



ASSET INTEGRITY OF PIGGABLE HYDROCARBON PIPELINES AND THEIR REMAINING LIFE ESTIMATION

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❖ Introduction

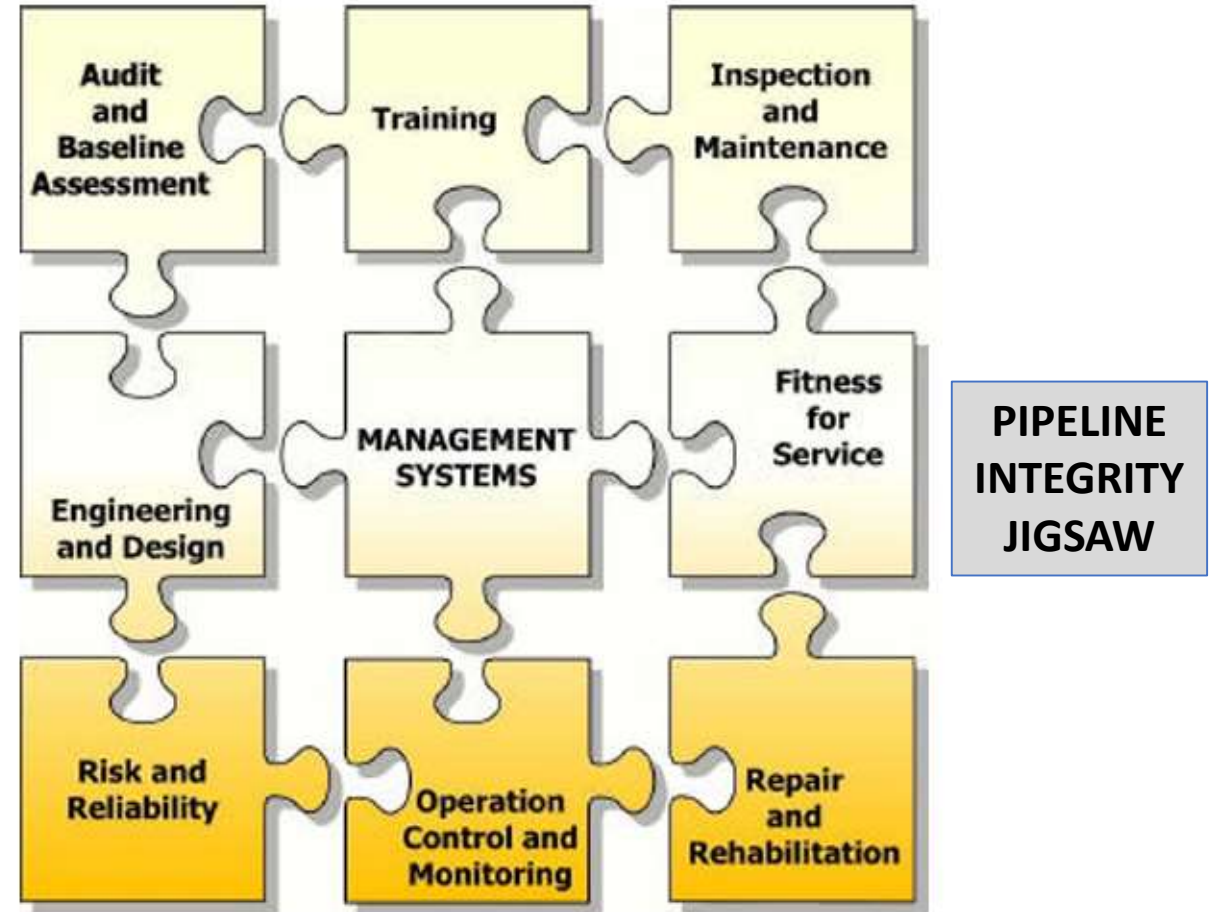


- Oil & Gas Pipelines – most efficient, cost-effective & reliable mode of transporting hydrocarbons over long distances (from ports – refineries – consumers).
- Pipelines are safest means of transport, still risks associated due to oil & gas leaks.
- Leaks / failures leads to severe negative environmental, social & economic impacts for pipeline operators and their surroundings communities.
- Risk of failure / leak is more likely in aged / old pipelines due to natural ageing processes of materials such as erosion, corrosion, creep, fatigue, wear, shock loading and associated microstructural damages.
- 33% of the pipelines in operation are more than 25 years old in our country.
- Therefore, it is utmost important to assess the integrity and remaining life of these pipelines.

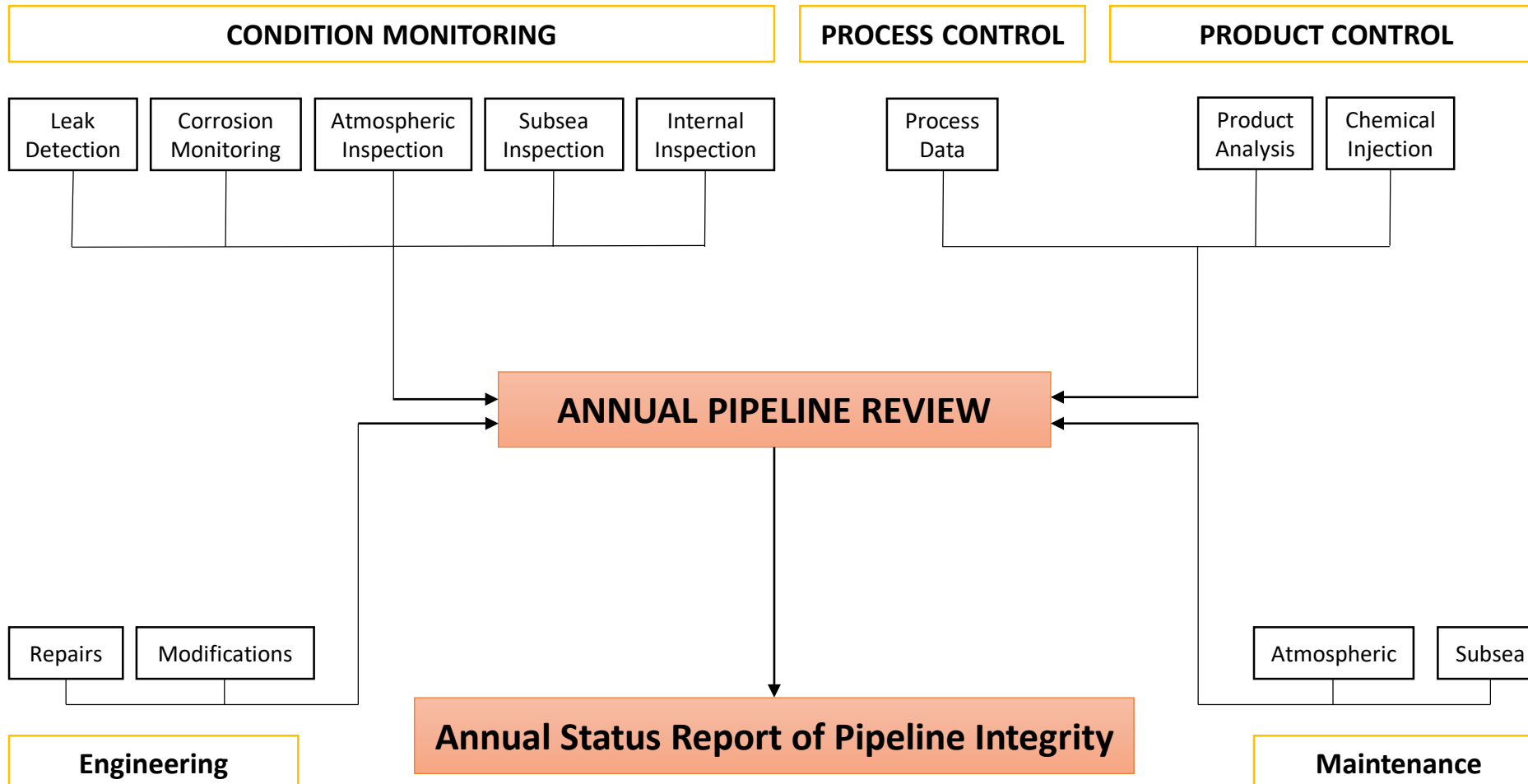
❖ Pipeline Integrity and Integrity Management Plan

- Pipeline integrity is ensuring a pipeline is safe and secure for efficient transportation covering all aspects of design, management, inspection and maintenance.

Pipeline Integrity Management is the management of all the elements of this complex jigsaw



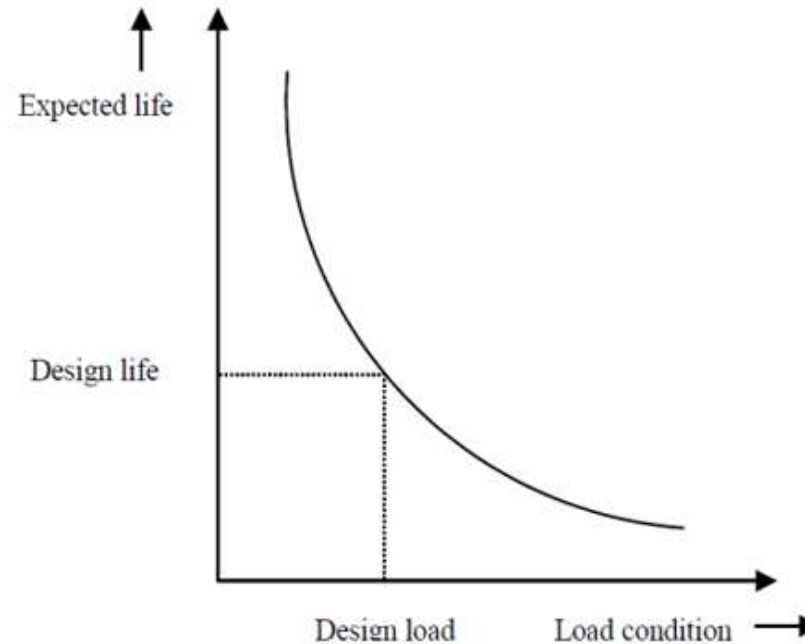
Pipeline Integrity Monitoring Scheme



Pipeline Integrity Management system identifies the need for pipeline monitoring scheme collating all the data from condition monitoring, process control and production control to provide an overall picture of the pipeline's condition

❖ Pipeline design considerations

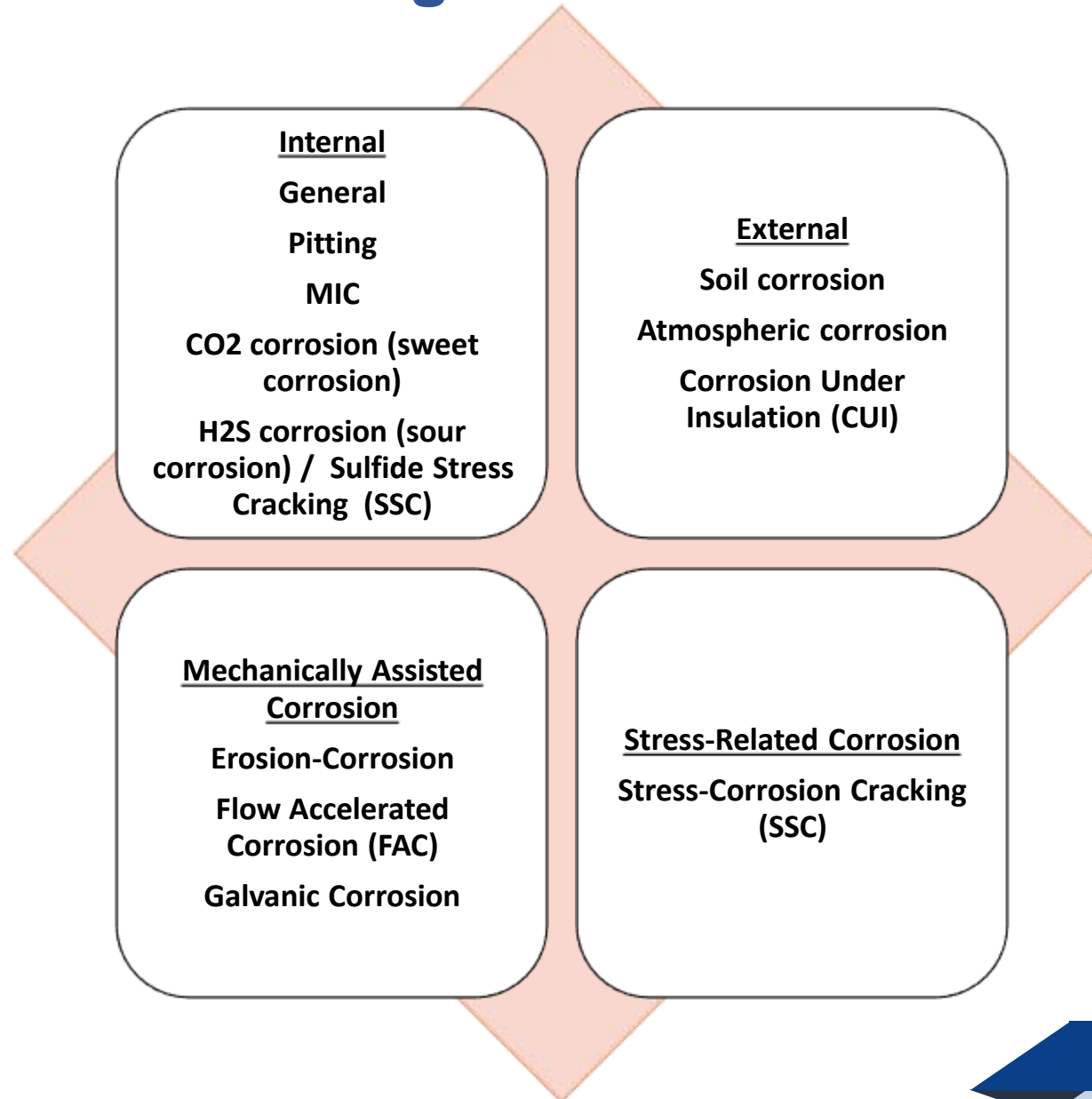
- Pipelines are designed to work under certain conditions for certain expected life / design life.



Expected lifetime is a function of operating conditions

- ❖ *If operating load < design load - **expected life > design life** _ safe & secure operations*
- ❖ *If operating load > design load - **expected life < design life** _ failure / accidents occurs*

❖ Probable Corrosion Damage Mechanisms



❖ Calculation of Corrosion Rate (CR)

- Estimating the most realistic and credible corrosion rate is essential in assessing the integrity of the pipeline and planning for monitoring and mitigation activities.
- Estimation of the CR is usually carried out by the following methods (pertaining to availability of the inspection data)
 1. Process fluid conditions of the pipeline
 2. Corrosion Coupons Weight Loss
 3. Based on latest ILI report (Long-Term Corrosion Rate)
 4. Based on two consecutive ILI reports (Short-Term Corrosion Rate)

1. Feed Quality Analysis

Identify the corrosive parameters of the process fluid (liquid / gas)



Anticipate the most active corrosion damage mechanism causing metal degradation



Estimation of corrosion rate using relevant corrosion models / industry accepted software i.e. ECE (Electronic Corrosion Engineer)

2. Corrosion Coupons Weight Loss

- Small metallic samples of pipeline MOC (weighed before) will be placed within the pipeline to be exposed with process fluid
- Then, coupons are removed at specified intervals (usually 6 months), cleaned & reweighed; the weight loss is converted into corrosion rate (CR) as follows:

$$\text{Corrosion Rate} = \frac{\text{Weight loss (gm)} * K}{\text{Alloy Density (gm/cm}^3\text{)} * \text{Exposed Area (A)} * \text{Exposure time (hr)}}$$

Constant K can be varied to calculate the corrosion rate in various units

<u>Desired Corrosion Rate Unit (CR)</u>	<u>Area Unit (A)</u>	<u>K-Factor</u>
mils/year (mpy)	in ²	5.34 x 10 ⁵
mils/year (mpy)	cm ²	3.45 x 10 ⁶
millimeters/year (mmy)	cm ²	8.75 x 10 ⁴

3. Long Term Corrosion Rate

- Long Term corrosion resembles deterioration in pipeline wall thickness from initial to actual thickness over long time.
- Here, time span between commissioning and latest ILI has been considered as governing time for change in corrosion depth.
- Each individual anomaly depth as per latest ILI has been divided by this governing time to obtain the individual long term corrosion rate.

$$CR_{LT} = \frac{t_{initial} - t_{actual}}{\text{no. of years between commissioning and latest ILI}}$$

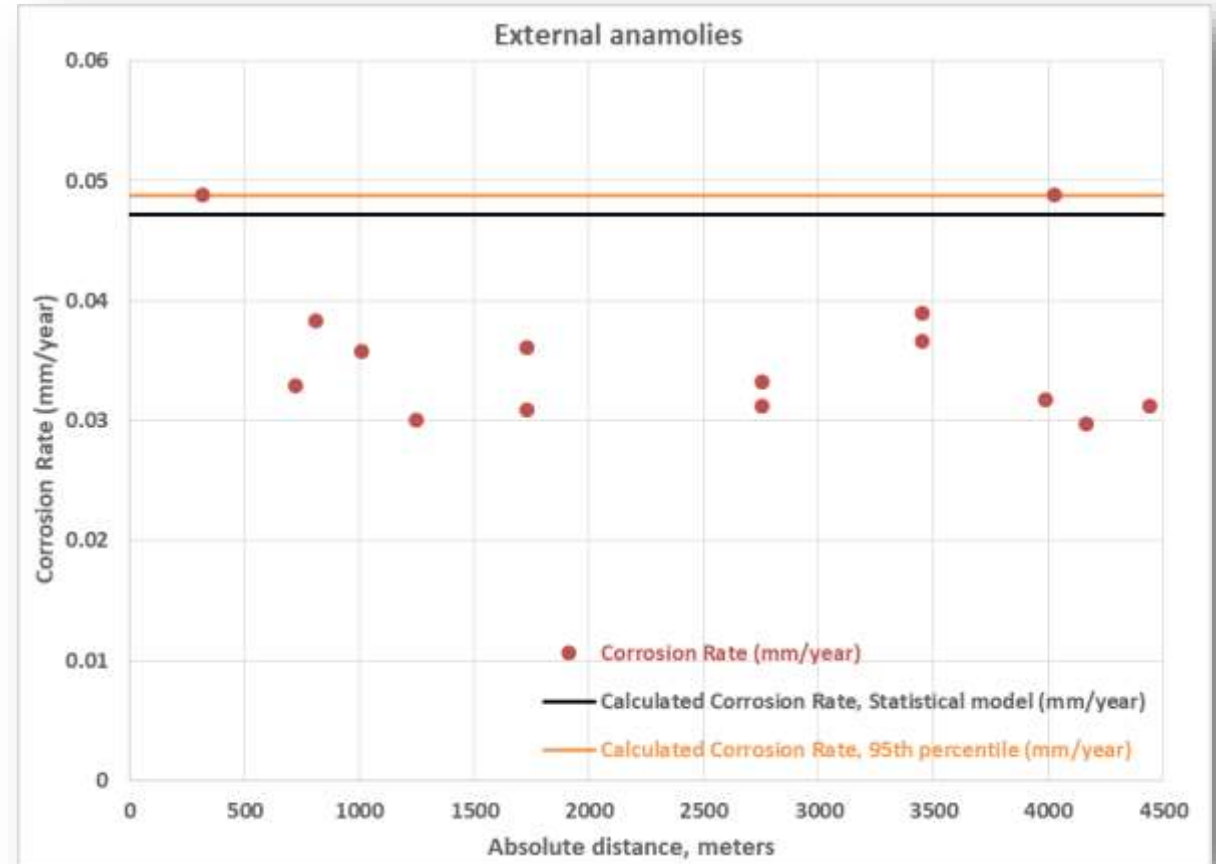
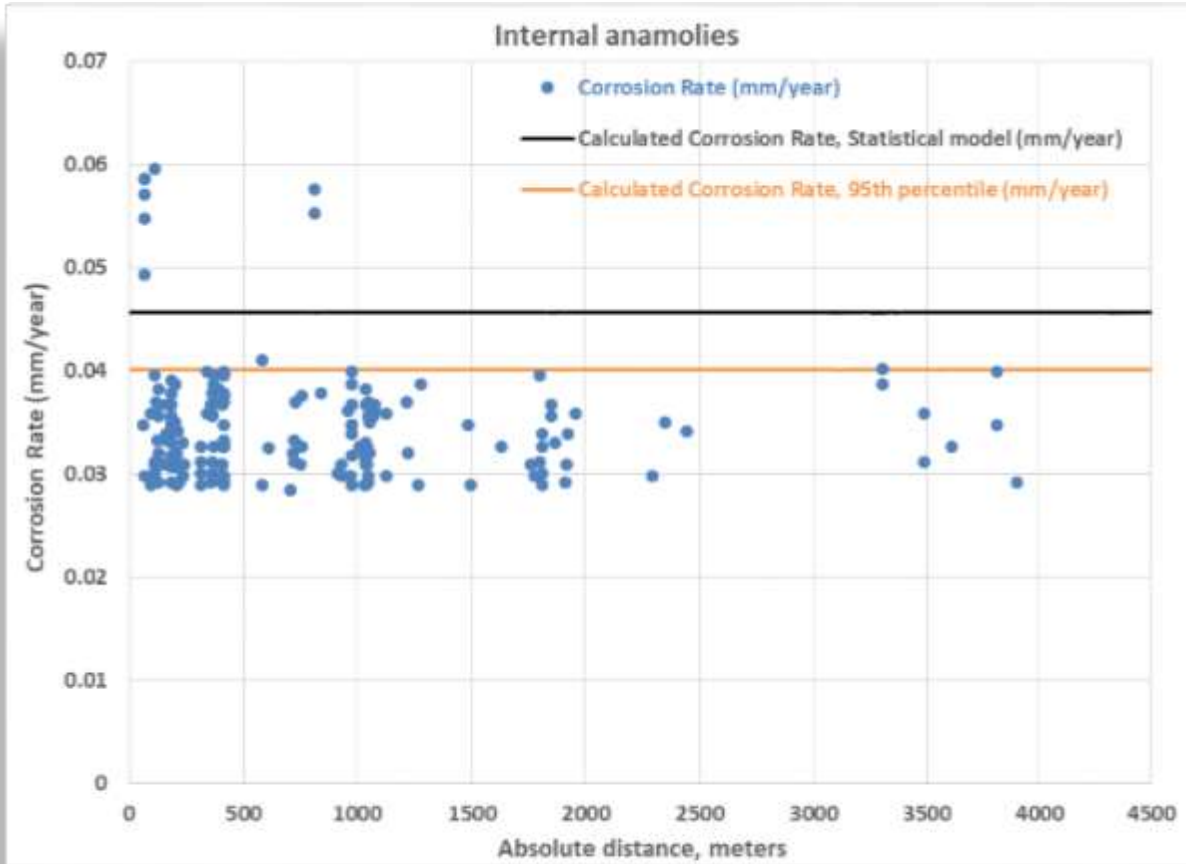
4. Short Term Corrosion Rate

- Short Term corrosion resembles deterioration in pipeline wall thickness from previous ILI reported thickness to actual thickness (as per latest ILI) over confined time gap.
- Here, time span between two consecutive ILI's has been considered as governing time for change in corrosion depth.
- Each individual anomaly depth as per latest ILI has been divided by this governing time to obtain the individual short term corrosion rate.

$$CR_{ST} = \frac{t_{previous} - t_{actual}}{\text{no. of years between previous ILI and latest ILI}}$$

- Estimation of Short term corrosion rate is bit complex when compared to Long Term corrosion rate.
- **Short term corrosion rate: Box Matching (weld to weld matching)**
- To establish a Global Corrosion Rate (GCR) considering all the anomalies, two different models are utilized:
 1. Statistical Model / 95% confidence model (Corrosion Rate = Mean + 1.96*Standard deviation)
 2. 95th percentile method
- Corrosion rate is calculated for all the internal anomalies and all the external anomalies separately since the medium leading to corrosion is varying in both the cases (process fluid constituents in internal corrosion and external atmosphere in external corrosion)

Procedure



❖ Corrosion Assessment

Deals with longitudinal extent of the defect

Considers circumferential extent of the defects

ASME B31G

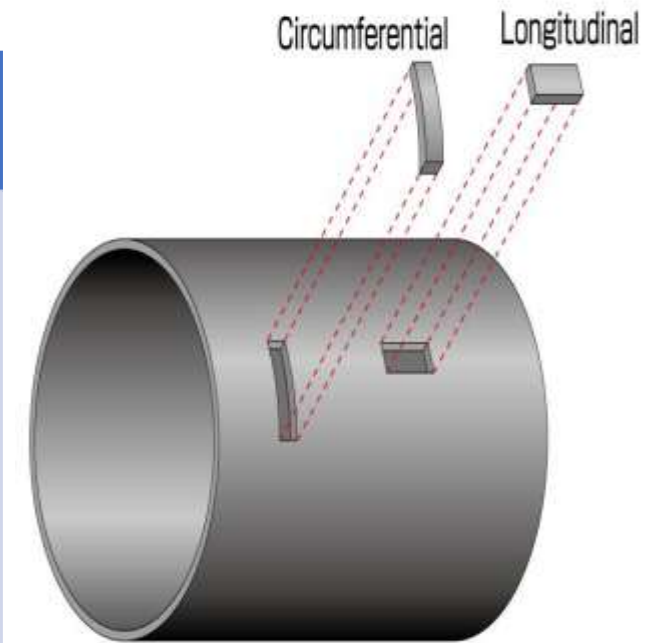
- Calculations are very conservative

Modified 31G

- To reduce conservatism in 31G
- Well accepted in industry
- Based on 0.85 dL method

Kastner

- More realistic for circumferentially oriented defects (such as circumferential grooving & circumferential slotting)



❖ Corrosion Assessment

- **Cluster Analysis:**
- Cluster assessment to be carried out as per ASME B31G guidelines. This helps in deciding the defects in a cluster as isolated defects or a single defect.

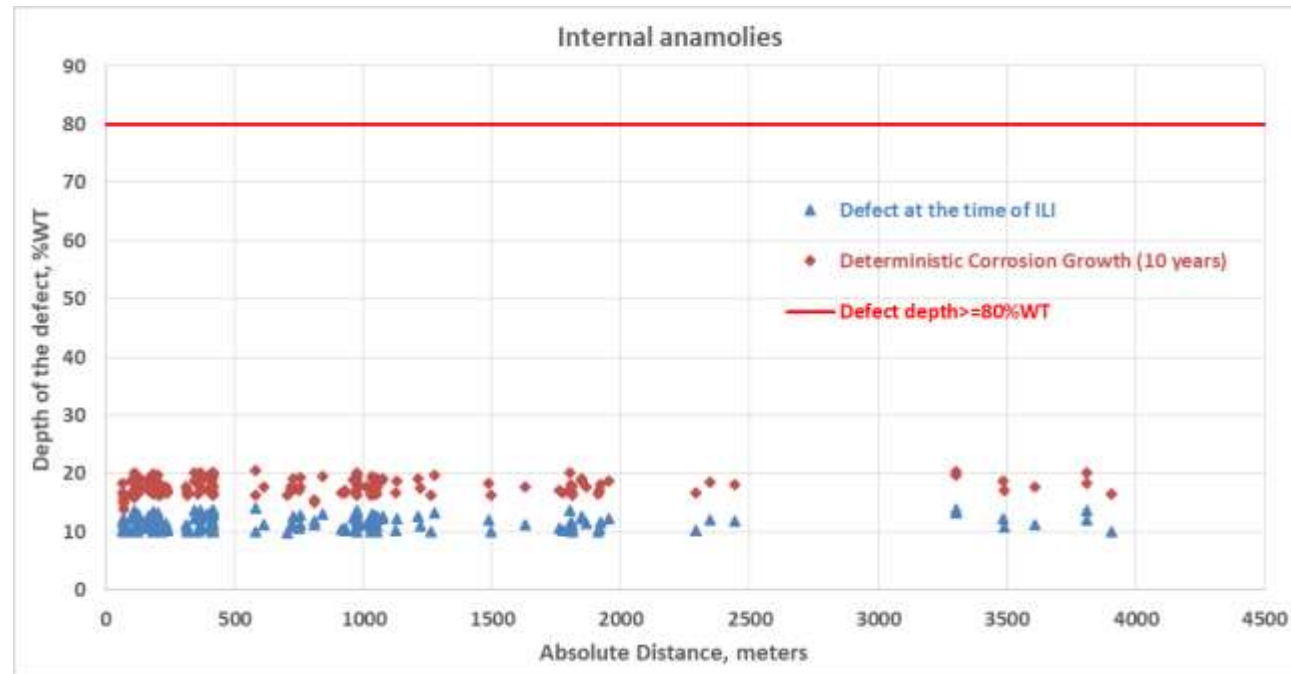
These methods determines the burst pressure using relevant equations considering defect dimensions such as size and shape and pipeline physical properties such as thickness, diameter and ultimate strength

This results in establishing the Safe Operating Pressure (P_s) and Estimated Repair Factor (ERF)

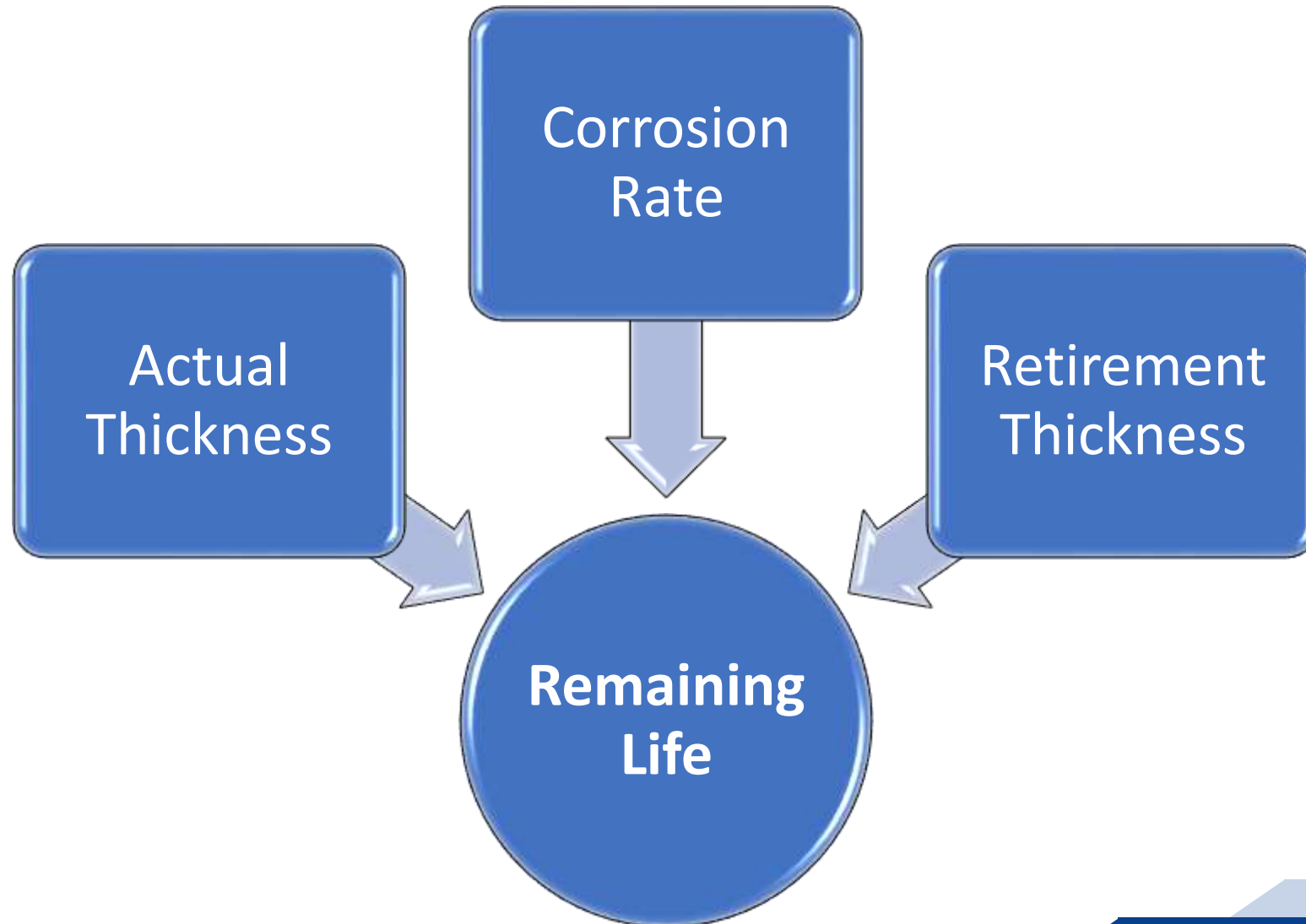
$$\text{Estimated Repair Factor (ERF)} = \frac{\text{Maximum Allowable Operating Pressure (MAOP)}}{\text{Safe Operating Pressure (PS)}}$$

❖ Re-Inspection Planning / Preventive Maintenance Planning

- To provide insight into the pipeline, the defect dimensions are grown with the reliably conservative corrosion rate till next scheduled inspection / to the fix the re-inspection year.
- With these dimensions, corrosion assessment is performed and defect severity has to be identified for deciding the response for repair / replacement if needed.



❖ Remaining Life Assessment



❖ Remaining Life Assessment

$$L_R = \frac{t_{actual} - t_{retiring}}{CR}$$

where L_R is the remaining life of pipeline (in years)

t_{actual} is the actual thickness measured at the time of inspection for a given location (in mm)

$t_{retiring}$ is the minimum pressure design thickness as per ASME 31.8 (in mm)

CR Is the CR of the pipeline (in mm/year)

Basis for extending operating life

Reducing costly unscheduled outages caused by in-service failures

Eliminating unnecessary replacements



THANK YOU