Pipeline Anomaly Management

Amendment Details:

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Purpose</th>
<th>Prepared by</th>
<th>Reviewed by</th>
<th>Approved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>03.05.2016</td>
<td>First draft</td>
<td>UNB</td>
<td>RA</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>03.03.2017</td>
<td>Issued for implementation</td>
<td>CIMG</td>
<td>Panel of GMs</td>
<td>ED (O&amp;M) - CO</td>
</tr>
<tr>
<td>03</td>
<td>05.03.2019</td>
<td>Revision</td>
<td>CIMG</td>
<td>Panel of CGMs</td>
<td>ED (O&amp;M) - CO</td>
</tr>
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1.0 Preamble

1.1 Anomalies in pipeline are features that may potentially threaten the safety and integrity of the pipeline. These anomalies may arise from damage introduced at the time of manufacturing and construction, in-service damages due to corrosion or external interference. The effect of these anomalies on pipeline’s health is assessed through an integrity assessment program.

1.2 Anomaly management is a structured process of addressing an anomaly from identification, examination and evaluation to mitigation. This methodology also needs to guide actions in response when an anomaly is discovered.

2.0 Objective

2.1 The objective of this document is to provide systematic guidance to manage each anomaly on pipeline including response to detection, classification, verification, assessment, monitoring, mitigation and documentation.

3.0 Scope

3.1 This document shall apply to all pipeline networks of GAIL constructed with ferrous material used for transportation of natural gas or liquid hydrocarbon.

3.2 Definitions

Anomaly: an unexamined deviation from the norm in pipe material, coatings, or welds.
Actionable anomaly: anomalies that may exceed acceptable limits as set in GAIL’s O&M Guidelines and instant document.
Corrosion: deterioration of a material, usually a metal, that results from an electrochemical reaction with its environment.
Buckle: A buckle can be described as a wrinkle that has advanced well into the post-wrinkling stage of deformation. Buckles that form under high-pressure conditions are typically characterized by severe distorted outward bulges. However, under low-pressure conditions, buckles can take on an inward/outward “diamond” lobe pattern around the pipe circumference. With very severe buckles, a “folding over” of the outward bulge of the pipe wall may be observed.
Crack: very narrow, elongated defect caused by mechanical splitting into two parts.
Central Pipeline Integrity Management Software (CPIMS): A software package licensed from M/S Rosen in the brand name of ‘ROAIMS’ to assess the overall integrity of
pipeline. It has ETL Launcher, Asset Manager, Alignment Manager, CP Analyst, Corrosion Analyst, Feature Assessment, Stress Analyst, Geospatial Analyst, Alignment Analyst, Task Manager and Verification Manager for different purposes.

*Defect*: a physically examined anomaly with dimensions or characteristics that exceed acceptable limits.

*Dent*: permanent deformation of the circular cross-section of the pipe that produces a decrease in the diameter and is concave inward.

*Evaluation*: a review, following the characterization of an actionable anomaly, to determine whether the anomaly meets specified acceptance criteria.

*Examination*: direct physical inspection of a pipeline that may include the use of non-destructive examination (NDE) techniques or methods.

*Failure*: general term used to imply that a part in service has become completely inoperable; is still operable but is incapable of satisfactorily performing its intended function; or has deteriorated seriously, to the point that it has become unreliable or unsafe for continued use.

*Feature*: any physical object detected by an in-line inspection system. Features may be anomalies, components, nearby metallic objects, welds, or some other item.

*Fit for Service (FFS)*: assessment process to determine whether a pipeline is capable to bear MAOP.

*Gouge*: mechanically induced metal-loss, which causes localized elongated grooves or cavities in a metal pipeline.

*Imperfection*: an anomaly with characteristics that do not exceed acceptable limits.

*Inclusion*: non-metallic phase such as an oxide, sulphide, or silicate particle in a metallic pipeline component.

*Indication*: finding of a non-destructive testing technique or method that deviates from the normal limits. It may or may not be a defect.

*In-Line Inspection (ILI)*: ILI involves the evaluation of pipelines using “smart/intelligent pigs” that utilize non-destructive examination techniques to detect and size damages. ILI measures and records irregularities in pipelines including corrosion, cracks, deformations, or other defects.

*Integrity*: defined here as the capability of the pipeline to withstand all anticipated loads (including hoop stress due to operating pressure) plus the margin of safety established by this section.

*Integrity assessment*: process that includes inspection of pipeline facilities, evaluating the indications resulting from the inspections, examining the pipe using a variety of
techniques, evaluating the results of the examinations, characterizing the evaluation by defect type and severity, and determining the resulting integrity of the pipeline through analysis.

*Leak*: unintentional escape of gas from the pipeline. The source of the leak may be holes, cracks (include propagating and non-propagating, longitudinal, and circumferential), separation or pullout, and loose connections.

*Maximum allowable operating pressure (MAOP)*: maximum pressure at which a pipeline system may be operated in accordance with the provisions of the ASME 31.8 or 31.4 Code. In normal circumstances MAOP should be the pipeline design pressure ($P_d$).

*Mechanical damage*: type of metal damage in a pipe or pipe coating caused by the application of an external force. Mechanical damage can include denting, coating removal, metal removal, metal movement, cold working of the underlying metal, puncturing, and residual stresses.

*Metal loss*: types of anomalies in pipe in which metal has been removed from the pipe surface, usually due to corrosion or gouging.

*Mitigation*: limitation or reduction of the probability of occurrence or expected consequence for a particular event.

*Operating stress*: stress in a pipe or structural member under normal operating conditions.

*Predicted failure pressure* ($P_f$): an internal pressure that is used to prioritize a defect as immediate, scheduled, or monitored. The failure pressure is calculated utilizing B31G or similar method when the design factor, $F$, is set to unity.

*Ripple*: A localized waveform deformation pattern in the pipe wall, typically consisting of several low-amplitude, alternating inward/outward lobes, is referred to as a ripple. Ripples are permanent features that result from plastic deformation of the pipe wall.

*Root cause analysis*: family of processes implemented to determine the primary cause of an event. All these processes seek to examine a cause-and-effect relationship through the organization and analysis of data. Such processes are often used in failure analyses.

*Rupture*: complete failure of any portion of the pipeline that allows the product to escape to the environment.

*Safe Operating Pressure* ($P_s$): the pressure at which pipeline can be operated safely. It is equal to predicted failure pressure ($P_f$) divided by safety factor (SF). It is also termed as estimated repair pressure (ERP).
Shall: “shall” or “shall not” are used to indicate that a provision is mandatory. Should: “should,” “should not,” or “it is recommended” are used to indicate that a provision is not mandatory but recommended as good practice.

Stress corrosion cracking (SCC): form of environmental attack on the metal involving an interaction of a local corrosive environment and tensile stresses in the metal, resulting in formation and growth of cracks.

Stress level: level of hoop stress, usually expressed as a percentage of specified minimum yield strength.

Third-party damage: damage to a pipeline facility by an outside party other than those performing work for the operator. For the purposes of this guidance document, this also includes damage caused by the operator’s personnel or the operator’s contractors.

Wrinkle: A wrinkle is defined as a localized deformation of the pipe wall, usually characterized by a dominant outward bulge. A wrinkle is more severe than a ripple and is usually formed at one of the outward lobes of a previously rippled section of pipe. Wrinkles formed under low-pressure conditions can be characterized by significant inward distortions. For a pipe subject to bending, a wrinkle forms on the compression side of the pipe. For a pipe with only axial force, the wrinkle may be axi-symmetric.

### 3.3 Symbols

- \( D \) = Specified outside diameter of the pipe;
- \( R \) = Radius of Pipe
- \( d \) = Depth of the Anomaly
- \( SF \) = Safety Factor [to be taken as 1.39 (reciprocal of 0.72) for defect assessment of in-service pipelines]
- \( ERF \) = Estimated Repair Factor
- \( L \) = Longitudinal length of Anomaly ; \( w \) =Circumferential width of Anomaly
- \( M \) = Bulging stress magnification factor
- \( MAOP= \) Maximum Allowable Operating Pressure
- \( P_d \) = Design pressure
- \( P_f \) = Estimated failure pressure = \( S_f*2t/D \)
- \( P_s \) = Safe operating pressure =\( P_f/SF \)
- \( S_f \) = Estimated failure stress level
- \( S_u \) = Specified ultimate tensile strength at temperature, may equal SMTS
- \( S_y \) = Specified yield strength at temperature, may equal SMYS
- \( t \) = Nominal Pipe wall thickness
- \( z \) = \( L^2/D_t \)
3.4 **Flow chart for Anomaly Management**

- **Integrity Assessment**
- **Identification of Anomaly**
- **Maintenance, Patrolling**
- **Detected in ILI?**
  - No
  - Yes
    - **FFS done by Vendor?**
      - No
        - **Post ILI Assessment through CPIMS**
      - Yes
        - **Uploading of data to CPIMS**
  - Yes
    - **Screening**
      - Immediate
      - Scheduled
      - Monitored
  - **Site Examination of Anomaly**
- **Defect Assessment**
- **Updating of Category of Anomaly**
- **Time interval for Re-inspection**
- **Mitigation**

*Click the number at the top left corner of box to go to the section in this document.*
4.0 Identification of Anomaly

An anomaly in pipeline may be introduced by third party interference, corrosion, construction or manufacturing either individually or in combination.

These anomalies can be detected by following inspection activities:

1. Third party interference
   - In line inspection (ILI)
   - Pipeline patrolling
   - Information from people living in vicinity of pipeline (Third Person)
   - SCADA (OFC cut, leak detection system and pipeline intrusion detection system)

2. Corrosion
   - ILI
   - CP and Coating Inspection
   - Direct Assessment

3. Construction and manufacturing anomalies
   - ILI

5.0 Anomaly and Pipeline Data Analysis

Anomaly report shall be integrated and analysed along with pipeline data for further classification and characterization of anomalies.

5.1 Anomalies Reported during ILI

5.1.1 If the pipe tally received from the ILI vendor contains safe operating pressure and ERF for individual anomaly, the screening of actionable anomalies indicated in report shall be done as per Section 6 of this document.

Pipe tally and other data related to ILI shall be uploaded to CPIMS as per Appendix-B.

5.1.2 If the pipe tally received from the ILI vendor does not contains safe operating pressure and ERF for individual anomaly then a post ILI assessment shall be done through CPIMS as per Appendix-B to calculate safe operating pressure, ERF and remaining life of pipeline for each anomaly.

Note: ILI vendor shall be asked to submit the complete list of ungrouped features i.e. without clustering in pipe tally.
5.2 Anomalies detected during other Inspection

The anomalies detected in other inspection activities shall be evaluated and field examined as per Section 7 to find the extent of the anomaly.

6.0 Screening of Actionable Anomalies

All the actionable anomalies identified in ILI run shall be categorised as immediate, scheduled and monitored. The categorization of anomalies identified in other inspection activities shall be done after field verification (Section 7). These categories of anomalies shall be updated as per Section 9.1 after field verification and defect assessment (Section 8).

6.1 Immediate

a) Pipeline failure (Leak and Rupture)
b) Metal loss anomalies with depth greater than 70 % of wall thickness
c) Metal loss anomalies with ERF greater than or equal to 1.00
d) A dent with depth greater than 2% of nominal pipeline diameter on girth and seam welds
e) A plain dent with depth exceeding 6% of nominal pipeline diameter.
f) Dents with crack or SCC
g) Crack like anomalies that is confirmed as a crack when excavated
h) Any indication of adverse impact on the pipeline integrity in the immediate or near term.
i) In case of LPG pipelines, A dent located on top of the pipeline (above the 4 and 8 o’clock positions) with a depth greater than 2 % of pipeline diameter [greater than 0.250 in. in depth for a pipeline diameter less than nominal pipe size (NPS) 12].
j) In case of LPG pipelines, any dent that contains indications of stress risers (e.g. gouges, grooves, scratches), or corrosion. Alternately, an industry-recognized engineering evaluation may be used to determine a response schedule.

In case anomaly is of ‘Immediate category’ the operating pressure shall be immediately lowered to 80% of pressure at which pipeline was being operated or the affected section shall be isolated as the situation demands. It shall be followed by examination of anomaly for field verification. The detailed assessment of defect shall be carried out as per Section 8 within 5 days of defect verification to confirm whether pipeline is fit for its service or not. Temporary or permanent repair may be planned accordingly.
6.2 Scheduled
a) Metal loss anomalies with depth between 40% to 70% of wall thickness
b) Metal loss anomalies with ERF greater than or equal to 0.95 but less than 1.00

Detailed assessment of above anomalies shall be performed as per Section 8 to find out the remaining life of the pipeline containing time dependent defects and repair action shall be taken before its calculated remaining life or within two years from the date of discovery, whichever is earlier. The defect location shall be declared as “Vulnerable Location” and monitored accordingly until permanent repair action is taken.

6.3 Monitored
a) Metal Loss anomalies with depth up to 40% and having ERF less than 0.95
b) Geometric anomalies which are not covered in immediate and scheduled category

Detailed assessment of above anomalies shall be performed as per Section 8 to find out the remaining life of the pipeline containing time dependent defects and action shall be planned before its calculated remaining life for repair or re-inspection as per Section 9.2 or Section 9.3.

7.0 Site Examination of Actionable Anomaly
a) All anomalies of immediate category which are identified during ILI shall be examined for field verification.
b) At least 5 most severe anomalies of scheduled category which are identified during ILI shall also be examined for field verification.
c) If none of the anomalies identified during ILI is of immediate or scheduled category then at least 5 most severe anomalies shall be examined for field verification.
d) The anomalies identified in other inspection activities should be assessed and field verified to find the extent of the anomaly.

The main objective of examination of an anomaly is to verify whether the anomaly is a defect, imperfection or other feature; to confirm the type, location and dimensions of anomaly. CIMG guidance document “CIMG-GD-2015-0003: Field verification procedure for Feature Location, Conformation and Measurement in buried pipelines” shall be followed during field verification of anomalies.
If an anomaly is verified as defect then further action shall be planned as per following sections.

8.0 Defect Assessment

Level-1 assessment (as defined in ASME 31G) shall be performed on defects reported in ILI or verified during field verification having metal loss greater than or equal to 10% of wall thickness, plain dents having maximum depth greater than or equal to 2% of OD and any anomaly on seam or girth weld.

Main objective of defect assessment is to find the Safe operating pressure and Estimated Repair Factor of all defects and remaining life of time dependent defects.

8.1 Interacting Metal Loss Defects

The methods described herein are suitable for evaluating isolated areas of metal loss. Defects may occur such that multiple areas of metal loss are closely spaced longitudinally or transversely. If spaced sufficiently closely, the metal loss areas may interact so as to result in failure at a lower pressure than would be expected based on an analysis of the separate defect. The following steps shall be followed with reference to Fig. 8.1.1 based ASME 31G rule for interaction:

a) Flaws are considered interacting if they are spaced longitudinally or circumferentially from each other within a distance of 3 times the wall thickness (3t). Interacting flaws should be evaluated as a single flaw combined from all interacting flaws.

b) Flaws are considered non-interacting if spaced outside of the above dimensions. Non-interacting flaws should be evaluated as separate flaws.

Note: ILI vendors shall be asked to cluster the flaws based on this rule only.

8.2 Remaining Life Assessment

If defect is time dependent (such as metal loss due to corrosion) then it is essential to calculate the time when it grows to critical dimensions (i.e. time at which ERF would be
equal to 1 or depth of corrosion becomes equal to or greater than 70 % of nominal wall thickness). This time is termed as remaining life of pipeline containing that defect. To calculate remaining life it is essential to calculate the corrosion growth rate for the depth of corroded area.

### 8.2.1 Corrosion Growth Rate

Based on the availability of data, following methods shall be used to estimate the corrosion growth rate. If more than one analysis is performed, then most credible corrosion rate shall be adopted.

#### 8.2.1.1 ILI Run Comparison Analysis

The Run Comparison Analysis calculates statistically the depth growth of corrosion features by comparing two lists of anomalies, i.e., recent and previous.

To perform a run comparison analysis of the two ILI runs, the ILI data (using ETL template), has to be uploaded to CPIMS and aligned via Alignment Manager to each other and the recent ILI run has to be aligned to the centreline. Run comparison analysis is performed through Corrosion Analyst module of CPIMS.

*Note: In case future ILI is planned for a pipeline section for which data of previous ILI is available, ILI run comparison at signal and data (i.e. pipe tally / list of anomalies) level shall be included in the Scope of Work of future ILI to estimate the corrosion rate for different pipe segments.*

#### 8.2.1.2 Coupon Analysis

Corrosion coupons are used to detect the corrosion rate of specific metals, to determine how much metal weight is lost to corrosion in a particular amount of time. They provide an inexpensive mean of in-line monitoring and allow effective measurement of corrosiveness within a pipeline. By observing the mils-per-year corrosion rate of an exposed coupon, valuable information can be provided regarding the material's life expectancy.

Coupon Analysis can be performed through Corrosion Analyst module of CPIMS after uploading the coupon readings to CPIMS through ETL module.

#### 8.2.1.3 ER probe analysis

Electrical resistance (ER) probes are used to obtain the fluid corrosion rates from consecutive measurements of the resistance of a wire, strip, or tube wall as a function
of time. The cumulative metal loss is determined through the increasing electrical resistance of a metal sample as its cross-sectional area is reduced by corrosion since the last probe reading.

ER Probe Analysis can be performed through Corrosion Analyst module of CPIMS after uploading the ER probe readings to CPIMS through ETL module.

### 8.2.1.4 De Waard-Milliams Analysis

The de Waard-Milliams semi-empirical equation provides a prediction of corrosion growth rates in carbon steel pipelines operating in CO$_2$ containing environments.

This analysis can be performed by using corrosion analyst module of CPIMS by providing input parameters for CO$_2$ partial pressure, CO$_2$ fugacity or pH change and corrosion inhibition.

### 8.2.1.5 Linear Corrosion Growth Rate Analysis

**A.** A linear growth rate is calculated between the two inspections using equation

$$C_{rate} = \frac{d_{current} - d_{previous}}{(time)}$$

where

- $C_{rate}$ = Corrosion growth rate for depth (mm/year)
- $d_{current}$ = Absolute depth of deepest corrosion anomaly in latest inspection (mm)*;
- $d_{previous}$ = Absolute depth of matching corrosion anomaly in previous inspection (mm)*;
- $time$ = Time period between the inspections (years)

If data of previous inspection is not available then $d_{previous}$ shall be taken as 0(zero) and ‘time’ shall be taken as time interval between current inspection and commissioning of pipeline.

**B.** Corrosion growth rate shall be calculated from comparison of recent ILI with previous ILI. Corrosion features reported in recent ILI shall be cross referenced against the previous ILI in order to identify matches. During the process a box of 50mm x 50mm over the size of features identified in recent ILI shall be defined. If the window of the anomaly of the previous inspection is identified inside the window of the anomaly of the recent inspection, a match shall be assumed. Based on the box matching results, depth changes shall be estimated for each corrosion feature reported in recent ILI. A corresponding Corrosion Growth Rate (CGR) shall be estimated by assuming that growth has occurred linearly over the inspection interval. While selecting a single
corrosion rate for a pipeline section from corrosion rates calculated for individual pits, a 95% percentile upper bound approach shall be employed to exclude the outliers.

C. In case no inspection has been done before or data of the previous inspection is not available, Corrosion Growth Rate (CGR) shall be estimated by assuming that growth has occurred linearly over the number of years of operation of the pipeline. While selecting a single corrosion rate for a pipeline section from corrosion rates calculated for individual pits, a 95% percentile upper bound approach shall be employed to exclude the outliers.

8.2.2 Remaining life calculation
The remaining life of pipeline containing time dependent defects (such as metal loss due to corrosion) can be calculated through Feature Assessment module of CPIMS. The methodology used to calculate the remaining life is described below.

The depth of metal loss anomalies is grown till it reaches its critical dimensions i.e., depth / pressure based (in years from the date of latest inspection) using equation,

\[ d_{\text{future}} = d_{\text{current}} + (C_{\text{rate}} \times \Delta T) \]

where

- \( d_{\text{current}} \) = Absolute depth of a metal loss defect in latest inspection (mm)
- \( d_{\text{future}} \) = Estimated absolute depth (mm) of above defect in future
- \( \Delta T \) = Time interval from the date of current inspection (year)

This new depth shall be used to calculate the safe operating pressure and ERF as per Section 8.3.2 / Section 8.3.3. The above process shall be repeated by varying the time interval until the ERF becomes equal to or greater than 1. This new time interval shall be termed as remaining life of the defect.

8.3 Assessment of Metal Loss
Section 8.3.1 shall be used to assess metal loss defects based on its depths. Sections 8.3.2 and 8.3.3 shall be used to calculate safe operating pressure and ERF. The highest ERF calculated from sections 8.3.2 and 8.3.3 shall be used to categorise the metal loss defect.

8.3.1 Depth based Assessment
The depth limits of metal loss defects are defined as below:

- a. The metal loss defects which have depths greater than 70% of wall thickness are unacceptable and shall be categorised as “Immediate”.
b. The metal loss defects which have depths greater than 40% and less than 70% are acceptable and shall be categorised as “Scheduled”.

c. The metal loss defects which have depths below 40% of wall thickness are acceptable and shall be categorised as “Monitored”.

**8.3.2 Hoop Stress Assessment (Axial Extent)**

To assess metal loss defects (based on their classification) in axial extent, the following failure stress equations shall be used,

<table>
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<th>Type of Metal Loss</th>
<th>Equation for Failure Stress</th>
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<td>Corrosion (ASME 31G Original)</td>
<td>$S_f = \begin{cases} 1.1 \times S_y \times \left[ \frac{1 - (2/3)(d/t)}{1 - (2/3)(d/t)/M} \right] &amp; \text{for } z \leq 20 \ 1.1 \times S_y \times (1 - d/t) &amp; \text{for } z &gt; 20 \end{cases}$ Where, $M = (1 + 0.8z)^{1/2}$</td>
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| Milling (NG-18) | $S_f = (S_y + 10ksi) \times \left[ \frac{1 - d/t}{1 - (d/t)/M} \right]$ Where, $M$ 
| & $= \begin{cases} (1 + 0.6275z - 0.003375z^2)^{1/2} & \text{for } z \leq 50 \\ (0.032z + 3.3) & \text{for } z > 50 \end{cases}$ |
| Gouge (NG-18) | $S_f = \frac{S_y + S_u}{2} \times \left[ \frac{1 - (d + 0.5mm)/t}{1 - ((d + 0.5mm)/t)/M} \right]$ Where, $M = (1 + 0.52z)^{1/2}$ |

After evaluating failure stress ($S_f$), the failure pressure, safe operating pressure and ERF can be calculated as below,

$$P_f = \frac{2t \times S_f}{D}$$

$$P_s = \frac{P_f}{SF}$$

$$ERF = \frac{MAOP}{P_s}$$

**8.3.3 Axial Stress Assessment (Circumferential Extent)**
The circumferential extent of metal loss defects subjected to only internal pressure loading shall be assessed by “Kastner collapse method”.

The failure stress is calculated as,

\[ S_f = \frac{S_y + S_u}{2} \left[ \frac{(1 - d/t)\left\{ \pi - \frac{w d}{D t} \right\}}{\pi(1 - d/t) + 2\frac{d}{t} \sin \left(\frac{w}{D}\right)} \right] \]

After evaluating failure stress \( S_f \), the failure pressure, safe operating pressure and ERF can be calculated as below,

\[ P_f = \frac{4t \times S_f}{D} \]
\[ P_s = \frac{P_f}{SF} \]
\[ ERF = \frac{MAOP}{P_s} \]

### 8.4 Assessment of Dent

Dent in the pipe body or girth / seam welds shall be categorised as immediate or scheduled as per following sections 8.4.1. If any dents not covered in sections 8.4.1 shall be categorised as monitored.

### 8.4.1 Immediate category

a) A dent with depth greater than 2% of nominal pipeline diameter on girth and seam welds

b) Plain dents with depths greater than 6% of nominal diameter and associated strain levels greater than or equal to 6% (Strain associated with a dent can be calculated by using Appendix R of ASME 31.8 (2014) which is reproduced here as Appendix A)

c) Dent with cracks or SCC

d) In case of LPG pipelines, A dent located on top of the pipeline (above the 4 and 8 o’clock positions) with a depth greater than 2 % of pipeline diameter [greater than 0.250 in. in depth for a pipeline diameter less than nominal pipe size (NPS) 12].

e) In case of LPG pipelines, any dent that contains indications of stress risers (e.g. gouges, grooves, scratches), or corrosion. Alternately, an industry-recognized engineering evaluation may be used to determine a response schedule.
8.5 Assessment of Lamination

Laminations are planar defects that result from the steel manufacturing process. They are usually detected during an ultrasonic examination. Following dimension shall be recorded during examination to assess the lamination:

- The largest dimensions in the longitudinal and circumferential direction, L and W, respectively
- The lamination height, Lₜₜ
- Lamination Minimum Measured Wall Thickness, tₘₘ which is the smallest distance from either surface to the lamination

Apart from above, lamination shall be examined to determine if there are any cracks extending from the plane of the lamination in the through-thickness direction. If there is no indication of through-thickness cracking and distance between two laminations is less than or equal to two times the nominal wall thickness of pipe, then laminations shall be combined into single larger lamination in the assessment.

A Lamination is not acceptable if any of the following conditions are not satisfied:

a) There is no indication of through-thickness cracking
b) Lamination height \( Lₜₜ \leq 0.09 \times \text{max}[L, W] \)
c) Lamination minimum measured thickness \( tₘₘ \geq 0.1t \)
d) The distance between any edge of the lamination and the nearest weld is greater than 2t or 25mm, whichever is higher

e) The distance from any edge of the lamination to the nearest major structural discontinuity is greater than \( 0.6\sqrt{Dt} \)
f) If the lamination is in hydrogen charging service, then the planar dimensions (L and W) of lamination shall be less than \( 0.6\sqrt{Dt} \)

Alternatively, laminations can be assessed through Feature Assessment module of CPIMS by using BS7910 assessment method.

8.6 Assessment of Anomalies in Welds
All reported weld anomalies during ILI shall be assessed through spread sheet provided by M/s DNVGL and necessary action shall be taken as per the outcome of assessments. Signed report shall be prepared with reference to assessment of weld anomalies as per methodology suggested by M/s DNVGL.

If the assessment necessitates, field examination, same shall be done with either Radiography Testing, Magnetic Particle Testing, Liquid Penetrant Testing or Ultrasonic Testing or advanced NDT techniques (e.g. Phased array UT / TOFD) in combination as per requirement. The weld anomalies shall be categorised as immediate if these are unacceptable as per “Section 9: Acceptance Standards for Non-destructive Testing” of “API 1104 (2013): Welding of Pipelines and Related Facilities”.

The results of field examination should be compared with original radiographic film (construction records) of welds to confirm if the defects are pre-existing / time dependent.

8.7 Assessment of Wrinkle/Buckle
The allowable height of mild ripples (i.e. incipient wrinkle or Buckle) can be determined from Fig. 8.7.1, where h is the maximum depth or crest-to-trough height of the ripple and D is the specified outside diameter of the pipe.

8.8 Assessment of other Defects
Defects like plain dent, dent associated with metal loss, wrinkle/buckle and crack shall be categorised in immediate, scheduled or monitored based on the limits mentioned in Section 9.1 of this document.
Further detailed assessment of these anomalies may be conducted on the advice of SMEs.

9.0 Response to Defect Assessment

Once the detailed assessment of all the defects are carried out following actions shall be undertaken

9.1 Revision of category of a defect

The category of anomaly classified in Section 6 shall be revised based on the results of field verification, defect assessment and meeting following criteria. The dimensions and type of category shall also be updated in CPIMS.

<table>
<thead>
<tr>
<th>Anomaly Type</th>
<th>Immediate</th>
<th>Scheduled</th>
<th>Monitored</th>
</tr>
</thead>
</table>
| Metal Loss (Corrosion, Mill or Gouge) | • d/t ≥70% w.t  
• ERF≥1.0                                                      | • 40% ≤ d/t <70%  
• 0.95 ≤ ERF <1.0                                                      | • d/t < 40% and ERF<0.95                                           |
| Dent                  | • As per Section 8.4.1                          |                                  | • Not covered in immediate and scheduled category |
| Lamination            | • Not Acceptable as per Section 8.5             |                                  | • Not covered in immediate category          |
| Wrinkle / Buckles     | • Wrinkle / Buckles with ripple height greater than or equal to as specified in Section 8.7 |                                  | • Not covered in immediate category          |
| Weld Defects          | • Not Acceptable as per Section 8.6             |                                  | • Not covered in immediate category          |
| Other Anomalies       | • Crack                                         |                                  |                                              |
|                       | • SCC                                           |                                  |                                              |

9.2 Repair Scheduled for Unacceptable defects
The unacceptable defects shall be repaired as per the schedule given below

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Repair Schedule (from the discovery of defect)</th>
<th>Defect to be repaired</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 to 3 Months</td>
<td>All defects in immediate category</td>
</tr>
<tr>
<td>2</td>
<td>0 to 2 Years</td>
<td>All defects in Scheduled category and defects in Monitored category having remaining life less than 2.5 years</td>
</tr>
<tr>
<td>3</td>
<td>2 to 2.5 Years</td>
<td>Defects in Monitored category having remaining life between 2.5 to 5 years</td>
</tr>
<tr>
<td>4</td>
<td>4.5 to 5 Years</td>
<td>Defects in Monitored category having remaining life between 5 to 7.5 years</td>
</tr>
<tr>
<td>5</td>
<td>7 to 7.5 Years</td>
<td>Defects in Monitored category having remaining life between 7.5 to 10 years</td>
</tr>
</tbody>
</table>

9.3  Re-inspection Interval
9.3.1  Re-inspection of pipeline with regard to integrity assessment shall be carried out not later than earliest of the following:
   a)  Stipulated time interval for integrity assessment in PNGRB approved IMS document of the respective network
   b)  Stipulated time interval for integrity assessment in GAIL’s “Operation & Maintenance Guidelines for Pipelines and Compressor/Booster Stations”
   c)  Requirement of integrity assessment of pipeline as per latest Risk Assessment of the pipeline network

9.3.2  A special case may arise when large number of defects of monitored category is estimated to fail before the next scheduled integrity assessment (based on corrosion growth rate and interaction rule). In this case it may not be practical to repair all such defects. Following course of action may be adopted to deal with such scenario:
   a)  Verification of assumed/calculated corrosion growth rate by site examination of 3 most severe defects of monitored category and comparing its dimensions with estimated dimensions. Corrosion growth rate may be revised based on these site findings.
   b)  Recalculation of ERF may be done for such defects with respect to maximum operating pressure (MOP) instead of MAOP.
   c)  Integrity assessment of pipeline can be performed before its scheduled interval on the recommendation of pipeline headquarters.
10.0 Mitigation

Repair and prevention are two facets of mitigation. This section provides the generic guideline for use of permanent and temporary repair methods and identifies the appropriate repair methods for various types of defects in first three subsections. Prevention part is briefly covered in last subsection.

10.1 Permanent Repair Methods
Following repair methods (in the order of their preference) shall be employed to mitigate the non-acceptable defects:

10.1.1 Replacement of Defective Segment
The section containing non-acceptable defects shall be cut out as cylinder and replaced after shutdown, depressurization and isolation of the fluid from defective area. The length of the section removed/replaced should be a minimum of 1.5 D or 300mm whichever is longer. The replacement pipe section shall have strength at least that of the pipe it replaces and comply with original pipe specification.

The removed pipe segment shall / may be subjected to analysis as prescribed in guidance document of pipe sample test (Guidance document CIMG-GD-4-2015-0002).

10.1.2 Grinding
Grinding is the removal of material by hand filing or power disc grinding. External mechanical damage, cracks and gouge may be repaired by grinding out the damage, provided any associated indentation of the pipe does not exceed a depth of 4% of the nominal pipe diameter. Grinding is permitted to a depth of 10% of the nominal pipe wall thickness with no limit on length. Grinding is permitted up to a maximum of 20% of the pipe wall thickness, provided that the length of the ground area is no more than that allowed by ASME B31G (pressure-based assessment). The areas of grinding shall always be verified for the presence of cracks by NDT crack detection techniques (e.g. MPI / UT shear wave etc.). If cracks are observed, the same shall be removed by grinding subject to the maximum wall thickness allowed for grinding as above and the surface shall be re-inspected to ensure the cracks have been completely removed.
If the defective material cannot be removed entirely by grinding within the acceptable limits stated above, the attempt to repair by grinding shall be abandoned and another more suitable repair method shall be used instead.

10.1.3 Type B Split Sleeve

If it is not feasible to take the pipeline out of service and if number of unacceptable defects in a pipe allows, repairs shall be made by the installation of a pressure containing full encirclement welded Type-B split sleeve. However for dents & external damage, pipeline surface shall be ground-out and the missing wall shall be filled with in-compressible filler.

Since the full-encircling pressure-containing sleeve may contain pressure, it shall be designed, fabricated and installed in accordance with the same requirements as specified for the pipeline. A UT check on pipe shall be performed on a 100 mm wide circumferential band centred to location where sleeve is to be welded to pipe circumferentially, to ensure that the minimum wall thickness required for in-service welding is complied. The minimum required nominal wall thickness and steel grade of the sleeve shall be based on the wall thickness design factor and equation as required for the pipeline.

The sleeve should extend to a minimum of 100 mm beyond the defect and should not be less than 300 mm in length.

10.1.4 Composite Repair Sleeve

Composite sleeve which is applied with an adhesive with proven reliable engineering/qualification tests & proven case studies may also be installed. However for dents & external damage, the pipeline surface shall be ground-out and the missing wall thickness shall be filled with in-compressible filler. NDT shall be carried out to check for cracks/other defects before application of composite sleeve. If required the pipeline pressure may be reduced/ depressurized while executing the job.

10.1.5 Hot Tapping

This method is used to remove a section of pipe containing a defect from a pipeline in service. A hot-tap fitting is installed around the pipe and the defect is removed in the same way as removing a segment from the pipe wall for branch connections using the hot-tap. The size of the branch to be installed should be based on the need to contain
the entire defect within the area of pipe wall that is to be removed by hot tapping. In other words, the section of material to be removed by the hole-cutting saw should contain the entire defect

10.2 Temporary Repair
If permanent field repair of unacceptable defect requires more time than its repair schedule then following temporary measures shall be employed immediately to protect the property and public:

a) System pressure shall be reduced to safe operating pressure calculated in Section 8 or 80% of current operating pressures whichever is less till the completion of temporary measure.

b) Pressure containing bolt-on clamps may be installed in case of leaking or non-leaking metal loss. Bolt-on clamps are designed to contain full pressure. They are generally bulky and heavy to ensure an adequate clamping force. A UT check of adjacent pipeline material shall be performed to ensure that the pipeline can withstand the clamping force and any future seal welding. Circumferential and axial welding of the clamp shall be completed at earliest available opportunity or within three months whichever is earlier (Refer ASME 31.8) to convert it to permanent repair. In this case no further action is required for permanent measure.

10.3 Selection of Permanent Repair Methods
Replacement by cutting out a cylinder of defective pipeline section is the best available option to repair any defects permanently. Alternate Repair methods for various types of defects can be selected from the table given below.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Type of Defect</th>
<th>Grinding</th>
<th>Type-B Sleeve</th>
<th>Composite Sleeve</th>
<th>Bolt-on Clamp</th>
<th>Hot Tap (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Leak (from any Cause)</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>External Corrosion</td>
<td>No</td>
<td>Yes</td>
<td>Yes (d)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Internal Defect or Corrosion</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Gouge or other metal Loss on Pipe body</td>
<td>Yes (a)</td>
<td>Yes (c)</td>
<td>Yes (b) (d)</td>
<td>Yes (c)</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Arc Burn, Inclusion or Lamination</td>
<td>Yes (a)</td>
<td>Yes</td>
<td>Yes (b)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Smooth Dent</td>
<td>No</td>
<td>Yes</td>
<td>Yes (e)</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Rev. No. Report No. Issue Date
03 CIMG-GD-5-2016-0001 05.03.2019
<table>
<thead>
<tr>
<th>S.N.</th>
<th>Type of Defect</th>
<th>Grinding</th>
<th>Type-B Sleeve</th>
<th>Composite Sleeve</th>
<th>Bolt on Clamp</th>
<th>Hot Tap (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Dent with Stress Concentrators on seam weld or Pipe Body</td>
<td>No</td>
<td>Yes (d)</td>
<td>Yes (b)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Dent with Stress Concentrators on Girth weld</td>
<td>No</td>
<td>Yes (d)</td>
<td>No</td>
<td>Yes (g)</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>Shallow Crack</td>
<td>Yes (a)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Deep Crack</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>Defect in or near an ERW Seam</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>Girth Weld Defect</td>
<td>No</td>
<td>Yes (f)</td>
<td>Yes (i)</td>
<td>Yes (g)</td>
<td>No</td>
</tr>
<tr>
<td>13</td>
<td>Wrinkle, Buckle</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>14</td>
<td>Blisters, HIC</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Notes:

a) Grinding alone up to 0.2t depth may be used, provided that defect and defective metal are removed and that local wall loss is acceptable as per ASME 31G.

b) Repair may be used for defects less than 0.7t deep, provided that damaged material has been removed by grinding and removal has been verified by inspection.

c) It is recommended that the damaged material be removed and removal shall be verified by inspection.

d) Use of incompressible filler material in dent and external damage is recommended.

e) Code and regulatory restrictions on maximum dent size should be followed.

f) Sleeve should be designed and fabricated to special "humped" configuration to accommodate girth weld.

g) The split-sleeve clamp should be the type that transfers axial loads and provides full structural integrity.

h) Hot tapping can be applied only to defects that are small enough to be removed by the hot tap.

i) By using Clockspring® Composite Sleeves

j) If one pipe length have more than 2 defects of Immediate or Scheduled category at an interval of less than 1.5 m or cluster of defects with metal loss more than 20% and at least one of them is of immediate or scheduled category, then the repair shall be done by replacement of full pipe length.
k) Whenever a pipeline remains pressurized while being exposed to investigate or repair a likely defect, the operating pressure shall be at a level that provides safety during excavation, investigation and/or repair operations.

l) For permanent repair of defects not covered here, advice of SMEs, CIMG and RIMG may be sought.

10.4 Root Cause Analysis and Prevention
If defect in pipeline is due to internal corrosion, external corrosion or cracks, Root Cause analysis shall be conducted to arrive at the root cause which is responsible for introduction of defect in pipeline. Based on the results of Root Cause analysis prevention activities may be planned. Prevention can stop or slow down future deterioration of the pipeline.

11.0 Review and Data Integration
Data collected during inspection and mitigation activities shall be analysed and integrated with previously collected data. This is in addition to the other type of integrity management-related data that is constantly being gathered through normal operation and maintenance activities. The addition of new data is continuous process that, over time, will improve the accuracy of future integrity and risk assessment via its integration.

11.1 Updating of data in CPIMS
All the data collected during inspection and mitigation activities shall be updated in CPIMS.

11.2 Anomaly Register
All the sites and RIMG’s shall prepare an anomaly register preferably on online portal/Excel sheet including immediate, schedule and monitored category of anomalies which are expected to be unacceptable before next scheduled integrity assessment for pipeline assets under their jurisdiction. This register shall be reviewed on quarterly basis by WIC/OIC of that site/Region.

Format for the anomaly register is as below
12.0 Special cases for Anomaly Management

From time to time, there may be specific cases which may not be adequately addressed in the manner spelt out in this document. Recommended Methodology in such cases is detailed below:

12.1 Case 1
If the numbers of unacceptable defects (of immediate and scheduled category) are so huge that repairing of all such defects is either practically or economically not feasible, then following course of action shall be taken:

12.1.1 Scenario 1
If it is feasible to operate the pipeline at minimum evaluated safe operating pressure till the replacement of entire pipeline, then MAOP of pipeline shall be reduced to minimum evaluated safe operating pressure and shall be operated till the completion of replacement job. However, the duration of such operation should be restricted to such period for which the safe operating pressure has been calculated.

12.1.2 Scenario 2
If it is not feasible to operate the pipeline at minimum evaluated safe operating pressure and requires maximum operating pressure (MOP) higher than minimum evaluated safe operating pressure but less than previously established MAOP for a certain time interval, then following actions shall be taken:

a) MAOP shall be reduced and fixed on the basis of pipeline operability.

b) The time limit for operation of pipeline at reduced MAOP shall be fixed on the basis of time required for the replacement of pipeline. This time interval should be ideally 6 (six) months but shall not be greater than 1 (one) year.
c) All the anomalies shall be re-assessed through CPIMS incorporating corrosion growth rate for the above mentioned time interval to calculate the safe operating pressure against each anomaly.

d) All the anomalies having safe operating pressure less than 1.1 times the reduced MAOP shall be repaired.

e) Inline inspection using the same technology or advanced technologies might also be considered or Hydro test of the pipeline shall be carried out at 1.25 times the reduced MAOP to validate the integrity of the pipeline. Pipeline shall be dried and put in operation till the completion of replacement phase with enhanced integrity measures such as injection of corrosion inhibitors/increased cleaning pigging frequency/CP monitoring/patrolling etc.

12.2 Case 2

If a defect of immediate or scheduled category is detected in pipeline which does not have any previous record of integrity assessment then following course of action shall be taken:

12.2.1 Scenario 1

If the pipeline is in operation and Piggable, then following actions shall be taken:

a) Calculate the safe operating pressure for that particular defect.

b) If the safe operating pressure calculated above is less than MAOP of pipeline then MAOP pipeline shall be reduced to 0.9 times the calculated safe operating pressure.

c) Carry out the integrity assessment of pipeline through ILI within 6 (six) months but not later than 1 (one) year from the discovery of defect. After ILI, mitigation measures shall be taken in accordance with this document.

12.2.2 Scenario 2

If the pipeline is not in operation or not piggable, then following actions shall be taken:

a) Establish the corrosion rate through De Ward & Milliams / ER probe / Corrosion coupon analysis / evaluation of identified defect.

b) Estimate the Safe operating pressure of defect after growing the defect with above corrosion rate for 1 (one) year till it reaches it critical dimensions.

c) ILI of the pipeline shall be completed within 1 (one) year by using process fluid or alternate fluid, if pipeline is piggable but not in operation. The line pressure during this ILI shall not exceed the safe operating pressure calculated above.
d) If the pipeline is not piggable irrespective of whether it is in operation or not, effort shall be made to convert it to Piggable line and Integrity Assessment shall be done by ILI. If conversion to piggable section is not possible then Integrity should be assessed through Hydro-test/Direct assessment.

e) Pipeline shall be put in operation with enhanced integrity measures such as injection of corrosion inhibitors/increased cleaning pigging frequency/CP monitoring/patrolling etc.

12.3 Case 3
If a defect of immediate or scheduled category detected in ILI is not accessible for verification and mitigation, the following course of action shall be taken:

12.3.1 Corrosion or other metal loss defect on the body of pipe:

a) Level-1 assessment (as defined in ASME B 31G) shall be done for the anomaly.

b) If the calculated safe operating pressure as per Level-1 assessment of the subject anomaly is less than MAOP then pipeline shall be de-rated to calculated safe operating pressure.

c) ILI vendor shall be asked to submit the remaining wall thickness grid of the pipe containing the particular anomaly.

d) Level-2 assessment (effective area method) (as defined in ASME B 31G) shall be performed to evaluate the safe operating pressure.

e) If new calculated safe operating pressure is still less than MAOP then pipeline shall be de-rated to this new calculated safe operating pressure.

f) If safe operating pressure calculated through Level-2 assessments is greater than MAOP then operating pressure of pipeline shall be normalised.

If the de-rating of pipeline is not possible or Level-2 assessment is not feasible due to non-availability of detailed measurement, the matter shall be referred to SME / external experts for the given nature of defect and action shall be undertaken as recommended by them.
References

3. *Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids*; ASME Code for Pressure Piping B31, ASME B31.4-2009
7. *Specifications and requirements for intelligent pig inspection of pipelines*; POF Guidelines 2009
10. *Operation & Maintenance Guidelines for Pipelines and Compressor/Booster Stations*; GAIL (India) Limited
11. *CPIMS user manuals for ETL, Alignment Manager, Corrosion Analyst, Feature Assessment and Task Manager etc.*; CPIMS 15.2 user Manual, November 2015
Appendix A

Estimating Strain in Dents

Estimating Strain

$R_0$ is the initial pipe surface radius, equal to $1/2$ the nominal pipe O.D. Determine the indented O.D. surface radius of curvature, $R_1$, in a transverse plane through the dent. The dent may only partially flatten the pipe such that the curvature of the pipe surface in the transverse plane is in the same direction as the original surface curvature, in which case $R_1$ is a positive quantity. If the dent is re-entrant, meaning the curvature of the pipe surface in the transverse plane is actually reversed, $R_1$ is a negative quantity. Determine the radius of curvature, $R_2$, in a longitudinal plane through the dent. The term $R_2$ as used herein will generally always be a negative quantity. Other dimensional terms are the wall thickness, $t$; the dent depth, $d$; and the dent length, $L$.

Bending strain in the circumferential direction $= \epsilon_1 = \frac{1}{2} t \left( \frac{1}{R_0} - \frac{1}{R_1} \right)$

Bending strain in the longitudinal direction $= \epsilon_2 = \frac{1}{2} t \left( \frac{1}{R_2} \right)$

Extensional strain in the longitudinal direction $= \epsilon_3 = \frac{1}{2} \left( \frac{d}{L} \right)^2$

Total Strain on inside pipe surface $= \epsilon_i = \left[ \epsilon_1^2 - \epsilon_1 (\epsilon_2 + \epsilon_3) + (\epsilon_2 + \epsilon_3)^2 \right]^{1/2}$

Total Strain on outside pipe surface $= \epsilon_o = \left[ \epsilon_1^2 + \epsilon_1 (-\epsilon_2 + \epsilon_3) + (-\epsilon_2 + \epsilon_3)^2 \right]^{1/2}$
Appendix B

Post ILI Assessment through CPIIMS

Data related to centreline (distance, latitude and longitude), valve, tap, tee, coating, pipeline section, ILI, ER probe and corrosion coupon etc. of a pipeline section which is to be analysed shall be prepared in an standard excel template available at O&M data store before proceeding to coming sections.

i. Create a new Line and Section
   1. Open Asset Manager of CPIMS (ROAIMS), in the ‘Navigation’ view, select PIMS note.
   2. In the Assets Tab, click on button ‘New’ in the Line group to create a new Line.
   3. In the Assets Tab, click on button ‘New’ in the Section group to create a new Section.
   4. Enter all properties for Line and Section.

ii. Upload Centreline/ Asset /Physical Inspection data
   1. Select the Section in the ‘Navigation’ view of Asset manager and start ETL Module.
   2. Upload the following data in this order:
      - Centreline definition from shape files to PODS
      - Launcher /Receiver, Tap, Tee, Valves and other AGMs
      - Coating details
      - Segmentation of Section based on thickness (optional)
      - Coupon reading to PODS (optional for Corrosion Analysis)
      - ER probe and ER probe readings to PODS (optional for Corrosion Analysis)
   3. Select the first Template from above step and click on the ‘New’ button.
   4. Select the excel file which contains the data.
   5. Remove all the worksheets which are not required (only one should remain in the list) and click on the ‘Next’ button.
   6. Use the ‘Default’ mapping scheme and click on the ‘Next’ button.
   7. A warning may appear about the ‘Inconsistent data format’ click on ‘OK’ button to do the necessary correction automatically.
   8. Click on ‘…..’ button to create a new group for the data which is to be uploaded.
   9. Click on the ‘Add’ button, type a name for the new group and click on the ‘OK button.
   10. Click on the ‘OK’ button and then on the ‘Finish’ button.
   11. Security check-up information will appear if you are sure to upload the data. Click on the ‘Yes’ button and the upload start.
12. The message ‘execution of the ETL job was successful’ will appear in the process status information window and ‘Close’ button become active.

13. After clicking on the close button, a new row in the ETL module for the selected template will appear.

14. Continue with the other data mentioned in step ‘2’. Follow the same procedure to upload the data.

iii. **Upload third Party ILI data**
1. Select the Section in the ‘Navigation’ view of the Asset Manager and start ETL module.
2. Select the ‘ILI data to ROPIMS’ template and click on the ‘New’ button.
3. Click on the ‘….’ Button and add the excel sheet with 3rd party ILI data.
4. Enter the ‘First data row’ in the excel sheet containing the ILI data.
5. Select the name of vendor which has performed the ILI in ‘Type mapping’
6. Select ‘Vendor’ in ‘Column mapping’.
7. Write the name of Inspection Company in ‘Inspection Company’.
8. Select the date of ILI run in ‘Inspection date’.
9. After clicking on the ‘Continue’ button the information ‘Please set the following default values’ appear. Enter the default values which are required for uploading of 3rd party ILI data.
10. The information ‘Data is in correct format, start upload now?’ will appear. Click on the ‘OK’ button to start the upload.
11. In the ‘Process status information’ window message ‘Execution of the ETL job was successful’ will appear and the ‘Close’ button becomes active.
12. Repeat the above processes to upload the multiple ILI run datasets.

iv. **Align ILI data to Centreline and ILI data to ILI data**
1. Select the Section in ‘Navigation’ view of the Asset Manager and launch the Data Alignment Manager
2. Click on ‘New’ button in the ‘Project list’.
3. Select the Section as ‘Master’, the latest ILI dataset as ‘Slave’ and click on ‘Accept’.
4. In the ‘Table alignment’ set the filter for ‘Type Name’ as Launcher Receiver in the left table (data from section).
5. Set the filter for ‘Type Name’ as Launcher Receiver in the right table (data from recent ILI).
6. Select the first matching entry with respect to distance in both the table and click on the new button to create a new linkage between the selected rows.
7. A connection line between two tables will appear.
8. Click on ‘Find automatic linkage’ to create automatic linkages between matching entries.
9. Click on ‘Accept automatic linkages’
10. Repeat step 4 to 9 for ‘Type name’ as valve, tap, tee and AGM etc.
11. Select the ‘Home’ tab and click on ‘Publish Alignment’ button.
12. Click on ‘Save project as …’ button and give your project a name.
13. Repeat ‘Steps 2 to 12’ for alignment of two ILI datasets, treating recent ILI data set as ‘Master’ and previous ILI data set as ‘Slave’
14. Close the data alignment manager.

v. Create ILI run comparison and publish Segmentation
1. Select the Section in navigation view and Launch the Corrosion Analyst module
2. In the ‘Analysis’ tab, click on ‘New’ button in ‘Analysis’ group.
3. Type the name for analysis, select the method ‘ILI run comparison’ and click on ‘Next’ button.
4. Select the Recent Inspection, Select the Previous Inspection, Specify the wall thickness parameter and click on the ‘Next’ button.
5. Specify the correlation strategy ‘Fixed Search Window’ and set the length/width as 5cm for search window and click on ‘Next’ button.
6. Click on ‘Finish’ button.
7. Segmentation for external corrosion growth and internal corrosion growth rate will appear in navigation pan and chart view.
8. Click on ‘Global’ button in the segmentation group in Analysis Tab. A warning for saving the segmentations before using global segmentation will appear. Click on ‘OK’ button.
9. Select the ‘Internal corrosion growth’ segmentation in left list and click on the ‘Publish’ button. Repeat the same for External corrosion growth segmentation.

vi. Calculate Safe Remaining Life
1. Select the Section in navigation view and Launch the Feature Assessment module.
2. Click on ‘New’ button in the Analysis Tab in the analysis group.
3. Give name to the new analysis, select the ILI dataset (connection) at which analysis is to done and click on ‘OK’ button.
4. Import the Global segmentations created in Corrosion Analyst.
5. If global segmentation is not created in CA then click on ‘New’ button in Segmentation group of Analysis tab. Select ‘External corrosion growth’ from drop-down and click on
‘OK’. Specify the corrosion growth rate for depth/length/width and click on ‘OK’. Do the same for creation of ‘Internal corrosion growth’ segmentation
6. Click on ‘Configure’ button. Setup the corrosion growth for a time of 5 years for liquid hydrocarbon pipeline and 10 years for gas pipeline for depth/length/width. Select the time to fail option with ASME 31G code and set the new list parameters for feature.
7. Safe remaining life and grown depth/length/width of corrosion defect will appear in the list view of features.

vii. **Calculate ERF and Safe operating pressure**
1. Select the Section in navigation view and Launch the Feature Assessment module.
2. Set the already created analysis as current analysis via right click on the analysis in the navigation view.
3. Click on the ‘Add’ button in the Assessment group of Analysis tab.
4. Select the method ‘ASME 31G, and click on the ‘OK’ button.
5. ERF and safe operating pressure for corrosion features will appear in list view of features.
6. Verification sates like ‘to be verified’ and repair state like ‘to be repaired’ can be set for a feature by clicking on feature and updating these states in feature’s properties box.
7. Publish assessment results to the database via clicking on ‘Publish’ button in the Assessment group of Analysis tab.
8. Close Feature Assessment module to save created Analysis.

viii. **Verify Features and enter field verification data**
1. Select the Section in navigation view and Launch the Verification Manager module.
2. Select the ILI Inspection in the navigation view and create a new verification via clicking the ‘New’ button in the Verification tab in verification group. Give a name to verification and click on ‘OK’.
3. Create new Dig via clicking on the ‘New’ button in the Verification Tab in Dig group. Give name to the Dig and click on ‘OK’ button.
4. Select the joint via clicking on the ‘New’ button in Verification Tab in Joint group. Select a Joint in the list and click on the ‘OK; button.
5. Add the field verification feature to a Joint by clicking on the ‘New’ button in Verification tab in the Field Verified Feature group. Select the feature from the list and click on the ‘OK’ button.
6. Enter the data from field verification for log distance, classification and click on the ‘OK’ button.
7. Enter the data from field verification in the Properties view.
8. Publish entered verification results via clicking the ‘Share’ button in the Verification Tab in the Field Verified Feature group.
9. Click on the ‘Save’ button in the Verification tab in the Data group and close the verification Manager.
10. The verification state in the Feature Assessment module should be changed to ‘verified.’