more transparent and market-oriented.
- The Ministry of Petroleum and Natural Gas has announced a new 'Marginal Fields Policy', which aims to bring into production 69 marginal oil and gas fields with 89 million tonnes or Rs 75,000 crore (US$ 11 billion) worth of

reserves, by offering various incentives to oil and gas explorers such as exemption from payment of oil cess and customs duty on machinery and equipment.

- Government of India entered into bilateral discussion with Norway to extend co-operation between the two countries in the field of oil and natural gas and hydrocarbon exploration.
- To strengthen the country's energy security, oil diplomacy initiatives have been intensified through meaningful engagements with hydrocarbon rich countries.
- PAHAL - Direct Benefit Transfer for LPG consumer (DBTL) scheme launched in 54 districts on November 11, 2014 and expanded to rest of the country on January 1, 2015 will cover 15.3 crore active LPG consumers of the country.
- 24 x 7 LPG service via web launched to provide LPG consumers an integrated solution to carry out all services at one place, through MyLPG.in, from the comfort of their home.
- The Government of India launched the 'Give It Up' campaign on LPG subsidy that helped it save Rs 140 crore (US$ 20.54 million) as on July 22, 2015 with nearly 1.26 million Indians registering for the cause. As per recent statistics from oil ministry, as many as 30,000 to 40,000 households are giving up LPG subsidy each day.
- As part of the special dispensation for North East Region, for incentivizing exploration and production in North East Region, 40 per cent subsidy on gas price has been extended to private companies operating in the region, along with ONGC and OIL.
- The Cabinet Committee on Economic Affairs (CCEA), chaired by Prime Minister Mr Narendra Modi, has approved a mechanism for procurement of Ethanol by Public Sector Oil Marketing Companies (OMCs) to carry out the Ethanol Blended Petrol (EBP) Program.

CHAPTER – 6: CONCLUSION AND SUGGESTIONS

6.1 Pipeline Operation :

Implementation of the up-gradation of pumping station / terminal facilities of NBPL crude oil pipeline will have reliable, safe , cost effective , efficient , environment friendly pipeline operation with enhanced operating life of the pipeline system.

6.2 Proposed Maintenance Methodology :

Since Reliability Centered Maintenance (RCM) encompasses (a) Reactive (b) Preventive & (c) Predictive maintenance and the cost of maintenance is also reasonable so this mode of maintenance may be adopted.

6.3 There is a continuous need for studies various critical aspects of efficient operation & best maintenance methodologies for effective & efficient operation & maintenance of Pump Stations.

CHAPTER 7 : REFERENCES AND BIBLIOGRAPHY

1. Centrifugal pumps: Basic concepts of operations and maintenance and trouble shooting PART-I ----- Mukesh Sahdev
2. Pipeline pumps- Efficiency & Reliability - Harindra Samarasekera
3. Understand the Basics of Centrifugal Pump Operation ---- Bernadette Pyzdrowski, Drew W. Schiller and Michael B. Smith,
4. Types of Maintenance Programs --- O&M Best Practices Guide, Release
5. New Development in Centrifugal Pumps for Optimum Cavitation Performance - ----- Moufak A. Zaher, Head of Research, Faculty of Applied Skills, Unitec Institute of Technology,Auckland, New Zealand
6. Operation & Maintenance - Best Practices A Guide to Achieving Operational Efficiency ----- W. D. Hunt, Pacific Northwest National Laboratory, U.S. Department of Energy, G. P. Sullivan , R. Pugh, A. P. Melendez
7. Oil and Gas Pipelines in India -----, This report is published by India Infrastructure Research, a division of India Infrastructure Publishing Private Limited.
8. Pipeline Transportation of Oil & Gas – Past, Present & Future : Pulak Jyoti Sarma, Oil India Limited
9. Pump Maintenance – Repair : Brian Trombly Mo Droppers Cummins Bridgeway, Gaylord, Mi
10. "Vision 2030" Natural Gas Infrastructure in India
11. Indian Petroleum and Natural Gas Statistics
12. OIL Industry - in brief – Internet collection
13. Improving Operational Safety in Oil Pipelines --- 6th Pipeline Technology Conference 2011
14. Tight-line pumping ----Dr. Bradley Hull, John Carroll University
15. VFD : Variable Frequency Drive : Christopher Jaszczolt
16. See more at: http://www.vfds.com/blog/what-is-a-vfd#sthash.ZbdQy1Wf.dpuf
17. - See more at: http://www.vfds.com/blog/what-is-a-vfd#sthash.ZbdQy1Wf.dpuf
18. - See more at: http://www.vfds.com/blog/what-is-a-vfd#sthash.ZbdQy1Wf.dpuf

****