"HYDRO TESTING OF BARMER SALAYA PIPELINE"

A thesis submitted in partial fulfilment of the requirements for the Degree of
Master of Technology
(Pipeline Engineering)

By

KRISHNA RAJ SINGH SISODIYA
R160207005

Under the guidance of

Mr.....
College of Engineering
UPES, Dehradun

Mr. R. PARAM SHIVAM
Project Manager
Kazstroy Service Infra India Pvt. Ltd, Rajkot

College of Engineering
University of Petroleum & Energy Studies
Dehradun
April, 2009

"HYDRO TESTING OF BARMER SALAYA PIPELINE"

A thesis submitted in partial fulfilment of the requirements for the Degree of
Master of Technology
(Pipeline Engineering)

By

KRISHNA RAJ SINGH SISODIYA
R160207005
2007-09

Under the guidance of

Mr.....
College of Engineering
UPES, Dehradun

Mr. R. PARAM SHIVAM
Project Manager
Kazstroy Service Infra India
Pvt. Ltd, Rajkot

Approved

.....
Dean

College of Engineering
University of Petroleum & Energy Studies
Dehradun
April, 2009

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

(ISO 9001:2000 Certified)

CERTIFICATE

UPES Guide has ascertained quality of the project – II, Anti Plag certification etc for asserting this high quality academic activity.

Signature.....

Name .....P.K. BAHL.....

Pipeline Engineering

UPES Dehradun

Corporate Office:
Hydrocarbons Education & Research Society
3rd Floor, PHD House,
4/2 Siri Institutional Area
August Kranti Marg, New Delhi - 110 016 India
Ph.: +91-11-41730151-53 Fax : +91-11-41730154

Main Campus:
Energy Acres,
PO Bidholi Via Prem Nagar,
Dehradun - 248 007 (Uttarakhand), India
Ph.: +91-135-2102690-91, 2694201/ 203/ 208
Fax: +91-135-2694204

Regional Centre (NCR) :
SCO, 9-12, Sector-14,
Gurgaon 122 007
(Haryana), India.
Ph: +91-124-4540 300
Fax: +91-124-4540 330

Regional Centre (Rajahmundry):
GIET, NH 5, Velugubanda,
Rajahmundry - 533 294,
East Godavari Dist., (Andhra Prades
Tel: +91-883-2484811/ 855
Fax: +91-883-2484822

Email: info@upes.ac.in URL: www.upes.ac.in

StroyService Infrastructure India Pvt. Ltd.

Corporate Office: 1st Floor, Vatika Towers
Sector 54, Gurgaon -122002, India
Ph. : +91 124 4566800
Fax : +91 124 4566866
Website: www.kazstroyindia.com

KAZ STROY SERVICE INFRA

CERTIFICATE

This is to certify that the work contained in this thesis titled **Hydro testing of BSPL Project** has been carried out by **Mr. Krishna Raj Singh Sisodiya** under my/our supervision and has not been submitted elsewhere for a degree.

Mr. PARAM SHIVAM

Project Manager

Kaz Stroy Service infrastructure India Pvt. Ltd

Rajkot.

Registered Office.
StroyService Infrastructure India Pvt. Ltd.
12 Bhagat Singh Marg, New Delhi-110001- India
Ph. : +91 11 23362414

A wholly owned Subsidiary of:
JSC OGCC "KazStroyService"
248 "B" Dostyk ave., Almaty, 050020, Kazakhstan
Ph.: +7 (3272) 58 46 06, Fax: +7 (3272) 58 31 71

Abstract

Hydrostatic testing is universally known and accepted as a means of demonstrating the fitness of a pressurized component for service. After a test, a pipeline or pressure vessel can be expected to safely contain its intended operating pressure. The confidence level that a pipeline or pressure vessel is fit for safe service increases as the ratio of test pressure to operating pressure increases. This highly beneficial aspect of hydrostatic testing applies not only to a new component to be placed in service for the first time. A similar benefit accrues to an in-service Component if that component is taken out of service after a period of time and subjected to a Hydrostatic test. A "revalidation" test of the latter type assures either that no significant imedependent deterioration of the component has taken place or that any segment that has been significantly degraded will be revealed and eliminated.

Acknowledgement

It has been an immense pleasure and truly enriching experience doing my project at the Rajkot division of **Kazestroy Service India Pvt limited**. I take this opportunity to thank all those people who have made this experience a memorable one. Firstly, I would like to thank my guide **Mr. Sourab Jain, Quality Manager** who has been instrumental and a guiding force behind the completion of this project. He has been constantly eliciting insights and viewpoints on the subject matter.

I would also like to thank the complete Project Team especially **Mr. R. Paramshivam, Mr. Ranjit Singh Yadav and Mr. R.P. Bacchani** who were there throughout my stint **Kazestroy Service India Pvt limited** at Rajkot for any help I needed.

Krishna Raj Singh Sisodiya
UPES M. Tech (Pipeline Engg)

COMPANY PROFILE

About Company

KazStroy Service is the leading engineering procurement and construction company in the Kazakhstan oil and gas sector. In 2006, the Company listed in the top thirty companies in Kazakhstan.

KSS's value lies in its employees. Today KSS employs more than 5,000 people. Building on a core of high quality Kazakh experience and talent, we also employ leading experts from, Germany, India, Great Britain, Russia, Ukraine, Italy, New Zealand and South Africa.

Based in and focused on Kazakhstan, KSS is now looking to leverage its local position and international partnerships to grow its business, both within the region and further a field.

The ongoing and constantly increasing exploitation of Kazakhstan's natural resources has provided massive growth potential, for not only upstream operators, but companies such as KSS, who provide the vital logistical services necessary to unlock the value of the Caspian region. KSS has successfully completed over 100 construction projects in Kazakhstan and India to the highest of international standards. We have proved ourselves to be a valuable partner for such companies as Agip KCO, KPO BV, KazGerMunay, KazTransOil, KazTransGas, Intergaz Central Asia, Exploration & Production KazMunayGas, Kazakhstan – China Pipeline, Kazakhoil Aktobe and Almaty Power Consolidated.

Through these projects, KSS has managed a key role in the economic development of Kazakhstan; helping to unlock is vast natural wealth.

In line with the growing needs of the Kazakh market, KSS has diversified its business activities and therefore expanded its sphere of influence in the Kazakh engineering market.

To its original activity of construction of oil and gas pipelines, the company has successfully added:

- Operation and maintenance of industrial sites

- Construction of oil refineries and installations
- Civil construction
- Construction of railways
- Offshore construction and logistics

In 2007 KSS became the only Kazakh Company to join the International Pipeline and Offshore Contractors Association (IPLOCA).

The company's financial growth, impressive performance indicators and first class international management are all testimony to its sound development strategy. In a resource hungry world, with predicted long-term high-energy prices, we look forward to our future with confidence.

Group Structure

KazStroy Engineering India Private Limited (**KEI**), established in January, 2006 has its corporate office located in Gurgaon, near New Delhi, India.

KEI is established to serve as a knowledge base and provides Engineering, Project coordination services and specialized inputs on project control / contract administration activities to all KSS Group projects covering cross-country Pipelines, Oil Field development, Refineries and Petrochemicals and GasProcessing plant projects in Kazakhstan and India.
KEI has a multi disciplinary setup including Process, Civil/Structural, Piping & Plant Design, Electrical & Instrumentation Engineers and Project Management & control and Procurement services and the setup is well equipped with state-of-the-art facilities to provide specialized technical support services to projects

JOINT VENTURES

1. Keppel Kazakhstan Limited

Keppel Kazakhstan Limited (KKL), 50 % owned by KSS, is located in Aktau and is engaged in offshore construction services for the Kashagan project. Strategically located adjacent to port Aktau, KKL has excellent access to resources and infrastructure, vital for supporting heavy industrial construction projects.

2 PSN KazStroy

PSN KazStroy - is a 50 / 50 joint venture with Aberdeen based Production Services Network, located in Atyrau. The company is engaged in the management of sea and coastal oil, gas, chemical, petrochemical and power projects, and assistance to companies, which work on a late development cycle.

3. KGNT

KSS owns 50 % of KGNT. KGNT is the leading Kazakh hydrocarbon engineering technology development company. For more than thirty years, KGNT has rendered highly skilled engineering services to the companies, engaged in field development, transportation and the processing of oil products.

4. PLK-KSS Caspian Offshore Construction LLP

"PLK-KSS Caspian Offshore Construction LLP" is a Joint Venture between "PUNJ LLOYD KAZAKHSTAN LLP" & "OGCC KAZSTROYSERVICE" for executing Offshore and shallow water Pipe laying & other construction activities associated with Oil & Gas Sector in Caspian Region.

CONTENTS

List of figures Page no

List of Tables Page no

Chapter 1

1.0 Introduction

This specification covers minimum requirements related to various activities to be performed by an agency, hereinafter referred to as the Contractor, entrusted with the responsibility to hydrotest the pipeline covered in the Contract between Company and the Contractor. This specification shall be read in conjunction with scope of work, specifications, documents, drawings and other requirements indicated in and included in the Contract between the Company and the Contractor. This specification does not cover the requirements of dewatering, caliper pigging and drying I preecommissioning of the test. Planning , Execution, Control and Supervision of all activities like Cleaning, Gauging, Hydrotest, Dewatering, Swabbing, Drying, Leak testing with Nitrogen/Helium ,etc of pipeline of different material like, (Corrosion resistance alloy lined/cladded inside) and GRE carrying hydrocarbon at high pressure range, in compliance with Project specification, International codes and Project HSSE plan; Co-ordination with Pipe Line spread incharge, QA/QC and HSE team in the organization and those of client for related activities; Identifying prerequisites and planning and coordination for organizing resources; attending/generating punch points as a part of mechanical completion activities, Preparation/ review of work procedures for above activities, Controlling overall Pre-commissioning/commissioning activities, Preparing reports for Client submission, etc.

1. The scope of this procedure covers the hydrostatic testing of natural gas pipeline of 8" dia and insulated crude line of 24" dia.
2. Hydro testing of mainline shall exclude permanent facilities like, Mainline valves, Launcher etc.
3. In this procedure main line hydro test activities are covered in detail which include, Cleaning, gauging, water filling, hydro testing and dewatering.

Chapter 2

2.0 Codes And Standards used for Hydro Testing

- Pipeline Construction specification Volume 2 Part 1 Exhibit 8
- Pipeline data sheet
- OISD – 141
- OISD – 226
- ASME B 31.8
- ASME B 31.4
- API RP 1110

Reference has been made in this specification to the latest edition of the following codes, standards and specifications:

- ANSI B 31.8: Gas Transmission and Distribution Piping Systems
- ANSI B 31.4: Liquid Petroleum Transportation Piping System.
- API RP 1110: Pressure Testing of Liquid Petroleum Pipelines.
- ASME Sec VIII: Boilers and Pressure Vessels Code Div.1.
- DNV 81: Rules for Submarine Pipelines.
- IP Part: Institute of Petroleum.
- Model Code of Safe Practice.

Chapter 3

3.0 Health, Safety & Environment

All relevant elements of HSE plan BSPL-2000-L&T-HS-PLN-0001 shall be followed. Tool box meeting shall be conducted for involved persons to make sure that they are aware of safety requirements for hydrotest.The Contractor shall take all necessary safety precautions during the hydro test. As a minimum, the following shall be taken during the hydrostatic test: Warning signs stating 'PIPELINE UNDER TEST-KEEP OFF" with local language translation shall be placed where the pipeline is uncovered, and particularly where the provisional traps/test headers and stations are located. Such areas shall be suitably fenced in such a way as to prevent access of unauthorized personnel and no unauthorized personnel shall be closer than 40 m to the testing equipment or pipeline under test. Warning tapes and signboards shall also be placed near the crossings and regular intervals along the route to warn the public around those areas. Provisional scraper traps shall be installed in compliance with methods and suitable location so that their rupture cannot cause any injuries to the personnel or third parties. The test station shall be placed in such a location as to prevent it from being affected by a catastrophic failure in the test head.

Chapter 4

4.0 Instruments and equipments

4.1 Instrument List

Sl	Instrument	Specification	Accuracy
1	Dead Weight Tester	1 - 250 bar	0.5%
2	Flow meter	8" - 300 M3/hr	0.1
3	Flow meter	2''-10 M3 / hr	0.1
4	Pressure Recorder	250 bar,24 hrs, Mechanical / Electronic	0.5
5	Temperature Recorder	50 degc,24 hrs, Mechanical / Electronic	0.5
6	Thermometers	50 deg c	+/ -0.5 deg c
7	Digital Thermometer	50 deg c, 3 pin type	+/ -0.1 deg c
8	Temperature probe	50 deg c, 3 pin type	+/ -0.5 deg c
9	Pressure Gauges	0-10	
		0-21	
		0-42	
		0-210	
10	Measurement Drum	200 ltr	
11	Measurement Jar	5ltr	+/-2 ltr
12	Measurement Jar	1ltr	
13	Colour of ink for recorders		
	Pressure Wall Temperature or Water temperature	Blue Red Green	

However the quantities can change as per site requirements. All instruments shall be calibrated to confirm their accuracy prior to their initial use and every six (6) months there after and record of calibration shall be maintained.

4.2 Equipment List

Sl	EQUIPMENT	SPECIFICATION
1	Air Compressor	1100 CFM / 25 BAR
2	Power generator	15 KVA
3	Welding generator	22kw
4	Dewatering pump	5HP
5	Excavator EX-200	EX-200
6	6 Pipelayer	-70 T 70 T
7	Test Cabin	20 feet
8	Air Pigging Manifold	
9	Hydro Test Manifold	
10	Water filling Pump	300 M3/Hr
11	Pressurization Pump	7 M3/Hr

Figure 1: Air Compressor

4.3Method

After construction of the pipeline is completed, it is necessary to hydrostatically test the pipeline to demonstrate that the pipeline has the strength to meet the design conditions, and to verify that the pipeline is leak free. Hydrostatic testing of pipeline is certainly major operation and should be carefully planned. The hydrostatic testing for pipelines is done at a pressure of 76-kg/sq cm g, which is 1.5 times the design pressure of the pipeline.

Hydrostatic testing is universally known and accepted as a means of demonstrating the fitness of a pressurized component for service(1, 2). After a test, a pipeline or pressure vessel can be expected to safely contain its intended operating pressure. The confidence level that a pipeline or pressure vessel is fit for safe service increases as the ratio of test pressure to operating pressure increases. This highly beneficial aspect of hydrostatic testing applies not only to a new component to be placed in service for the first time. A similar benefit accrues to an in-service component if that component is taken out of service after a period of time and subjected to a hydrostatic test.

A "revalidation" test of the latter type assures either that no significant imedependent deterioration of the component has taken place or that any segment that has been significantly degraded will be revealed and eliminated. There are limitations to the use of hydrostatic testing to revalidate integrity. Some are economic, some are technical, and some are both economic and technical in nature. First, taking a segment of a pipeline out of service means loss of service for the period of the test. Some operators may have this option; others may not. Certainly an operator cannot afford to cut offcustomers without providing alternative supplies. For single-line systems, this may not be possible. Technical limitations include the fact that a test is a go/no-go device. A test reveals weaknesses by causing ruptures or leaks; it does not indicate, for example, other areas where active corrosion may be taking place.

A limitation that has both technical and economic implications is that a level of test pressure to operating pressure sufficient to generate high confidence may result in numerous test breaks or leaks. Repeated test failures may actually 2 reduce confidence in the final margin of safety(2) demonstrated by the test, and such failures will certainly add significantly to the cost of the test and the time out of service. With careful weighing of the benefits and limitations nevertheless, some pipeline operators will be able to use

hydrostatic testing as a means of integrity assessment. The objective of this presentation is to show how such testing might be used to assess the integrity of existing gas pipelines.

Chapter 5

5.0 General Procedure

5.1General

1. The Entire pipeline shall be divided into test sections, based on water source availability, section profile etc.
2. A detailed Hydro test plan will be submitted, which shall outline test section length, location of test points, Water source, Access provision and actual anticipated maximum and minimum test Pressures. Also the plan shall include following criteria.
3. Before start of hydro test PART A +PART B of Pipe book shall be completed and certified.
4. Calculation for minimum and maximum hydro test pressures.
5. Gauge plate dimension calculation.
6. Calculation for Test section length, theoretical volume, Average inner radius, Average wall thickness.
7. Estimated Quantity of water for filling and pressurization and source of water.
8. Material class and location (where necessary).
9. Maximum delta head differences of elevation.
10. Elevation chart and levels.
11. A diagram showing water filling, pressurizing & instrumentation arrangements.
12. Organization chart with contact details.
13. Details of chemicals/ inhibitors and dosage.

5.2Internal Cleaning by Air Pigging

5.2.1 Cleaning scrapper tool

1. Cleaning scrapper tool shall be propelled through all sections of the pipeline using air compressor. A four rubber batch scrapper without wire brushes shall be used. Cleaning scrapper tool shall be subject to approval by Company.
2. The removal of the cleaning scrapper tool shall be witnessed by Company.
3. Extra cleaning scraper tool runs shall be made if ,in the opinion of Company, a proper level of internal cleanliness has not been achieved

5.2.2 Launching and receiving headers

Temporary air pigging Launcher header and receiver header will be fabricated for using in pigging operation .The sketch will be included in the test plan and submitted to Company for review and approval.

5.2.3 Internal cleaning by air pigging

Additional scraper runs shall be carried out till a small quantity of Debris is found in front of the last cleaning pig run.

5.2.4 Dirt and debris containment

1 Dirt and debris generated by the cleaning operation shall not be allowed to blow over the adjacent land.

2 The dirt and debris will be contained in the receiver pigging header by means of keeping the header flange closed during the operation, and after the pig run ,will be removed manually and

disposed subsequently

5.3Gauging

1 After satisfactory cleaning of the section, a gauging pig mounted with an Aluminum plate of dia equal to 95% nominal I.D of heaviest wall pipe and 10 mm thick shall be launched in order to check possible out of roundness along the pipeline.

2 Document Number A column of clean water shall be filled in front of the pig for lubrication and to flush out the remaining dirt's inside the test section.

3 The results of gauge plate shall be analyzed to evaluate internal surface of the pipe line. The acceptance of gauge plate shall be jointly decided with client representatives.

5.4Hydrostatic testing

1 Company shall be informed in advance, at least 48 hours prior to start of pipeline sectional cleaning and hydro testing.

2 L&T-shall be responsible for all liaison with Regulatory Authorities and obtaining acceptance of hydro tests as required.

5.4.1 Test Medium

The test medium shall be clean, un-contaminated water free from sand or silt, having pH between 6 to 8 and total suspended solids (TSS) less than 400 PPM. Chloride content in the test water shall be less than 300 PPM. The Contractor shall submit a laboratory test report of water used for testing.

5.4.2 Inhibitors

The pH value of the test water shall be adjusted to a value of between 6.5 and 7.5 by the addition of suitable chemicals. No other inhibitor shall be added to the test water provided the water does not remain in the pipeline longer than 1 month.

Should the Contractor's procedure determine that inhibitors are necessary for the test water, details of such inhibitors shall be submitted for approval by the Engineer-in-Charge.

Inhibitors shall be uniformly mixed with the test water in the dosage recommended by the Manufacturer, and in sufficient concentration to ensure the inhibitor remains active for the duration of the test, and any possible delays to testing. An oxygen scavenger chemical and a biocide chemical shall also be added with the use of any inhibitors.

5.4.3 Cleaning

The pipeline shall initially be cleaned by running a series of wire brush cleaning pigs propelled by compressed air, at a velocity between 5 km/hr and 8 km/hr, to remove all mill scale, rust, sand, etc. from the internal of the pipe section. For these purpose temporary headers for air cleaning shall be attached to the pipeline. The number of pig runs is depending upon the cleaning results and shall be determined by the Engineer-in-Charge at site.

5.4 .4Gauging

After cleaning the pipeline by using air and acceptance by Engineer-in-charge, gauging shall be carried out by using gauging pig. The gauge plate diameter shall be equal to 95% of inside diameter of the heaviest wall pipe in the test section. While computing the Inside Diameter (10) of heaviest wall pipe, manufacturing tolerances of pipe shall not be taken into account. A 10 mm thick aluminium plate with radial incision at an interval of 45° shall be used for making gauge plate. Compressed air shall be used to run Gauging pig.

After receipt of gauging pig at the other end, the gauge plate shall be inspected in the presence of Engineer-in-Charge. A deformed, bent or severally nicked plate or damaged pig shall be evidence of gauging pig run failure and the same is not acceptable to Company. In such cases, the Contractor shall locate any obstruction and/or faults such as dents, buckles, flat spots, etc. and rectify the same to the satisfaction of the Engineer-in-Charge. A written approval shall be obtained from Engineer Charge regarding successful completion of gauging pig run. After acceptance of the gauging, air headed shall be cut and removed.

5.4.5Filling

After acceptance of gauging run, water filling of the testing shall commence. For this purpose, pretested test headers loaded with three numbers of batching pig shall be welded to the test section. Un-inhibited water equal to 10% of the volume of test section shall be introduced ahead of the first pig. The first batching pig shall be launched using un-inhibited water equivalent to 1.5 km length of the test section. Then the second pig shall be launched using inhibited water till the second pig is received at the other end. The pig velocity shall be maintained between 3 - 5 km/hr during filling operation. The Contractor shall continuously monitor the volume and pressure and, at approximately thirty minute intervals, the temperature of the fill water during the filling operation. When it has been confirmed that the filling pigs have arrived in the receiving test head, maintain water flow until the exhausting water is clean, to the satisfaction of Engineer-in-Charge. The thermal stabilization and pressurization operations can commence subsequently.

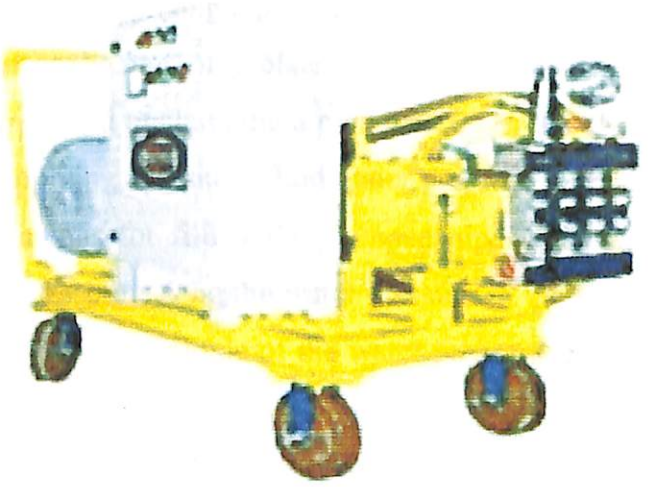

Figure 2: Hydro testing pump

5.5 Pre tested pipe

L&T-shall pre test lengths of 8" and 24'' pipelines, of various diameters and wall thicknesses as required, to a pressure maximum specified in this procedure. The pipes to be pretested shall be full length joints without any circumferential welds.

1. Pipes shall be subjected to a 4 hour above ground hydrostatic test. Pipe shall be emergency stock and accompanied by the documentation of the test. A pipe testing machine comprising a pair of spaced clamping plates, means for applying clamping pressure to the clamping plates to seal opposite ends of a test pipe against internal test pressure, means for subjecting the test pipe to internal fluid pressure, means for continuously sensing the magnitude of the internal pressure in the pipe and providing an electrical signal varying in magnitude in accordance with the magnitude of the internal pressure in the pipe, and electrically adjustable modulating valve means for receiving the electrical signal and proportioning the clamping .

2. A pipe testing machine as claimed in claim 1 including means for releasing the internal test pressure and wherein the proportioning means is effective while the pressures are decreasing.

3. A pipe testing machine as claimed in claim 1 wherein the means for subjecting the test pipe to internal fluid pressure comprises means for introducing water into the pipe.

4. A pipe testing machine as claimed in claim 1 wherein the clamping pressure is suppliedbhydraulicactuatorandpumpmeans.

5. A pipe testing machine comprising a pair of spaced clamping plates, hydraulic actuating means for moving one of the clamping plates selectively toward and away from the other for respectively clamping and unclamping a pipe there between at opposite ends, hydraulic pumping means for supplying hydraulic fluid under pressure to the actuating means to seal the ends of the pipe, means for filling the clamped pipe with water through one of the clamping plates, means for increasing the water pressure in the pipe to test the pipe, means for continuously sensing the magnitude of the water pressure in the pipe and providing an electrical signal varying in magnitude in accordance with the magnitude of the water pressure in the pipe, and electrically adjustable modulating valve means for receiving the electrical signal and proportioning the hydraulic fluid pressure in the actuating means to the sensed magnitude of the water pressure.

6. A pipe testing machine as claimed in claim 5 wherein a plastic test pipe expands under the water pressure therein and the machine includes controlled vent valve means for gradually releasing water from the expanded pipe and permitting the water pressure in the pipe to decrease sufficiently slowly to enable the hydraulic fluid pressure in the actuating means to be reduced .proportionately therewith under the control of the water pressure sensing means and modulating valve means while the expanded pipe contracts back to its normal condition.

7. A pipe testing machine comprising a pair of spaced clamping plates, means for applying clamping pressure to the clamping plates to seal opposite ends of a test pipe against internal test pressure, means for subjecting the test pipe to internal fluid pressure, means for continuously sensing the magnitude of the internal pressure in the pipe and providing an electrical signal varying in magnitude in accordance with the magnitude of the internal pressure in the pipe, and electrically adjustable modulating means for receiving the electrical signal and proportioning the clamping pressure to the sensed internal pressure.

5.6 Test length test pressure and test duration for natural gas pipeline (8'')

• Test length: The length of a test section shall not be more than 25000 m or as approved by the Company.

• Minimum Test Pressure – 1.4 times the design pressure of the pipeline. Maximum test pressure- 90% of SMYS.(The test section start and end for 8'' and 24'' will be same locations)

• Test Duration: All hydro static tests shall be 24 hours minimum duration. If during the period of test, any faults discovered and repaired, repeat test shall also be for a minimum period of 24 hours. For definition purposes, the hydrostatic test shall be deemed to commence on satisfactory completion of flushing, filling and stabilization of the line test pressure.

5.7 Test length test pressure and test duration for liquid pipeline (24'')

1 Test length: The length of a test section shall not be more than 20000 m or as approved by the Company. L&T-shall prepare the hydrostatic test plans to ensure the smallest possible differences in the elevation of the test section.

2 Minimum Test Pressure – 1.4 times the design pressure of the pipeline.

3 Maximum test pressure- 90% of SMYS.

4 Test Duration: All hydro static tests shall be 24 hours minimum duration. If during the period of test, any faults discovered and repaired, repeat test shall also be for a minimum period of 24 hours. For definition purposes, the hydrostatic test shall be deemed to commence on satisfactory Completion of flushing, filling and stabilization of the line test pressure.

5.8Test Pressure table

Sl	Dia	Material	Wall thickness	Desing pr	Mini pr	Maxi pr
1	8	X56	6.35	93	130.2	201.49
2	24	X65	10.63	95	118.75	140.70

5.9Test manifolds

1 L&T-is responsible for the design and procurement of all materials required for the fabrication and testing of Test manifolds. All test manifolds shall be assigned a serial number and a record of their usage shall be compiled.

2 All weld joining the test manifolds to the 8'' and 24'' pipelines to be tested shall be radio graphed and approved prior to filling the section with water.

3 Test manifolds shall be designed and pressure tested to 1.25 times the maximum pipeline test pressure.

4 Holding time shall be 1 hour.

5.10Water source

1 L&T-shall acquire water for hydro test in a manner satisfactory to the authorities having jurisdiction, the landowners affected by this operation and company.

2 The source of water shall be sufficient to permit continuous filling without interruption.

3 The test medium must be of suitable quality. Water containing silt, suspended material of harmful corrosive components will not be sued unless it can be satisfactorily treated by use of filter or chemical additives. The water intake will be screened and located so that it will not permit air to be drawn in with the water while water filling.

4 If required corrosion inhibitor may be added. The dosage will be as per the recommendation of the Corrosion inhibitor manufacturer, which will be submitted to Company prior to test for review and approval.

5.11Water Filling of Test Section

1 All valves and appurtenances must be checked prior to start of water filling.

2 On acceptance of gauging pig run, the air pigging headers shall be cut and removed and the test manifolds shall be welded.

3 The filling operation shall begin with pumping uninhibited water in the amount equal to 1 KM of the volume of test section after which first pig is launched.

4 The second pig shall be launched after pumping about 1 Km of uninhibited water behind the first pig.

5 Water filling is continued till the 2nd Pig is received at the other end.

6 During the whole filling operation the valves at the receiving end test headers shall be throttled suitably to maintain about 0.5 – 1 bar backpressure to control the pig movement.

7 The first two columns of water between the first and the second pig shall be drained out from the receiving end.

8 During pipeline water-filling monitoring should be performed and following information shall be recorded:

a) quantity of water before the first pig (m3).

b) time of pig launching.

c) quantity of water between pigs (m3).

d) quantity of water filled per hour (m3).

e) quantity of added chemicals per hour (liters/hour).

f) first pig receiving time.

g) second pig receiving time.

h) water temperature at pump delivery.

5.12Thermal Stabilization

1 A temperature recorder shall be installed at 500 mtr back from the exposed pipe at one end of the test section. One sensing element shall be placed against the pipe wall, suitably insulated and

backfilled. The second element shall be installed in the pipe backfill material a minimum of 0.3 m from the pipe wall and suitably insulated and backfilled. Temperature recorders shall be checked every 6 hours during filling and testing to ensure the proper functioning.

2 A check on thermal stabilization shall be started, after the pressure on pipeline reaches 1 bar (g) on the highest section.

3 Thermal equilibrium between the pipeline and environment shall be checked through the thermocouples installed on the pipe line.

Thermocouples shall be attached to mainline pipe by ensuring proper contact.

4 Temperature readings shall be made at 4hrs interval (24 hoursafter water filling). Thermal stabilization shall be considered to have been achieved when a difference not higher than one deg C is attained between average values last any two consecutive readings of 4 hrs interval.

5 After completion and acceptance of hydro testing, thermocouples shall be demounted and coating repair patch work done as per the approved procedure

5.13Pressurization

Prior to pressurizing warning signs shall be placed along the Right Of Use at all public crossings and at all points where there is exposed pipe or appurtenances. All valves on the test manifolds that will not be used for pressurizing or instrumentation shall be blind flanged, plugged or capped and left in the open position. Prior to testing, for contingency purpose in the event of failure during testing L&T shall ensure the availability of a minimum of 100 mtr of each pipe size and wall thickness combination.

5.14 Housing of test equipment and personnel

A test cabin shall be provided at site which will be weather proof, to house hydro test instruments and test personnel. The test cabin shall be properly lighted, air conditioned and shall remain at site for the duration of the test.

5.14.1 Hydro Testing Process

1. The petroleum inside the pipeline is removed and replaced with water. This water contains an environmentally safe green dye to aid in determining the location of a defect, in the event of a leak.

2. The water inside the pipeline is pumped up to a pressure much higher than the normal operating pressure of the pipeline while transporting petroleum. This high pressure is typically held for at least 8 hours.

3. During this test, which will likely occur during the late evening and early morning hours, Buckeye representatives will be conducting visual inspections along the pipeline route. Each Buckeye employee will be wearing a hard hat and will carry a Company Photo Identification Card for safety and identification purposes. If you have any questions, please do not hesitate to speak with one of our representatives.

4. In the event of a sudden leak of water from the pipeline, the pressure will be reduced rapidly and the green water should rise to the surface quickly.

5. In the event of a small leak of water from the pipeline; the pressure will be reduced slowly and the green water may not immediately reach the surface. To locate the leak, Buckeye will excavate the pipeline at determined locations for further investigation and testing protocols.

6. In the event that defects in the pipeline are identified, repairs will be made as soon as possible and the testing will continue until the pressure remains intact for at least 8 hours.

7. Following the successful completion of the hydrostatic test procedures, all of which is in accordance with U.S. Department of Transportation / Office of Pipeline Safety regulations, the water will be removed from the pipeline. The pipeline will be refilled with petroleum products and the petroleum distribution service to the area will be resumed.

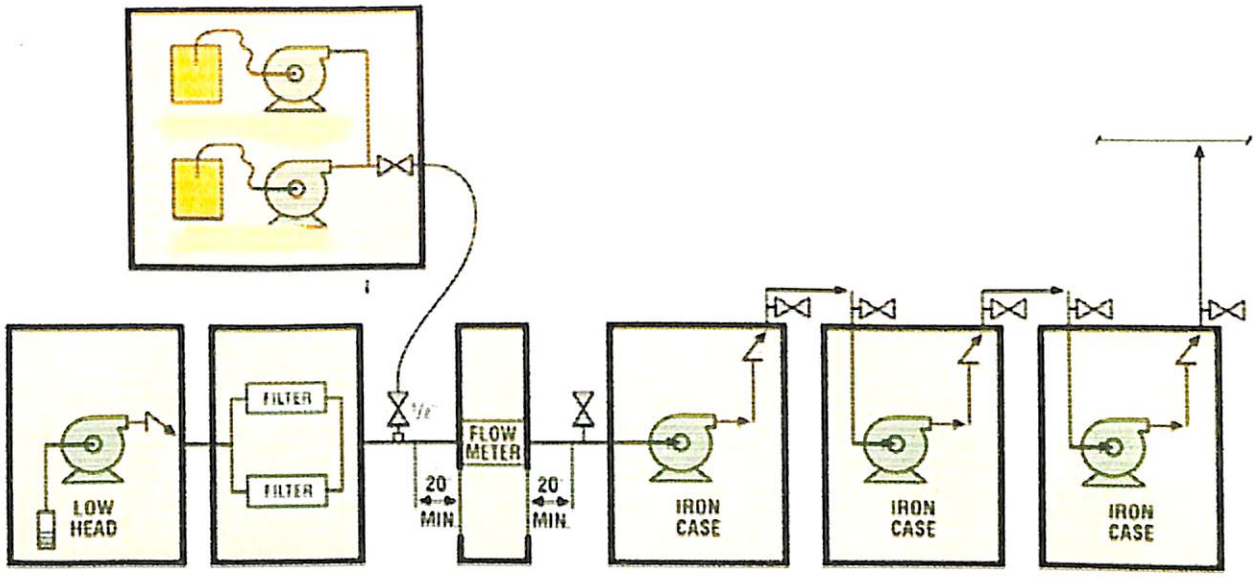

Figure 3: Hydro testing procedure.

Chapter 6

6.0 Operational Steps

The pressurization rate shall not be more than 2 bars/min. Pressure shall be recorded by using a dead weight tester and conformation shall be done with pressure gauge on the same header. Volume of water required to reach the test pressure shall be recorded periodically throughout the pressurization as follows.

- Each 5 bar increments up to 80% of test pressure as recorded by the dead weight tester
- Each 2 bar increment between 80% to 90% of test pressure as recorded by the dead weight tester.
- Each 0.2 bar increments between 90% of the test pressure up to full test pressure as recorded by the dead weight tester. The pressurizing shall be cycled according to the following sequence:
- Pressurize to 50% of test pressure, hold pressure for 1 hour, and collect water for air volume calculations.
- Drop pressure to static head +1 bar of test section at test head.
- Re-pressurize to 75% of test pressure, hold pressure for 1 hour, and collect water for air volume calculations.
- Drop pressure to static head + 1 bar of test section at the test head.
- Re-pressurize to test pressure and hold for stabilization.

During the hold period no decrease in pressure shall be permitted and leaks any shall be rectified and tests repeated until pressure is stabilized. The test section and associated pipe work may yield during stabilization. The resulting drop in pressure together with temperature should be

checked at suitable intervals over the decay period and wait until the pressure stabilizes. Leaks if any shall be rectified as per specifications. Re pressurization shall not be carried out during decay period or stabilization period.

However, the test can be repeated to achieve stabilization. During pressurization to each test pressure, two tests shall be carried out for the calculation of air volume in the pipeline under test.

6.1Air volume calculation

In order to check the presence of air in the pipeline, two separate lowering of 0.5 bar shall be carried out. For calculation of air in the pipeline the second pressure lowering shall be used, and the relevant drained water shall be accurately measured (V1). This amount measured shall be compared to the theoretical amount (V2) corresponding to the pressure lowering that has been carried out, by using the procedure outlined in specification. If no air is present in the length under test, V1/V2=1 In order that the above ratio is acceptable, it shall not differ from 1 by more than 6% (i.e. 1.06). If ratio is found to be within limits, then the pressurizing can proceed. If not, water refilling shall be carried out by another run of batching pigs after depressurizing the pipeline.

6.2 .Water Quantity calculation

The quantity of water added to the test section shall be measured during the filling stage through a positive displacement meter (a turbine meter may also be used) and the quantity of water added to pressurize shall be measured during the pressurization stages.

The theoretical quantity of water necessary for filling the test section shall be obtained from the geometrical volume of the section and the theoretical quantity of water necessary for pressurizing the test section shall be calculated as per the following formula:

$$Vp= (0.884\ r/t +A) \times 10\text{-}6\ X\ Vt \times \Delta p \times K$$

Where:

Vp = computed water quantity required to raise the pressure in the test section (m3) geometrical volume of the section (m3)
Vt = geometrical volume of the section (m3)
Δ p = pressure rise (bar)
rj = nominal inner radius of the pipe (mm) nominal pipe wall thickness (mm)
A = isothermal compressibility value for water at the pressurization temperature in the P range (bar(-1) x 106.
K = dimensionless coefficient equal to a value of 1.02 for longitudinally welded pipe.

6.3Testing (Pressure holding test)

After completion of 100 % pressurization, pipeline shall be left for stabilization for at least 1 hour. All the fittings and connections are inspected for any leakages. Then 24''-hold period shall be started. The pressure and temperature recorders shall then be started once again with the charts in a real time orientation for continuous recording through out the test duration. No further pumping is permitted during the hold period. During the testing period the following measurements shall be recorded /reported. Every one hour pressure measurements from dead weight testers. Every two hours the ambient temperature and the pipe/soil temperature at the thermocouples. All data shall be recorded on appropriate forms attached with this procedure. Care shall be taken that the maximum test pressures are not exceeded. If water temperature increases resulting in increased test pressure above maximum test pressure limits, then bleeding of water shall be done to bring the test pressure within limits. Bleed off water shall be accurately measured and recorded.

Chapter 7

7.0 Test acceptance

The hydrostatic test shall be considered as positive if, The test pressure is maintained for a minimum of 24 hour consecutive hours above the minimum specified test pressure.

Without addition of additional test media. The test pressure has kept a constant value throughout the test duration, except for change which is explainable due to temperature effects. The pressure change value as a function of temperature change shall be algebraically added to the pressure value as read on the meters. The pressure value thus adjusted shall be compared with the initial value and the test shall be considered as acceptable if unaccountable pressure loss is less than or equal to 0.3 Bar.

In case of doubt or if for any reason the test pressure has been reduced other than for bleed-off excess pressure, the testing period shall be extended by 24hours. The hydrostatic test shall be considered as positive if pressure has kept a constant value throughout the test duration, except for change due to temperature effect. Such changes shall be evaluated as described under clause 9.2 of this specification. The pressure change value as a function of temperature change shall be algebraically added to the pressure value as read on the meter. The pressure value thus adjusted shall be compared with the initial value and the test shall be considered as acceptable if the difference is less than or equal to 0.3 bar. In case of doubt, the testing period shall be extended by 24 hours.

If test section fails to maintain the specified test pressure, the Contractor shall determine the location of leakage or failure by suitable means. All leaks and failures within the pipe wall or weld seams shall be repaired by replacement of entire joint or joints in which leakage or failure has occurred. In those cases where leak occurred in circumferential welds, the Company shall determine the method of repair. Contractor shall comply with instructions of the Company whether to replace a section of the line pipe that includes the line leak or whether to repair the circumferential weld. This repair shall, however, meet the requirements of applicable welding specification enclosed with the Contract. Where failures occur in pipeline field bends, bends shall be replaced with same degree of bends. After completion of repairs, the hydrostatic test shall be repeated in full, as per this specification.

The cost of repairs or replacements, followed by refilling and repressurising the line, due to poor workmanship, shall be borne by the Contractor. In the event of leaks or failures

resulting from faulty Company furnished materials, Contractor shall be reimbursed as per the provisions of Contract. All work of reinstalling line pipe, to replace failures, shall be done in accordance with the relevant specifications included in the Contract.

Contractor shall haul and stockpile all damaged and defective pipes to a storage location designated by the Company. All cracks and splits resulting from failure shall be coated with an application of grease to preserve the characteristics of failures from corrosion. Joint of failed' pipes shall be marked with paint, with a tag indicating failure details, date and location of failure and pressure at which failure has occurred.

Barmer to Salaya Pipeline Project Hydro Testing

Difference between Water and Steel Thermal Expansion Factor ($^0C^{-1}$) 10^{-6}

^0C Bar	1	2	3	4	5	6	7	8
.981	-98.62	-79.89	-61.81	-44.34	-27.47	-11.14	+4.66	+19.99
10	-95.55	-76.94	-58.99	-41.65	-24.89	-8.67	+7.02	+22.23
20	-92.15	-73.68	-55.86	-38.64	-22.01	-5.92	+9.65	+24.24
30	-88.74	-70.40	-52.72	-35.63	-19.14	-3.16	+12.29	+27.26
40	-85.32	-67.12	-49.58	-32.62	-16.24	-0.41	+14.93	+29.78
50	-81.90	-63.84	-46.43	-29.60	-30.36	+2.36	+17.57	+32.31
60	-78.47	-60.55	-43.27	-26.58	-10.46	+5.15	+20.23	+34.85
70	-75.03	-57.25	-40.10	-23.54	-7.56	+7.92	+22.89	+37.89
80	-71.60	-53.96	-36.94	-20.51	-4.65	+10.70	+25.55	+39.94
90	-68.16	-50.66	-33.77	-17.47	-1.73	+13.50	+28.23	+42.50
100	-64.72	-47.35	-30.60	-40.14	+1.18	+16.29	+30.90	+45.05
110	-61.28	-44.05	-27.43	-11.38	+4.10	+19.08	+33.58	+45.67
120	-57.84	-40.74	-24.26	-8.34	+7.02	+21.88	+36.26	+50.18
130	-54.40	-37.44	-21.08	-5.29	+9.95	+24.68	+38.94	+52.75
140	-50.96	-34.13	-17.90	-2.25	+12.87	+27.49	+41.63	+55.32
150	-47.53	-30.83	-14.73	+0.80	+15.79	+30.29	+44.31	+57.89
160	-44.10	-27.53	-11.56	+3.85	+18.72	+33.10	+47.00	+60.46
170	-40.67	-24.23	-8.40	+6.89	+21.64	+35.90	+49.69	+63.04
180	-37.24	-20.94	-5.23	+9.94	+24.56	+38.17	+52.37	+65.62
190	-33.83	-17.65	-2.06	+12.98	+27.48	+41.51	+55.06	+68.19
200	-30.42	-14.37	+1.09	+60.01	+30.40	+44.30	+57.75	+70.77

Barmer to Salaya Pipeline Project Hydro Testing

^0C / Bar	9	10	11	12	13
.981	+34.82	+49.22	+63.20	+76.78	+89.99
10	+36.97	+51.26	+65.15	+78.64	+91.75
20	+39.36	+53.65	+67.33	+80.71	+93.72
30	+41.76	+55.84	+69.51	+82.79	+95.70
40	+44.18	+58.14	+71.70	+84.87	+97.68
50	+46.60	+60.45	+73.90	+86.96	+99.68
60	+49.90	+62.76	+76.90	+89.07	+102.67
70	+51.44	+65.08	+78.32	+91.17	+103.68
80	+53.88	+69.73	+80.54	+93.29	+105.69
90	+56.32	+72.07	+82.75	+95.45	+107.70
100	+58.74	+74.14	+84.98	+97.53	+109.73
110	+61.21	+76.74	+87.22	+99.66	+113.79
120	+63.64	+79.09	+89.45	+101.79	+115.83
130	+66.12	+81.45	+91.69	+103.93	+117.87
140	+68.58	+83.80	+93.93	+106.07	+119.90
150	+71.05	+86.15	+96.18	+108.21	+121.96
160	+73.51	+88.51	+98.43	+110.36	+124.01
170	+75.97	+90.87	+100.68	+112.51	+126.06
180	+78.44	+93.02	+105.19	+114.66	+128.12

Chapter 8

8.0 Test Failures

If test section fails to maintain the specified test pressure after isolation, a search shall be made to determine the location of leakage or failure. To locate buried leaking pipe, the following procedure by elimination shall be followed.

8.1 To cut the section in an intermediate position.

8.2 To insert two test heads.

8.3 To refill the sections.

8.4 To pressurize the two sections.

8.5 To determine the faulty section.

1 This procedure shall be applied until the determination of the defect. As soon as the defect has been located and repaired, the test section shall be tested again.

2 All leaks and failures within the pipe wall or weld seam shall be repaired by replacement of entire pipe or pipes in which leakage or failure occurs or as directed by the Company.

3 In those cases where leaks occur in circumferential welds the method of repair shall be determined by the owner. As per owner's representative instruction, pipe that includes the leak shall be replaced by a pipe section or the circumferential weld shall be repaired. This repair shall be done as per approved procedures.

Chapter 9

9.0Termination

After the positive results of testing and all the data's have been gathered, the test shall be terminated. After the positive result of testing and all the data have been gathered, the test shall be terminated upon written approval given by the Company. The pipeline shall be slowly depressurized at a moderate and constant rate as instructed by Company. Subsequent operations such as dewatering, installation of sectionalizing valves, pre-commissioning checks and commissioning shall be carried out as per the applicable specifications enclosed with the Contract. All thermocouples installed in the pipeline shall be removed and damaged coating shall be repaired using Company approved materials and procedure.

Chapter 10

10.0 Depressurization

1 The pipeline shall be slowly depressurized at a moderate and constant rate of 2 to 3 bars / minute.

2 The pipeline pressure shall be bled down slowly to a pressure which will keep at least 2 bar pressure at the high point of the section.

Chapter 11

11.0 Dewatering

1 The hydro test water shall be disposed off in a manner satisfactory to the authorities having jurisdiction, landowners.

2 Necessary arrangements shall be made for safe disposal of hydro test water.

3 The dewatering shall be carried out by using propellant and a pig train driven and major amount of water shall be removed from the pipeline. All drain lines shall be adequately braced during dewatering.

4 The dewatering operation shall consist of a 4 cup batch pig run. The pig velocities during dewatering runs shall not exceed 1.5 Km/hr & 3.5 Km/hr respectively. • The line shall be considered dewatered when the amount of water flushed out by the last pig is less than 2 meters full pipe length.

5 If required, water of the tested section may be transferred by pigging to next section for hydro testing through temporary piping connection by adding additional corrosion inhibitors.

6 Thermocouples shall be removed & coating shall be repaired & holiday tested before backfilling. Same shall be under witness of Company.

Chapter 12

12.0 Test Certificates

Following completion of hydro test individual test sections, following test certificates shall be furnished for approval.

1 Water analysis and inhibitor mixing

2 Filling report indication fill point, fill rate and time of start and finish, temperature of water.

3 Temperature charts from all temperature recorders.

4 A log of pressure Vs Volume of water during initial and final pressuring phase of test.

5 Graph showing plot pressure Vs volume during initial and final pressuring phase of test

6 A log of pressure Vs time during leak test phase

7 Log of pressure Vs time during 24 hour proof test phase

8 Dewatering report indicating start and finish time, location of water disposal

9 Serial number of test manifold.

Chapter 13

13.0 Documentation

a. List of attachments – BSPL-2000-ML-FM-20

b. Test Plan – BSPL-2000-ML-FM-20J

c. Mechanical clearance report for hydrostatic test of mainline – BSPL-2000-ML-FM-20A

d. Air cleaning report - BSPL-2000-ML-FM-B

e. Pipeline Gauging report - BSPL-2000-ML-FM-20I

f. Pipeline Water filling report - BSPL-2000-ML-FM-20H

g. Thermal stabilization report - BSPL-2000-ML-FM-20D

h. Pipeline Pressurization report - BSPL-2000-ML-FM-20F

i. Air volume calculations report - BSPL-2000-ML-FM-20G

j. 24 hours hold period report - BSPL-2000-ML-FM-20E

k. Hydrostatic Test Calculations & Evaluation - BSPL-2000-ML-FM-20C

l. Pipe-Book (part-B) for hydro testing clearance

m. Dewatering – BSPL-2000-ML-FM- 20K

n. Inspection and test plan -BSPL-2000-L&T-PL-ITP 0020

Chapter 14

14.0TEST REPORT

A complete report signed by Contractor and the Company Representative shall be submitted upon completion of the hydrostatic testing operations for each test section.
The report shall contain as a minimum.

- Cleaning, flushing, filling and testing procedure used
- Schematic layout of cleaning, filling and testing facilities
- Instruments calibration certificates
- A profile of the pipeline that shows the test sites, all instrument and injection connections
- Pipe filling logs and records
- Hydrotest chemicals specification, dosage, injection records
- Pig specifications
- Pig inspection records including photographs of the damages
- Records of gauging pig survey and photographs
- Records of caliper pig survey and interpretation of results
- Pressurization and stabilization records
- Pressure and temperature recording charts with appropriate information inscribed thereon
- Dead weight tester logs and recordings
- Air volume calculations
- Pressure – temperature change calculations
- Environmental data
- Depressurization logs and records
- Records and photograph of all leaks/failure

Chapter 15

15.0 Precaution during the test

In addition to all that has been expressly described in the procedures for carrying out the test, the following requirements shall also be complied with

1 During the hydro test, no other activities shall be performed on or near the pipeline being tested.

2 Signs stating "PIPE UNDER TEST – KEEP OFF" shall be placed where the test head/scraper traps are located. Such areas shall be suitably guarded throughout the duration of the test. In case pressurizing is done from the shore end, the entire operational area shall suitably be fenced to prevent entry of unauthorized personnel.

3 All personnel working on the hydrotest spread shall be instructed on the possible dangers connected with the high pressure test operations. During the testing, operations, no unauthorized personnel shall be allowed near by the test head location. Test cabin at shore shall be atleast 10 m from the pipeline so that it is not affected by the pipeline failure.

Chapter 16

16.0 Hydro test Engineer Responsibilities:

- Manpower equipment and material planning for cleaning, gauging, Hydro testing, Dewatering, Swabbing, Drying and leak testing.
- Preparation of test pack, Planning and execution of preparatory activities
- Checking hydro test equipments and instruments
- Making arrangement for sourcing and transporting of test water and disposal.
- Preparation / review of Procedures for cleaning, gauging, Hydro testing, Dewatering, Swabbing, Drying and leak testing.
- Preparation of HEMP and Job hazard analysis in consultation with HSSE team.
- Preparation / review of Pre-commissioning and Commissioning Procedure
- Execution and supervision of pigging, testing and drying of pipeline.
- Coordination with QC and HSE team for quality inspection and HSSE measures
- Pre-commissioning and Commissioning activities of pipeline.
- Preparation of reports for Client submission
- Co-ordination between different pipeline activities

Suggestion

- To follow proper hydro testing procedure according to the company requirments.
- To maintain propre pressure as per the design.

Conclusion

The purpose of hydrostatic testing a pipeline is to either eliminate any defect that might threaten its ability to sustain its maximum operating pressure or to show that none exists. A key word here is pressure. Hydrostatic testing consists of raising the pressure level above the operating pressure to see whether or not any defects with failure pressures above the operating pressure exist. If defects fail and are eliminated or if no failure occurs because no such defect exists, a safe margin of pressure above the operating pressure is demonstrated. Defects adversely affect the pressure-carrying capacity because they take away stress-carrying material.

The purpose of this Hydrostatic Test Plan is to outline a general approach as to how testing will be conducted, recognizing that detailed arrangements only can be made after detailed engineering has been completed and the contractor has been consulted.

Bibliography

Pipeline Construction specification Volume 2 Part 1 Exhibit 8

Pipeline data sheet

OISD – 141

OISD – 226

ASME B 31.8

ASME B 31.4

API RP 1110

Reference has been made in this specification to the latest edition of the following codes, standards and specifications:

ANSI B 31.8: Gas Transmission and Distribution Piping Systems

ANSI B 31.4: Liquid Petroleum Transportation Piping System.

API RP 1110: Pressure Testing of Liquid Petroleum Pipelines.

ASME Sec VIII: Boilers and Pressure Vessels Code Div.1.

DNV 81: Rules for Submarine Pipelines.

IP Part: Institute of Petroleum.

Model Code of Safe Practice.