For this presentation let us focus in broad based 2 major segments:

I. Those pipelines that are designed to operate above 30% of Specified Minimum Yield Strength (SMYS) - High pressure cross country pipelines e.g., oil & Gas

II. Those that are designed operate at less than 30% of SMYS - Low pressure like Jetty to tank farm, tank farm to tank farm etc.
Inspection of High Pressure Pipelines

Inspection plan of high pressure pipelines are designed primary on the basis of regulatory requirement for example in USA the inspection requirement is regulated by Office of Pipeline Safety (OPS) guidelines, while in India it is through Oil Industry Safety Directorate (OISD) guidelines.

Inspection and Maintenance requirements are quite well defined in various standards like ASME B 31.4, ASME B 31.8 etc. These standards also act as design guidelines.

Based on these guidelines and standards individual operators in India might have developed their in-house Inspection manual.
Inspection of High Pressure (HP) Pipelines

A general Model of inspection of HP pipelines is indicated in the next slides.

Objective of a good Pipeline Inspection system is:

“To ensure Safe, Reliable and Environment friendly uninterrupted operations of the pipeline System”
### Stages of Inspection

#### Inspection during Construction
- ROW inspection
- Inspection of crossings
- Inspection of Valve station
- Inspection of CP station
- Inspection of Coatings

#### Inspection during Commissioning
- Water quality test
- Hydrostatic testing
- Caliper pigging
- Base line IPS survey

#### Inspection during Operation

**Internal Corrosion**
- Product quality check
- Pigging
- Corrosion inhibitor quality
- Corrosion inhibitor injection rate
- Corrosion probe / coupon data

**External Corrosion**
- Cathodic Protection station Parameters
- Quarterly PSP check
- Row Inspection
- Bi-annual thickness survey at Rly.X-ings

#### Special Inspection
- In-line – Inspection (IPS)
- Coating survey (CAT/DCVG/ Pearson)
## A Model Inspection Plan

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Activity</th>
<th>ANSI B31.8(NG) / ANSI B31.4(LPG)</th>
<th>OISD138</th>
<th>OISD 226(NG) / OISD 214 (LPG)</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pipeline Patrolling</td>
<td>NG: Annual (Class location 1&amp;2)</td>
<td>NG: As per ANSI B31.4 Cl. 851.2 (Cl.4.0).</td>
<td>NG: Fortnightly (class 3 &amp; 4 ) Monthly (Class 1 &amp; 2 ) Twice a year pre &amp; post monsoon by company official)(Cl 12.3.2)</td>
<td>For PNG General Inspection: Daily (By operating personnel). Once a month by Engineer in charge of PNG Mktg. company . LPG : Ground Patrolling of On-shore LPG Cross Country Pipelines shall be carried out once in a week Line Walk by the official of the company at least once in a year is required to be conducted after the monsoon.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Half yearly (Class location 3)</td>
<td>LPG: Weekly (urban areas) Monthly (other areas)</td>
<td></td>
<td>Daily through Patrolman, Guards, Annual patrolling in a distributed manner by officers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly (Class 4 location)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ROW Inspection</td>
<td>Annually (Cl 5.0)</td>
<td>Quarterly (Road &amp; Highway) Water course crossings Twice in a year (Pre &amp; after monsoon) (Cl. 12.3.1)</td>
<td></td>
<td>Once in 6 months by station in charge otherwise regular by officers of mainline group</td>
</tr>
</tbody>
</table>
## A Model Inspection Plan

<table>
<thead>
<tr>
<th>S.No</th>
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<th>OISD 226(NG) / OISD 214 (LPG)</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Rail/ Road Bridge &amp; suspended crossing</td>
<td>Greater frequency than pipelines in open country (Main Highways &amp; Rail road crossings) (Cl.851.2)</td>
<td>Quarterly (Cl.6.1)</td>
<td></td>
<td>Once in a year by Sr. officers</td>
</tr>
<tr>
<td>4</td>
<td>Road &amp; Highway crossing</td>
<td>Greater frequency than pipelines in open country (Main Highways &amp; Rail road crossings) (Cl.851.2)</td>
<td>Quarterly (Cl.6.2)</td>
<td>Quarterly (Road &amp; Highway) Water course crossings Twice in a year (Pre &amp; after monsoon) (Cl. 12.3.1)</td>
<td>Once in a year by sr. officer</td>
</tr>
<tr>
<td>5</td>
<td>Cleaning Pigging</td>
<td>Annually (Wet Gas) Once in two years (Dry gas) LPG pipeline (as per OISD 214) (Cl.7.1)</td>
<td>NG:Annual (for wet gas) Once in three years (for dry gas) (Cl.12.3.3) LPG:Once in year (Cl.15.4(i))</td>
<td>Quarterly / need based but max. interval of 3 months</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Intelligent pigging</td>
<td>Once in 10 years (Cl 7.2)</td>
<td>NG:Once in 10 years (Cl12.3.4) LPG:Once in 10 years (Cl15.4(ii))</td>
<td>Once in 10 years/ need based</td>
<td></td>
</tr>
<tr>
<td>S.No.</td>
<td>Activity</td>
<td>ANSI B31.8</td>
<td>OISD138</td>
<td>OISD 226</td>
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<td>----------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>PSP Measurements</td>
<td>Frequency based on various parameters (Cl. 862.217)</td>
<td>Fortnightly at feeding points (Cl.19.1.i)</td>
<td>Fortnightly at feeding points (Cl.19.1.i)</td>
<td>Weekly in CP station</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quarterly at other locations (Cl.19.1.ii)</td>
<td>Quarterly at other locations (Cl.12.3.5.a.i)</td>
<td>Quarterly at TLPS ON &amp; 1 on-off In 6 months max.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Annual On -off (Cl.12.3.5.a.ii)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>PEARSON/ CAT &amp; DCVG</td>
<td>Once in 5 years (Cl 9.2.1)</td>
<td>Once in 5 years (Cl12.3.6)</td>
<td></td>
<td>Need based but max in 5 yrs</td>
</tr>
<tr>
<td>9</td>
<td>CPL survey</td>
<td>Once in 5 years (Cl 9.2.2)</td>
<td>Once in 5 years (Cl12.3.6)</td>
<td></td>
<td>Need based but max in 5 yrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Insulating joint/ Coupling inspection</td>
<td>Annually (Cl. 9.2.3)</td>
<td>Once in 5 years (Cl12.3.6)</td>
<td></td>
<td>Once in a year and Along with PSP monitoring</td>
</tr>
</tbody>
</table>

A Model Inspection Plan
## A Model Inspection Plan

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</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>External Overground piping</td>
<td></td>
<td>Anually Cl. 9.2.4</td>
<td></td>
<td>Once in a quarter</td>
</tr>
<tr>
<td>12</td>
<td>Soil testing</td>
<td></td>
<td>Mentioned- Frequency not defined</td>
<td></td>
<td>Need based</td>
</tr>
<tr>
<td>13</td>
<td>Inspection of pipes, valves &amp; fittings</td>
<td></td>
<td>Anually Cl. 9.2.4</td>
<td>As per OISD 130</td>
<td>Regular</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Cl.12.3.8)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Internal corrosion monitoring</td>
<td>Mention of Inhibitor Injection system, Corrosion coupons, Corrosion probes exists but no frequency defined. (Cl. 863.3)</td>
<td>Annual (Corrosion Coupon) (Cl.10.i) Quarterly (ERP) (Cl.10.ii) Once in two years (UT) (Cl.10.iii)</td>
<td>No specific duration defined except for I.P.</td>
<td>Quarterly: Corrosion coupon Quarterly: ER probe Once in two years: U.T over ground piping</td>
</tr>
</tbody>
</table>
Finally you can end up with this
could have been worse
Pipeline Inspection and O&M of Pipelines

A Typical Pipeline Wash Out
Only one particular inspection plan may not be sufficient.

- Experience indicates that absence of synthesis of data collection through various inspections (by different departments at different times) has been a cause of many pipeline failures. Merging of data and analyzing the same together gives the best possibility of safe/failure free (and cost effective) operation of a pipeline.

- Realization of advantages of analyzing the entire data base together has given birth to Risk and Integrity Management.

- Every Pipeline Operator may have a Risk and Integrity Management Programme covering the elements of API 1160. Major elements of which are indicated in the subsequent slides.
Pipeline Inspection and O&M of Pipelines

Elements of a typical pipeline integrity management scheme - API 1160

- Identify potential impact to HCAs
- Initial data gathering, review and integration
- Initial risk assessment
- Develop baseline plan
- Perform inspection and/or mitigation
- Evaluate program
- Update, integrate, and review data
- Manage change
- Revise inspection and mitigation plan
- Reassess risk

*HCA = High Consequence Area*
A typical approach to Integrity Management of Pipeline (High Pressure) – Designing inspection schemes suitable for a particular area rather than applying same scheme for the entire pipeline.

In the following slides an approach to a model Pipeline Integrity Management (PIM) Plan is presented.
A) Time Dependent

- External Corrosion
- Internal corrosion
- Stress Corrosion Cracking
B) Stable

- **Manufacturing Related Defects**
  - Defective pipe seam
  - Defective pipe

- **Welding/Fabrication Related**
  - Defective pipe girth weld
  - Defective fabrication weld
  - Wrinkle bend or buckle
  - Stripped threats/broken pipe/coupling failure
Integrity Threat Classification

Equipment

- Gasket O-ring failure
- Control/Relief equipment malfunction
- Seal/pump packing failure
- Miscellaneous
Integrity Threat Classification

C) Time Independent

- Third Party/Mechanical Damage
- Incorrect Operations
- Weather related and outside force
  - Cold weather
  - Lightning
  - Heavy rains or floods
  - Earth movements
Pipeline Inspection and O&M of Pipelines

How to Proceed - A Typical Model

- **Internal Inspection or Pressure Test**
  - Start with the Highest Risk HCA (High Consequence Area)
  - Complete 50% of HCA’s Based on Risk
  - All HCA’s 100% Complete
  - Except for Class 3 or 4 Locations of Moderate Impact – 100% Complete
How to Proceed - A Typical Model

- Direct Assessment

- Start with the Highest Risk HCA
- Complete 50% of All HCA’s Based on Risk by
- All HCA’s Complete
- Except for Class 3 or 4 locations of Moderate Impact – 100%
Responding to Integrity Issues in HCA’s

- Discovery of a Condition in an HCA – say 180 Days to Determine Threat to Integrity Except for
- Immediate Remediation Conditions
  - Predicted Failure Pressure < 1.1 x Established MOP at Location
  - Any Dent with a Stress Raiser Regardless of Size or Orientation
  - An Anomaly that Requires Immediate Action
  - Must Reduce Operating Pressure to a Safe Level
  - Must Follow ASME B31.8S, Section 7 or equivalent code/practice
Pipeline Inspection and O&M of Pipelines

Responding to Integrity Issues in HCA’s

- **180 Day Remediation Conditions**
  - Plain Dents > 6% of OD Regardless of Orientation
  - Plain Dents > 2% of OD Affecting a Girth Weld or Seam Weld

- ** Longer Than 180 Day Remediation Conditions**
  - Only If Anomaly Cannot Grow to a Critical Stage
  - Only If Internal Inspection used –
    - An Anomaly with a Predicted Failure Pressure > 1.1 x Established MOP at Location
  - Any anomalous Condition Not Covered Above
Re-Assessments of HCA’s

- As Frequently as Needed – Operator Decides
- But No Longer Than 7 Years Unless A Confirmatory Direct Assessment is carried Out
  - Very Specific Rules Apply
  - Only Available with Performance Plan

- Internal Inspection or Pressure Test - Maximum Periods are
  - 10 Years - Equal to or Greater Than 50% SMYS
  - 15 Years Equal to or Less Than 50% SMYS

- Maximum Periods must be Justifiable
Pipeline Inspection and O&M of Pipelines

Re-Assessments of HCA’s

- Direct Assessment – Maximum Periods are
  - 5 Years for Remediation by Sampling
  - 10 Years for Remediation of All Anomalies
Pipeline Inspection and O&M of Pipelines

Data Gathering

- Identify Company Data Sources for Integrity Management Plan (IMP) Development
- Evaluate Records and Procedures for
  - Pipeline Design and Construction
  - Pipeline Operation
  - Pipeline Maintenance
  - Service History
  - Prior Integrity Assessments
- Evaluate systems already in place – database, risk assessment, etc.
- Document Results
HCA Identification Impact Assessment

- Apply Final Rule Definitions of HCA’s to System to:
  - Identify HCA Locations and Classify
  - Determine Potential Impact Zones
  - Justify Non-HCA Locations
  - Document Results
Pipeline Inspection and O&M of Pipelines

Focus of any Inspection and Maintenance plan of pipelines shall be

1. Improved safety of pipelines
   - Reduce Number of Incidents
   - Reduce likelihood of major incidents
   - Mitigate the consequence of incidents

2. Provide the basis for increased public confidence in pipeline safety
Pipeline Inspection and O&M of Pipelines

Inspection and maintenance of low pressure pipelines
What is a Low Pressure Pipeline?

Low pressure (LP) pipelines are those line which run between Jetty to tank farm, within tank farm or such lines that operates within a pressure limit of 5 to 15 kg/sq cm.

However, technically a low pressure pipeline is the one that operates at a pressure corresponding to maximum of 30% of SMYS, irrespective of nature of service.
Scope of this presentation is limited to commonly found low pressure (LP) pipelines that run between Jetty to tank farm, within tank farm or small diameter gathering lines.

Important aspect in Inspection and maintenance of LP pipelines:

- During design
- During construction
- During commissioning
- During Operation

Requirements are clearly specified in ANSI B 31.3 or API 570 and OISD guidelines
Pipeline Inspection and O&M of Pipelines

Typical nature of a low pressure pipeline

- Commonly found in most facilities
- Non-piggable
- Short lengths
- Complicated configurations
- Limited access
- In some cases operators not much aware of design parameters
There are many different considerations to be given when inspecting buried piping. Some include:

1. Piping location, size and length
2. Accessibility of buried portion
3. Any value of cathodic protection
4. Potential for corrosion
Typical nature of a low pressure pipeline

Reviewing past history can provide a wealth of information:

- Years of service
- Past corrosion problems
- Similar service
- Changes in service
- Piping specifications
Pipeline Inspection and O&M of Pipelines

Typical nature of a low pressure pipeline

- Inspection of low pressure buried piping typically involves more planning to perform similar inspection in above ground pipelines. Several conditions arise when performing inspections on buried piping - only the solutions get more difficult.

Some damage mechanisms

- Erosion/Corrosion
- Internal/External
- Coating dis-bondment
- Inherent mill defects
- Instability
- Third Party Damage
- Soil to Air Interface
- Environmental cracking
Some important points for LP pipelines for operators:

1. Selection of pipe grade.

2. Welding whether done requirements are in line with API standards and largely relaxed small contractor

3. Hydrostatic testing: Inspection during the test and record keeping is poor.

4. Crossings: Ensuring minimum distance is maintained both vertically and horizontally, in line with guidelines available in ASME B 31.3

5. Incorporating new development (e.g., new lines, tanks, buildings etc.) in the original drawing/lay out plan
Points to be considered while drawing inspection scheme:

1. Corrosion control –
   - Corrosion monitoring scheme to be drawn similar to HP lines
   - Inspections to be done routinely on a fixed time interval.
   - Inspection to be done by a team of experienced and qualified personnel
   - Documentation and expert review of inspection findings are essential

2. Corrosion mitigation measures shall be upgraded / strengthened on the basis of inspection finding only.

3. Each small or big failure shall be analyzed and documented.

4. In case of over ground lines visual inspection and thickness survey by qualified personnel shall form a part of corrosion monitoring scheme.

5. In buried lines provision of CP system shall be considered along with proper coating.
Operators of low pressure pipelines in marketing terminals, refinery tank farms and other areas may consider developing an inspection scheme similar to that of pressure lines.

In accordance with the prevailing regulations a period based inspection scheme like Monthly, bi-monthly, annually, 3 yearly or 5 yearly etc., shall be devised and put into action.

The monthly inspections may include the following:

- **Signs of Corrosion – Visual Inspection**
- Condition of coating – Through bell hole
- **Condition of insulation (if required)**
- Proper operation of alarm system
- **External leak detection monitoring using detection wells and ground water monitoring**
- Over ground piping not in contact with soil – visual inspection
- **Condition of all above ground valves, and flanges in the system.**
- Impressed current cathodic protection system – tested by a Corrosion Professional or Cathodic Protection Tester
Some useful codes and standards, that may assist in designing a good inspection and maintenance programme of low/high pressure pipelines

1. ASME B31.3 : Process Piping
2. OISD –149 : Inspection of cross country pipeline
3. API –570 : Inspection, repair, alteration, and re-rating of in-service piping system
4. ASME B31.4 : Pipeline transportation systems for liquid hydrocarbons and other liquids
5. API 1104 : Standard for Welding Pipeline and Facilities
6. ANSI B 31.8 : Gas Transmission and Distribution Piping System
7. OISD 141 : Design & Const. req. for liquid hydrocarbon pipelines other than LPG.
8. API 1160 : Managing System Integrity for Hazardous Liquid Pipelines
9. OISD 214 : LPG Pipelines
10. OISD 138 : Onshore Pipeline.
11. OISD 139 : Offshore Pipelines & SPMs
12. OISD 140 : Unloading / loading pipelines at Jetty.
13. OISD 188 : Corrosion monitoring for pipelines
MANAGING SYSTEM INTEGRITY FOR HAZARDOUS LIQUID PIPELINES

(API 1160)
INDEX

10. Mitigation options
11. Revision of the integrity management plan
12. Integrity management of pipeline pump stations and terminals
13. Program evaluation
14. Managing change in an integrity program
PURPOSE AND OBJECTIVES

- Error free, Spill free and Incident free operation of pipeline.
- Assessing risks and its mitigation.
- Baseline assessments and periodic reassessments for continuous upgradation.
FRAMEWORK FOR AN INTEGRITY MANAGEMENT PROGRAM (SECTION 5)

1. Identify potential impact to HCAs
2. Initial data gathering, review and integration
3. Initial risk assessment
4. Develop baseline plan
5. Perform inspection and/or mitigation
6. Evaluate program
7. Update, integrate, and review data
8. Reassess risk
9. Revise inspection and mitigation plan
10. Manage change
Identify potential pipeline impacts to HCAs (Section 6)

- Identification of HCAs.
- Using HCA information for data gathering, risk assessment and inspection.
- Determination of pipeline’s effect on HCAs.
- Documentation of HCA data & periodic up-gradation.
Data collection:

- Highest quality and consistency.
- No decision on suspect data.
- Resolution of input data.
- Never make assumptions.
Data gathering, review & integration (Section 7 & 12)

- **Data sources**
  - Design, material & construction records.
  - ROW records.
  - Operation & Maintenance records.
  - Incident and risk reports.
DATA GATHERING, REVIEW & INTEGRATION (SECTION 7&12)

- **Identification and location of data:**
  - Identifying data needs based on the risk encountered.
  - Preparation of a List of data required for integrity assurance.

- **Establishing common reference systems.**

- **Data integration:**
  - Data management systems for integration.
Developing a risk assessment approach:
- Identify and prioritize risks.
- Allocation of risk mitigation resources.
- Selection of data based on importance, completeness, quality and timeliness.

Pipeline risk:
- Likelihood
- Consequences
Assess threats that can reduce the system integrity.

Assess the environmental and external factors causing risk.

Risk assessment = prediction of risk with the help of quality and sound inputs.

Risk assessment – not a one time event.
Pipeline Integrity Management

RISK ASSESSMENT AND IMPLEMENTATION (SECTION 8)

Simplified Depiction of Risk

Consequences
- Low
- Medium
- High

Likelihood of occurrence
- Low
- Medium
- High

Lowest Risk Region
Medium Risk Region
Highest Risk Region

Pipeline Integrity Management
Identification of appropriate inspection technique.

Prioritizing and scheduling of work.

Initial risk assessment determines which factors are to be considered and the approach to be followed.

Internal inspection tools:

- Metal loss tool
- Crack detection tool
- Geometry tool
Hydrostatic testing technique:
Understanding pipeline anomalies and defects.
Determination of inspection interval/frequency.
Responding to anomalies identified.
PERFORM INSPECTION AND/OR MITIGATE OPTIONS (SECTION 10)

- Prevention of third party damage.
  - Improved line marking.
  - Optical or ground intrusion electronic detection.
  - Improved public education.
  - ROW maintenance.
  - Additional pipeline wall thickness.
PERFORM INSPECTION AND/OR MITIGATE OPTIONS (SECTION 10)

- **Controlling corrosion.**
  - Monitor & maintenance of CP.
  - Rehabilitation of Pipeline coatings.
- **Detecting unintended releases.**
  - Reducing volume lost from unintentional releases.
  - Improved emergency response.
  - Isolation and control of release sources (EFRD).
- **Operating pressure reduction.**
REVISION OF THE INTEGRITY MANAGEMENT PLAN (SECTION 11)

- Data should be analyzed and integrated with the previous collected data.
- Ongoing data integration and risk assessment = revision of plan
Required to check the effectiveness of the operator’s Integrity Management Program.

Performance measures:

- Reduction in unintended releases?
- Reduction in the number of unintended releases?
- Effectiveness of operator’s community outreach activities.
- Summary of the integrity program, qualitative & quantitative.
Internal/external audits.

To check the efficiency of the integrity program.

Performance measures methodology:

- Selected process measures.
- Deterioration measures.
- Failure measures.
- Internal/external comparisons.

Performance improvement.
MANAGING CHANGE
(SECTION 14)

- Changes to the pipeline by the operator.
- Changes affecting pipeline by the others.
- Recognize changes before or shortly after they occur.
- Ensure that those changes do not create risks.
- Update the affected portion of the pipeline integrity program.
Pipeline Inspection
and O&M of Pipelines

Thanks