SANMARG PROJECTS PVT. LTD.
Asset Management Company
ISO 9001:2015, ISO 14001:2015 & ISO 45001:2018

INTEGRATED MODEL OF O&M

FOR GAS PIPELINE

OM PRAKASH

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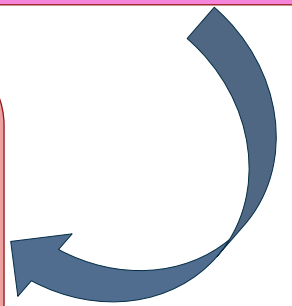
OM PRAKASH

Present Affiliation	Head Techno Commercial at SANMARG Projects Pvt. Ltd.
Academic Qualification	B. Tech. (IIT G)
Area of Specialization	Project Management, Process / Engineering
Achievements / Awards	Cumulative project experience of over 30,000 cr Part of Core PM team of India's one of first two UMPPs. Set-up Asia's largest Ferro Alloy Plant phase - I. Conceptualized India's first solar thermal plant. One of early trainers for Hydrogen sector (generation & pipeline)
Title of Paper	Integrated model of O&M for gas pipeline and pipeline integrity and gas loss optimization
Authors	Om Prakash

O&M : INTRODUCTION

- An earlier Notion : a measure against problems? OR cost center with no commitment to generating profits?

- Current Graduation :
  - from a mere "equipment restorer" to "managing the lifecycle of the assets"
  - traditional Time-Based Maintenance to Condition Based Maintenance
  - Computerized Maintenance Support
  - Predictions, Precautions and Preventions
  - Repositories of data
  - Analysis, Modeling, Simulations ---- Real time Analysis, Modeling and Simulations



- Small reductions in the area of Maintenance can bring significant increases in corporate profits

- Small investment in Maintenance brings significant increase incorporate profits and keeps corporation sustained

PIPELINE INTEGRITY MANAGEMENT SYSTEM

Introduction

- Any asset is prone to wear and tear, which are functions of a number of variables.
- Pipelines are no exceptions.
- Environment, Chemicals, Corrosion, Microorganisms, Pressure / Fatigue conditions, Manufacturing / Installation defects, and various other threats may result in a compromised / emergency situation or may significantly shorten lifespan of a pipeline.
- It is very important for an organization to take all necessary preventative actions to ensure pipelines remain safe and operating.
- Best Model : Integration of PIMS in O&M through a reliable professional agency

PIPELINE INTEGRITY MANAGEMENT SYSTEM

Major Threats

A. External Corrosion
B. Internal Corrosion
C. Stress Corrosion Cracking
D. Equipment, Equipment Failure / Malfunction / undesirable operating conditions
E. Manufacturing Defects / Latent Defects
F. Construction Defects (e.g. Welding/Fabrication Related)
G. Third Party Damage / Mechanical Damage
H. Incorrect Operations (Human Error)
I. Environment / Weather Related, Outside Force
J. Micro-oraganism
K. Chemicals / Soil properties
L. Externally induced properties

Factors guiding Analysis & Repair

- ✓ defect severity: location, depth, length, orientation,
- ✓ financial/strategic value of pipeline,
- ✓ threat to environment & public relations
- ✓ regulatory/legal/insurance considerations,
- ✓ failure consequences.

PIPELINE INTEGRITY MANAGEMENT SYSTEM

Threats

Time dependent

- ✓ Corrosions (Internal, External, SCC, MIC, HIC, SOHIC)
- ✓ Fatigue and creep

Stable

- ✓ Manufacturing defects
- ✓ Construction defects
- ✓ Equipment
- ✓ Alteration / Repair (compromised)

Time Independent

- ✓ Third Party damage
- ✓ Human Error
- ✓ Incorrect Operation
- ✓ Outside Force, Earth Movement
- ✓ Weather related
- ✓ Excavation / Drilling Damage

Interactive threats are the coincidence of two or more threats in a pipe segment

Types of defects

- External Metal Loss & Internal Metal Loss
- Leaks, Cracks (including stress corrosion cracking), Arc Burns
- Girth Weld Flaws
- Pipeline manufacturing defects such as pipe weld defects, ovality, laminations etc.
- Dents
  - Dents with Stress Concentrators
  - Plain Dents
  - Double Dents
  - Dents that Affect Welds
- Gouges
- Wrinkle Bends / Buckles
- Previous Repairs
- Mill-Related Anomalies

PIPELINE INTEGRITY MANAGEMENT SYSTEM

Integrity Assessment methods

- Pressure Testing / Hydro Testing
- Inline Inspection
- Desk study based on O&M and R&M History
- Desk study and assessment of critical areas
- Evaluation of design and operating parameters

Preventive / Mitigation Measures

- Pipeline Surveillance
- Line Locating and Marking
- Call Center / Control Room
- Emergency Response Center
- Monitored Excavations and construction, in vicinity
- Third Party Damage Prevention
- Damage Identification & Reporting
- Safety in Design
- Reliable Coatings and CP
- Sensors and Instruments and Interlocks
- Routine / Periodic Assessment
- Good O&M practices
- Technical & Safety Audits
- Repair actions

O&M : PIMS

Why an O&M agency leading PIMS?

- They are more closer / on ground / direct contact to Pipeline.
- They are responsible to maintain pipeline asset.
- They are supposed to prompt.
- They are one of the most vulnerable to be affected by accidents.
- They are in contact with various local stakeholders through ROU maintenance, Villagers / People Awareness Program, Mock Drills.
- It will lead to quality agency preforming O&M.
- Digitalized records will make more effective O&M as well as PIMS

O&M : PIMS

Objective of PIMS

- Ensuring the quality of pipeline integrity in all areas including which have potential for adverse consequences
- Improve the safety of pipelines so as to protect the personnel, property, public and environment
- Promoting a more rigorous and systematic management
- Evaluate the risk associated with pipelines and effectively allocate resources for prevention, detection and mitigation activities; Risks mitigation
- Have streamlined and effective operations to minimize the probability of pipeline failure.
- Preparedness for tackling an incident
- Bird eye view of Safety & Integrity for Owner, Project Proponents, Investors and Statutory / Regulatory Authorities; Increasing the general confidence of stakeholders
- Optimizing the life of Pipeline with investigation, data collection, review and analysis
- Statutory Compliances

O&M : PIMS

Integrity Assessment Tools (included)

- Maintenance Service Records / History and Pipeline data updates
- CP Monitoring
- Surveillance: Patrolling, Ground Survey, Drone survey, Satellite images, Night Patrol
- Surveillance Systems records & interpretations: Fiber Optics System, Ground Sensor System, Radar based detection System (microwave reflection), Fence secure System (sensors / physical fences)
- Awareness Programmes: Villagers', General Public, Do's & Don'ts, Safety Awareness
- Hydro testing
- ICDA, ECDA, SCCDA
- Thickness Assessment, NDT, and periodic reviews
- Equipment Health Monitoring including LLF
- ROU condition updates
- QRA, PDA and Consequence and Impact Analysis
- Periodic Pigging & ILI

O&M : MODELS

Various models:

Models / Resp.	Decision Makers	Key Resources	Resources (Man)	Major Tools & Machineries	Tools & Plants	Spares	OEM specific Maintenance	Consumables	Pipeline Intervention	Asset Manning	Routine Maintenance	Shutdown Maintenance	Stakeholders Management	Meeting Statutory G/L	Emergency Preparedness	Emergency Response	Scheduling	Integrity Aspects	Data interpretation
#1	O	O	C	O	O	O	O	O	O	O	DC	DC	O	O	O	DC	O	O	O
#2	O	O	C	O	O,C	O, C	O	O, C	O	C	C	O	O	O	O	O	O	O	O
#3	O	O	C	O, C	O, C	O, C	O	O, C	O	C	C	C	O	O	O, C	C	O	O	O
#4	O	O, C	C	O, C	O, C	O, C	O, C	O, C	O	C	C	C	O	O	O, C	C	O	O	O
#5	O	O, C	C	O, C	C	O, C	C	C	O	C	C	C	O, C	O, C	C	C	C	O, C	O
#6	O	C	C	C	C	C	C	C	C	C	C	C	C	O, C	C	C	C	C	C

O: Owner, C :Contractor, DC :Different Contractors

O&M : INTEGRATED AND PIMS BASED

New Paradigm

Asset Owner

- ✓ Decision Makers
- ✓ Key Resources (Owning, Liaison, Commercial, Finance, Quality, Stakeholders Management)
- ✓ Major Tools & Machineries (existing)
- ✓ Spares (Critical / Assets / Redundancy)
- ✓ Consumables (Fuel, Operational)

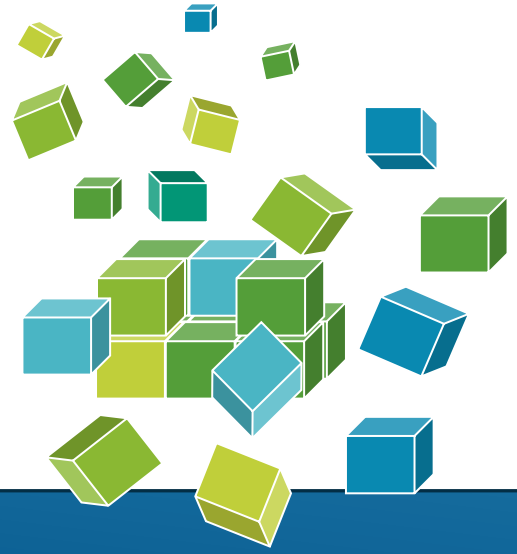
O&M Outsourcing Agency

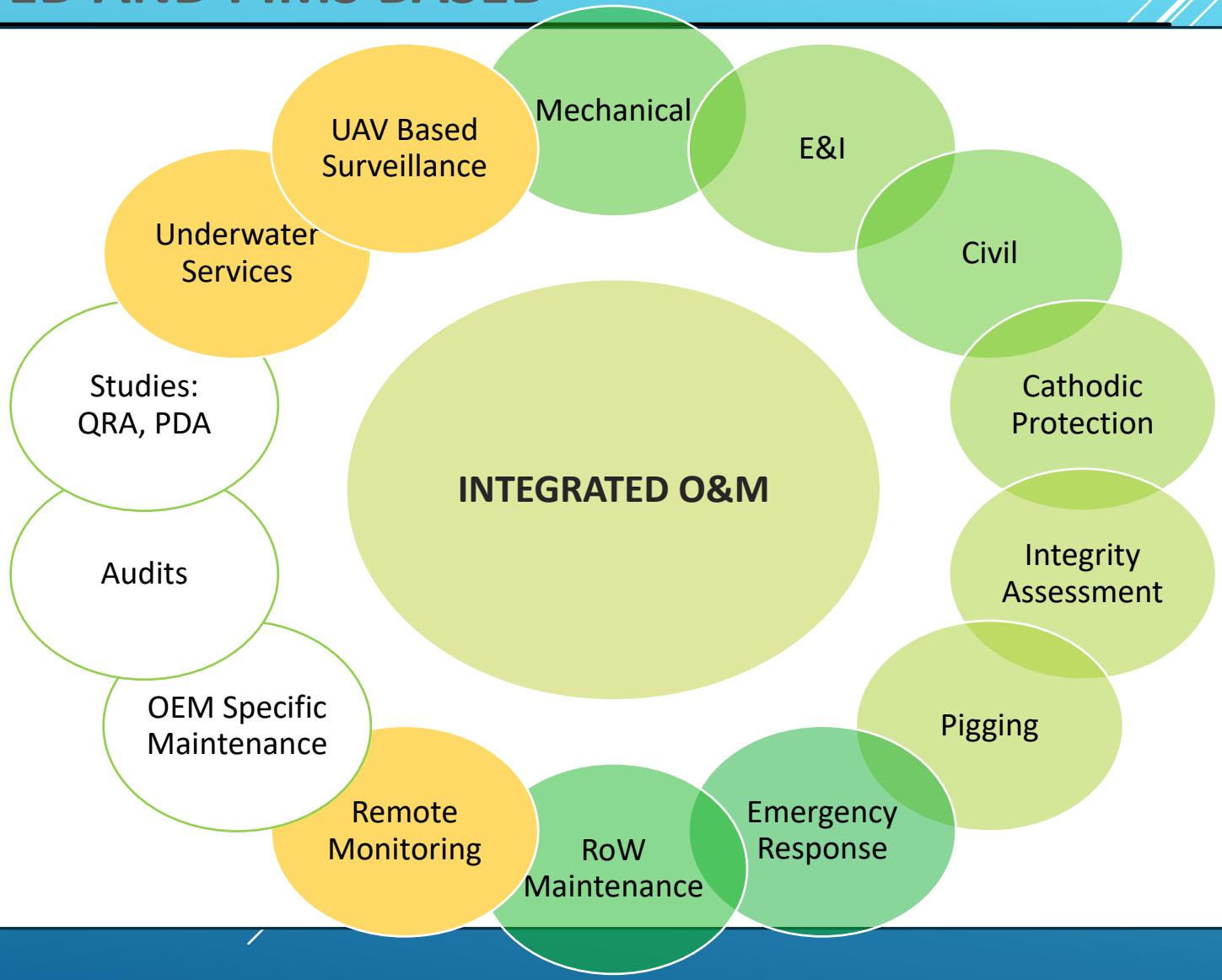
- ✓ Key Resources
- ✓ Resources (Man)
- ✓ Major Tools & Machineries
- ✓ Tools & Plants
- ✓ Spares
- ✓ OEM specific Maintenance
- ✓ Consumables
- ✓ Pipeline Intervention
- ✓ Asset Manning
- ✓ Routine Maintenance
- ✓ Shutdown Maintenance
- ✓ Stakeholders Management
- ✓ Meeting Statutory Guidelines
- ✓ Emergency Preparedness
- ✓ Emergency Response
- ✓ Scheduling
- ✓ Integrity Aspects
- ✓ Data interpretation

O&M : INTEGRATED AND PIMS BASED

O&M Solutions for:

- ❑ *Pipelines & Associated Infrastructure*
- ❑ *Terminals & Storage Depots*
- ❑ *Hydrocarbon Processing Plants*
- ❑ *City Gas / Distribution Networks*
- ❑ *Upstream Surface Facilities*
- ❑ *Power Generation and Utilities*





O&M : INTEGRATED AND PIMS BASED

One stop solution to all maintenance requirements

- Mechanical Maintenance
- Electrical Maintenance
- CP Monitoring & Maintenance
- Instrumentation & Control
- SCADA System
- ROU & Washouts
- Civil Maintenance
- Fire Fighting System
- Emergency Response
- Hot Tapping & Stoppling
- Pigging, Chemical cleaning, NDT

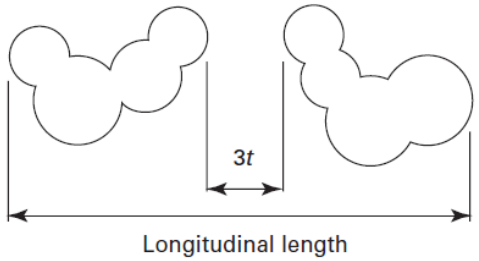
- Intelligent Pigging
- Technical support
- Pilferage Rectification
- Sleeve Welding
- Shorted Casing handling
- Extension of Cased Crossings
- Dynamic Dashboard Controlled O&M
- Round the clock Manning
- Advanced Technical and NDT Services
- OEMs specific Maintenance
- Calibration of various types of Instrument
- Calibration of Meters etc.
- Housekeeping, Horticulture

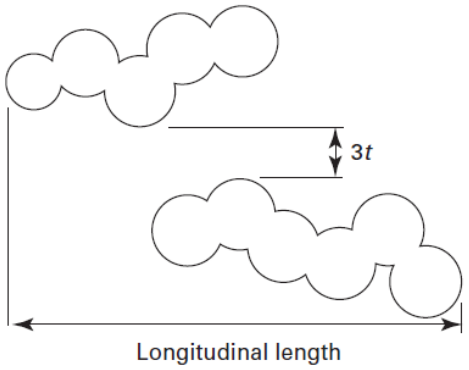
- New and miscellaneous construction / modifications.
- Washouts repair/ pipeline lowering etc.
- Audit of Pipeline / Terminal Assets
- Digitization of Pipeline data
- Logistic Support
- Mock Drills
- Villagers Awareness Program
- Environmental Monitoring
- Studies: QRA, PDA
- Coating Health Surveys
- Hydro Testing
- PIMS data and analysis
- FFS certificate

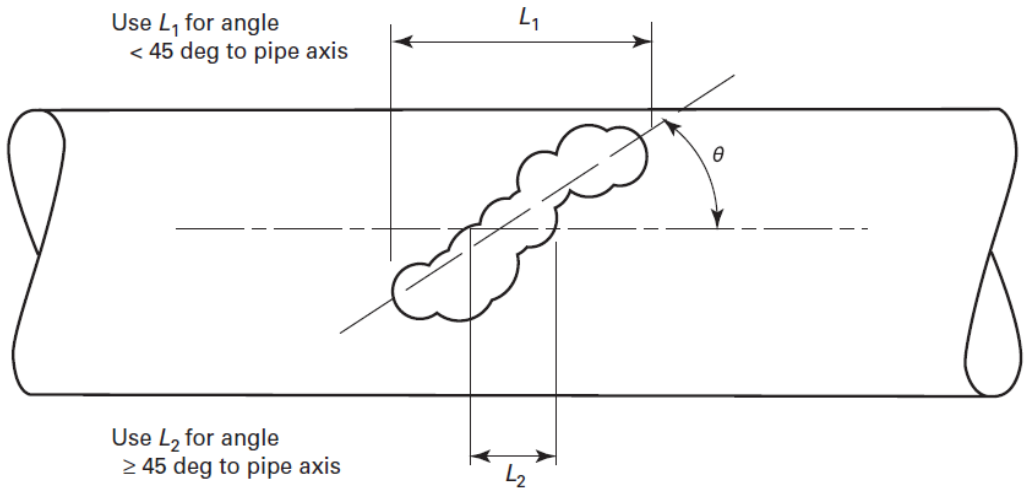
O&M : ASME B31G ANALYSIS

ASME B31G Analysis

- Measurement & Data record and Analysis at every possible occasions
- ASME B31G Analysis
  - Level 0 evaluation by site team based on manual & SOP provided to them
  - Level 1 evaluation by Engineering team
  - Level 2 evaluation by Engineering team on specific occasions or high risk / impact areas







O&M : ASME B31G ANALYSIS

➢ Level 0 Evaluation

- ✓ *Step 1.* Determine pipe diameter and nominal wall thickness from appropriate records or direct measurement of the pipe.
- ✓ *Step 2.* Determine applicable pipe material properties from appropriate records.
- ✓ *Step 3.* Clean the corroded pipe surface to bare metal. Care should be taken when cleaning corroded areas of a pressurized pipe.
- ✓ *Step 4.* Measure the maximum depth of the corroded area, *d*, and longitudinal extent of the corroded area, *L*.
- ✓ *Step 5.* Locate the table corresponding to the size of the pipe, *D*.
- ✓ *Step 6.* In the table, locate the row showing a depth equal to the measured maximum depth of the corroded area. If the exact measured value is not listed, choose the row showing the next greater depth.
- ✓ *Step 7.* Read across to the column showing the wall thickness of the pipe. If the nominal wall thickness is not listed, use the column for the next thinner wall. The value, *L*, found at the intersection of the wall thickness column and the depth row is the maximum allowable longitudinal extent of such a corroded area.
- ✓ *Step 8.* The metal loss area on the pipe is acceptable if its measured length, *L*, does not exceed the value of *L* given in the table.

Sample / typical table of crew's manual

Table 3-3M Values of *L* for Pipe Sizes ≥ 273 mm and < 406 mm O.D.

Depth, *d*, mm	Wall Thickness, *t*, mm							
	4.0	5.6	6.4	7.8	8.7	9.3	11.1	12.7
0.5	147.4	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.8	109.1	174.6	186.5	No limit	No limit	No limit	No limit	No limit
1.0	61.3	150.4	186.5	206.7	218.8	225.4	No limit	No limit
1.3	45.2	88.3	124.8	206.7	218.8	225.4	246.9	263.8
1.5	36.5	65.9	86.4	146.6	218.8	225.4	246.9	263.8
1.8	30.9	53.7	68.2	104.8	140.5	168.1	246.9	263.8
2.0	26.9	45.9	57.3	83.9	107.1	123.3	212.7	263.8
2.3	23.8	40.3	49.8	71.0	88.3	99.8	155.0	238.4
2.5	21.3	36.0	44.3	62.1	76.0	85.0	124.9	176.5
2.8	19.2	32.6	40.0	55.5	67.3	74.7	106.1	143.3
3.0	17.3	29.8	36.5	50.4	60.6	67.0	93.1	122.2
3.3	...	27.4	33.6	46.2	55.3	61.0	83.5	107.5
3.6	...	25.3	31.1	42.7	51.0	56.1	76.0	96.5
3.8	...	23.4	28.9	39.7	47.4	52.0	69.9	87.9
4.1	...	21.8	27.0	37.1	44.2	48.5	64.9	81.0
4.3	...	20.3	25.2	34.8	41.5	45.5	60.6	75.3
4.6	...	...	23.7	32.8	39.1	42.9	56.9	70.5
4.8	...	...	22.2	31.0	37.0	40.5	53.7	66.3
5.1	...	...	20.9	29.3	35.1	38.4	50.9	62.7
5.3	...	...	...	27.8	33.3	36.5	48.4	59.4
5.6	...	...	...	26.4	31.7	34.8	46.1	56.6
5.8	...	...	...	25.1	30.2	33.1	44.0	54.0
6.1	...	...	...	23.8	28.8	31.7	42.1	51.6
6.4	...	...	...	...	27.5	30.3	40.3	49.5
6.6	...	...	...	...	26.3	29.0	38.7	47.5
6.9	...	...	...	...	25.1	27.7	37.2	45.7
7.1	...	...	...	...	...	26.6	35.7	44.0
7.4	...	...	...	...	...	25.5	34.4	42.4
7.6	...	...	...	...	...	...	33.2	40.9
7.9	...	...	...	...	...	...	32.0	39.5

O&M : ASME B31G ANALYSIS

➢ **Level 1 Evaluation**

- ✓ *Step 1.* Determine pipe diameter and nominal wall thickness from appropriate records or direct measurement of the pipe.
- ✓ *Step 2.* Clean the corroded pipe surface to bare metal. Care should be taken when cleaning corroded areas of a pressurized pipe.
- ✓ *Step 3.* Measure the maximum depth of the corroded area, *d*, and longitudinal extent of the corroded area, *L*.
- ✓ *Step 4.* Determine applicable pipe material properties from appropriate records.
- ✓ *Step 5.* Select an evaluation method and calculate the estimated failure stress, S_F.
- ✓ *Step 6.* Define an acceptable safety factor, *SF.*
- ✓ *Step 7.* Compare S_F to *SF x* S_O.
- ✓ *Step 8.* The flaw is acceptable where S_F =>*SF x* S_O, or where P_F =>*SF* x P_O.
- ✓ If the flaw is unacceptable based on Step 8, the pressure can be reduced such that it is less than P_F/SF.

Original B31G

$$z = L^2/Dt$$

Bulging stress Magnification factor

$$M = (1 + 0.8z)^{1/2}$$

For z <= 20

$$S_F = S_{flow}\left[\frac{1 - \frac{2}{3}(d/t)}{1 - \frac{2}{3}(d/t)/M}\right]$$

For z > 20

$$S_F = S_{flow}(1 - d/t)$$

where

$$S_{flow} = 1.1 \times \text{SMYS}$$

Modified B31G

$$z = L^2/Dt$$

Bulging stress Magnification factor

For z <= 50

$$M = (1 + 0.6275z - 0.003375z^2)^{1/2}$$

For z > 50

$$M = 0.032z + 3.3$$

$$S_F = S_{flow}\left[\frac{1 - 0.85(d/t)}{1 - 0.85(d/t)/M}\right]$$

where

S_{flow} from modif. B31G

O&M : REMAINING STRENGTH

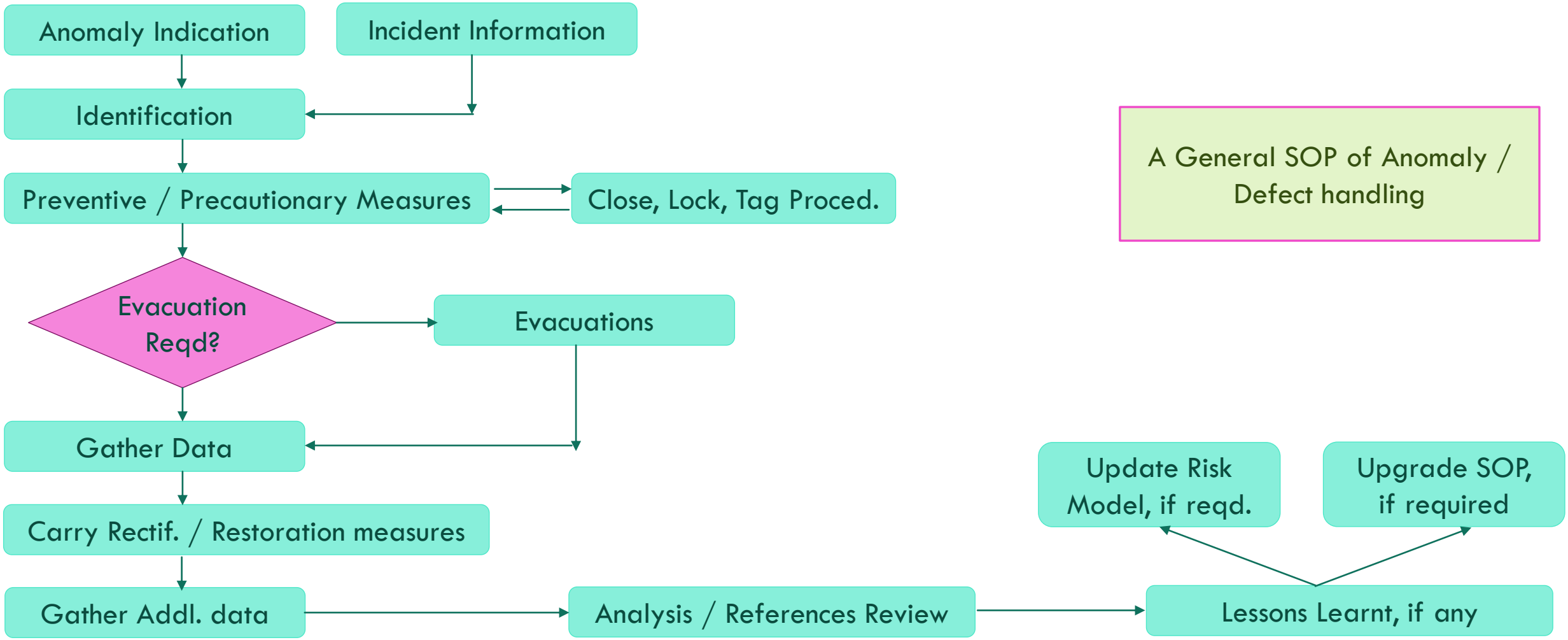
Remaining Strength Calculation of Pipeline, after every new measurement / data

- Defect Depth at T year is $D_T = D_{T0} + (T - T0) \times RC$ where RC is Rate of Corrosion
- Residual Life (years) at T0 is $T = [Dcr - D_{T0}] / RC$ where Dcr is critical defect depth
- Dcr can also be written as $Dcr = TH - R$ where TH is rated wall thickness
  R is minimum residual wall thickness
- Also Rate of Corrosion from field data / ILI may be calculated as
  $RC = [D_{T0} - D_{-n}] / n$
- Residual Life (years) at T0 may be rewritten as

$$T = n \times [TH - R - D_{T0}] / [D_{T0} - D_{-n}]$$

$$T = n \times [S_{F0} - SF \times S_O] / [S_{F-n} - S_{F0}]$$

O&M : A TYPICAL SOP



O&M : EXTREME WEATHER EVENTS

Extreme Weather Events : Followed Inspections

- Depends on the nature of the event and extent (to be incorporated in SOP)
- Consider physical characteristics, operating conditions, location, and prior history of the affected pipeline in determining the appropriate method for performing the inspection required.
- Initial inspection must occur within 72 hours after the cessation of the event, when the affected area can be safely accessed to perform the inspection.
- In case inspection could not be done in the 72-hour timeframe due to any reasons, the same may be recorded and activities to be updated to be carried in current month routine activities and to be carried as soon as practicable.
- Appropriate remedial action to ensure the safe operation of a pipeline based on the information obtained because of performing the inspection.
- Inspections mandatorily carried as per SOP even if operational parameters look normal and no reporting of incident / accidents from stakeholders.
- SOP prepared by Contractors PIMS / Engineering team and approved by Asset Owner.

O&M : EXTREME WEATHER EVENTS

Extreme Weather Events : Remedial actions (temp. / long term)

- Reducing the operating pressure or shutting down the pipeline
- Isolating pipelines in affected areas and performing “stand up” leak tests
- Modifying, repairing, or replacing any damaged pipeline facilities
- Preventing, mitigating, or eliminating any unsafe conditions in the pipeline rights-of-way
- Performing additional patrols, depth of cover surveys and adding cover over the pipeline, ILI or hydrostatic tests, or other inspections to confirm the condition of the pipeline and identify any imminent threats to the pipeline
- Implementing emergency response activities with Federal, State, or local personnel
- Notifying affected communities and of the steps that can be taken to ensure public safety

O&M : DEFECT CATEGORIZATION

Defects Categorization

- Category 1: Predicted Failure Pressure (PFP) is above 110 percent of corresponding SMYS
- Category 2: PFP is above 125 percent MAOP and below 110 percent of corresponding SMYS.
- Category 3: PFP is above 110 percent MAOP and below 125 percent MAOP.
- Category 4: PFP is below 110 percent MAOP.
- Category Zero: A crack below the threshold for Noteworthy cracks.
    - Those that are shallow (i.e., less than 10 percent through-wall depth)
    - Those that are so short that, even if they were 50 percent through-wall depth, they would not result in a hydrostatic test failure.

- Category 1: Failure life exceeds 10 years.
- Category 2: Failure life exceeds 5 years.
- Category 3: Failure life exceeds 2 years.
- Category 4: Failure may be imminent.
- Category Zero: Failure life exceeds 15 years (for short cracks) to 25 years (for shallow cracks).

Reference: ASME ST-PT-011

O&M : TYPICAL MAINTENANCE SCHEDULE

Sr. No.	Activity/ Description	Frequency	Contractor
1	**Patrolling of Pipeline sections through GPS application (GSPLwill provide the tablet/ mobiles with application)**		
1.1	Location Class 1 & Class 2	Q	√
1.2	Location Class 3 & 4	M	√
1.3	Location- High Consequence Area (HCA)	M/AWR	√
2	**Surveys**		
2.1	River Crossing	Q	√
2.2	Rail/Road/Canal Crossing	Q	√
2.3	Foreign Pipeline Crossing	Q	√
2.4	Bubble leakage test of Station Piping	HY	√
2.5	Checking of Casing Carrier System	Q	√
2.6	Sub-Surface Gas Detection Survey	AWR	√
2.7	Pressure drop test of integrated pipeline (As & when there is shut down or zero flow in particular segment)	AWA	√
3	**Monitoring & Maintenance of CP System**		
3.1	Monitoring & Maintenance of TR Unit	M	√
3.2	Calibration of Meters of TR Unit	Y	√
3.3	PSP Monitoring	Q	√
3.4	Instant pipe to Soil "OFF" potential Measurement at TLP of total pipeline section	Y	√
3.5	Current Measurement in applicable TLP	Y	√
3.6	Maintenance of Anode Ground Bed	HY	√
3.7	Monitoring & Maintenance of Insulating Joint	Q	√
3.8	Inspection of Interference Bonds	Y	√
3.9	Checking of corrosion Coupon	AWR	√
3.10	Checking of ER Probe/CTSU	HY	√
3.11	CP Mitigation Works	AWR	√
4	**Monitoring and Maintenance of Instruments**		
4.1	Calibration of Field Instruments (DPT/PT/TT/PG/TG/DPG, etc.)	Y	√
5	**Maintenance of Plant Equipments**		
5.1	Maintenance of Scraper Traps & QOC	Y	√
5.2	Maintenance of Filter & QOC	HY / AWR	√
5.3	Comprehensive Maintenance of D G Sets and Portable D.G. Sets	HY / AWR	√
5.4	Maintenance of Valves	HY	√
5.4.a	Maintenance of Actuators	HY	√
5.4.b	Maintenance of Manual Valves	HY	√
5.5	Overhauling & Calibration of PSV	Y	√
5.6	Calibration of safety valve in actuator valve cylinder	Y	√
5.7	Maintenance of Pressure /Flow control valve	Y	√

O&M : TYPICAL MAINTENANCE SCHEDULE

5.12	Inspection of Under Ground Valve Chamber	HY	√
6	**Electrical Equipments**		
6.1	Maintenance of Electrical & Instrument Panels	HY	√
6.2	Comprehensive Maintenance of UPS	HY / AWR	√
6.3	Maintenance of Battery Bank	HY	√
6.4	Maintenance of Earth Pits	HY	√
6.5	Cleaning of Cable Trench	Y	√
6.6	Comprehensive Maintenance of A/C Units	Q	√
6.7	Maintenance of Area lighting system(Outdoor) and Indoor lighting	HY/AWR	√
6.8	Maintenance of Solar lighting system	HY/ AWR	√
6.9	Maintenance of Automatic Voltage Regulator	HY /AWR	√
6.1	Checking and sealing of junction boxes	HY	√
6.11	Checking of Portable Electrical Equipment	Q	√

7	**Fire & Safety**		
7.1	Checking & Calibration of Gas Detection System	Q	√
7.2	Checking & Maintenance of Fire alarm & CO2 Flooding & Clean Agent System	Q	√
7.3	Monitoring of emissions environmental, ambient air & stake monitering	HY	√
7.4	Noice level monitoringn and illumination measurement	HY	√
8	Drinking water testing	Y	√
8	**General Activities**		
8.1	Visit of Unmanned Station	M	√
8.2	Health Checking of U/G installations including valves on sample basis	Y / AWR	√

O&M : TYPICAL MAINTENANCE SCHEDULE

8.3	Peel-off test for checking Cathodic disbandment on sample basis	Y / AWR	√
8.4	Cleaning of Underground and Overhead water tanks	Y	√
8.5	Maintenance of RO system	Q	√
8.6	Pest control in Control Room Buildings to ristrict entry of rats, snake and lizard, etc.)	Q	√
8.7	Gardening, Grass Cutting and Cleaning in process area	HY /AWR	√
8.8	Paintaining of Pipe Support (terracotta)	AWR	√
8.9	Inspection of Under Ground Valve Chamber	HY	
9	Assistance & manpower support for ILI activities	AWR	√
9.1	Pipeline awarness program for villagers/ Public	Q	√
9.2	Mock Drill - Internal	Q	√
9.3	Mock Drill - External	Y	√

M-MONTHLY,
Q-QUARTERLY,
HY- HALF YEARLY,
Y- YEARLY
5Y – 5 YEARLY
10Y- 10 YEARLY
AWR- AS & WHEN REQUIRED
AWA – AS & WHEN AVAILABLE

10	**Pipeline Integrity Management System**		
10.1	Quantative Risk Assessment. (Contractor shall submit the credential of experienced agency for GSPL approval)(approx. 400 Kms to be considered per Base).	5Y	√
10.2	Population Density Index (PDI) (min.100 Kms to be considered per Base).	5Y	√
10.3	Cleaning Pigging through HD foam pigs. (min.160 Kms to be considered per Base).	5Y	√
10.4	CIPL Surevy (min. 200 Kms per Base)	5Y	√
10.5	DCVG/ CAT Survey (min. 50 Kms per Base)	AWR	
10.6	Dig verification of pipeline sections	AWA	√
10.7	Pneumatic testing of pressure vessels at factory act terminals (4 locations)	4 Y	√

O&M : TYPICAL OPERATION ACTIVITIES

- Pipeline operations activities as scheduled
- Active participation in safety activities at locations
- Gas Chromatograph readings and verification
- Handling of pigging debris sample and Lab Testing.
- Minor maintenance of GOOV/GOV/HOVs (e.g. valve greasing etc.) and other equipment.
- Monitoring of booster compressors, mainline compressors, Fire Water pumps and other equipment process parameters like pressure, temperature, level, physical appearance etc. and maintaining records.
- Lineup of meters / filters
- Line up for calibrations
- Line-up for pipeline operation including operation of valves.
- Carrying out the locking arrangement for valves.
- Carrying out disposal of Samples into the sump tank/ETP.
- Loading and Unloading of Diesel into DG set/ Diesel tank using necessary PPE.
- Operation of DG set / Fire hydrant / monitors / valves/Fire engine etc.
- Carrying out/ assisting in maintenance / operational activity as advised by Plant Manager.
- Participating in mock drills & misc. operational jobs time to time.
- Proper handling of tools and spares at stores.
- Operation of Emergency Response Vehicle.
- Material Management / Consumable Management
- Spare Management

O&M : TYPICAL OPERATION ACTIVITIES

- Recording of observations.
  - Any abnormal noise, leakages or spillages in Compressors / Pig station area.
  - Booster / Main Compressors current drawn in Amp from LCS / Gas consumption.
  - CI dosing system parameters.
  - Lube oil level (pump under operation) / Lube oil flow from all bearings / Lube oil temperature / Lube oil filter.
  - Differential pressure across filter.
  - PCV Oil level
  - N2 pressure reading at SRV
  - Line parameters such as pressure / temperature / flow
  - HT & LT Capacitor Bank ON / OFF status from sub-station.
  - Recording of current / voltage / KWH reading / Hour meter reading.
  - Temperature shall be measured at site on compressor / motor bearing surface using temperature gun and recorded in performance sheet.
  - HT/ LT Transformer for visual inspection / oil leakage.
  - HT/LT DG room for DG tank fuel level / Lube oil level / DG in Auto mode
  - DG Battery parameters like battery voltage / battery charging current shall be checked and other indications shall also be checked
  - Operation of viscosity cum density meter.
  - Inspection of Station Block Valves & other valves for any leaks.
  - Checking of Battery Room in Substation and Control Room, (Battery water level, Petroleum Jelly, Sediment level in the battery housing)
  - Check UPS for any alarm or abnormal noise.
  - TSV isolation if any.
  - Checking of tap / eye shower for availability of water.

O&M : TYPICAL OPERATION ACTIVITIES

- To be alert and attending to all operations and events promptly without any delay.
- Carrying out operations correctly and accurately and recording the same in the relevant Log Books.
- Attending to all emergencies which may arise such as equipment failures, fire accidents, etc.
- Assuming responsibility for any damages that occur due to mal-operation of equipment
- Assuming responsibility for the equipment & other materials kept at the Process area
- Assisting in unloading/ loading of materials at site.
- Minor Painting of P/L, structures, others
- Operation of electrical equipment in station.
- Assembling and disassembling of PIGs, launching and receiving of PIGs at all stations, collection and storage of muck collected during pigging activities in designated area, cleaning of PIG barrels etc.
- Upkeep of stations, regular cleaning / housekeeping.
- CI dosing facilities operations and CI chemical handling.
- Adherence to work permit system
- Carry out the job as per the safety conditions specified in the work permit
- All safety norms and use of PPE shall be ensured.
- Operate fire fighting equipment available.
- Attend time to time training programmes.
- Station / Control Room Manning.
- Monitoring of SCADA
- GMC Manning and coordination

O&M : OEM SPECIFIC MAINTENANCE

OEM specific Maintenance Activities

- ✓ Meters
- ✓ Gas Chromatograph
- ✓ Gas Detection System
- ✓ UPS
- ✓ AVR
- ✓ DG / GEG
- ✓ Valves
- ✓ FM200 / CO2 Flooding System
- ✓ Gas Heating Systems / Bathheaters
- ✓ Compressors
- ✓ HVAC
- ✓ Panels
- ✓ SCADA
- ✓ PLC
- ✓ Dosing System
- ✓ Intrusion Detection System
- ✓ Remote Telemetry Unit
- ✓ PSV / TSV / PVRV / ERV
- ✓ Cranes / Lifting Equipment / EOT

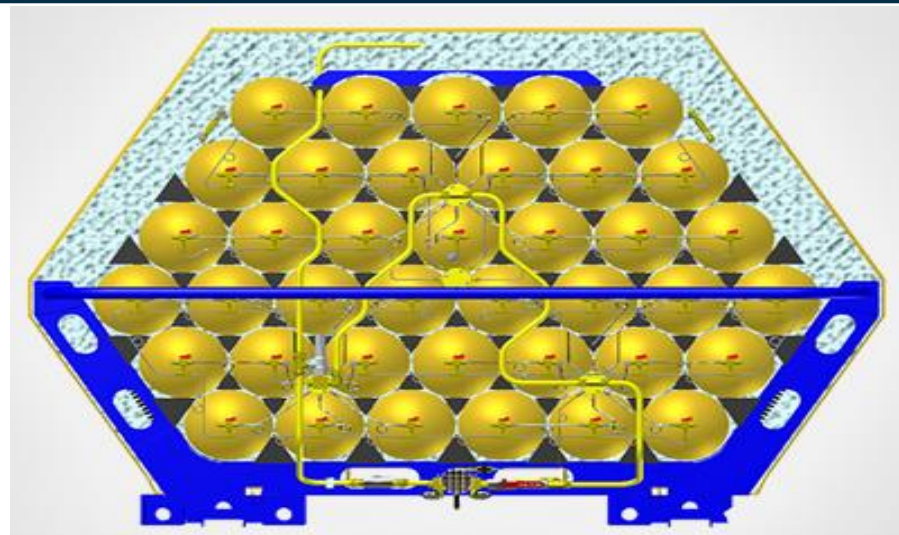
O&M : OISD PIMS SOP

Sl.	Integrity Assessment Test / Analysis	Responsibility
1	Feed Quality Analysis w.r.t. CO2, H2S, Cl, S, moisture / water, condensate, pH value etc.	O&M, Client
2	Geometric pigging	O&M
3	Scrapper pigging	O&M
4	Pig residue analysis Record of quantity and quality of deposits (pig residue) collected after descaling shall be examined to monitor condition of the Pipeline w.r.t. Fe, Fe2O3, Si, S,H2O, pH value, SRB, sulphates, carbonates	O&M
5	Internal Corrosion Monitoring corrosion coupons and ER probes, electrochemical noise technique (ECN probes) or Linear polarization technique (LPR probes), UT sensors etc.	O&M
6	Intelligent Pigging Survey	O&M, Client
7	Cathodic protection, monitoring, upgrading and effectiveness testing	O&M
8	Coating survey (CAT/ DCVG/CIPS)	O&M
9	Soil Testing	O&M
10	Regular line patrolling	O&M
11	Inspection of leak detection system	O&M
12	Inspection of communication and control system	O&M
13	Pressure testing / Hydro testing	
14	Risk assessment (QRA, PDA)	O&M
15	Fatigue Testing (for ERW and LSAW pipes)	O&M
16	Design conformity Test *(tests based on OISD SOP)*	O&M

VIRTUAL PIPELINE

- An innovative and flexible method for natural gas transport from the source to the end-user without using the traditional fixed pipelines.
- Natural gas is transported in its liquefied or compressed form.
- As the liquefaction reduces the volume, it takes much less space and can easily be transported using trucks, ships, trailers, and containers.
- The natural gas via virtual pipelines is transported in the form of LNG or CNG.
- They are known as LNG virtual pipelines or CNG virtual pipelines.
- In recent times, modularized mobile fuel transport are also used.

Integrated O&M agency can also manage interfaces with Virtual pipelines such as planning, filling, logistics, connections / disconnections, routine checks / maintenance, coordination with authorities.



GAS LOSS

Unaccounted for gas / Technical Losses

- Reasons: Leaks and measurement
- Lost revenue

Leaks

- gas escaping to the atmosphere at a given rate at an unknown location
- dependent on the pressure and the size of the hole
- Will increase gradually with time if not located and repaired

Measurement

- Gas lost through measurement or the lack of measurement is very deceptive and at times very difficult to detect.
- Gas measurement is defined as the accounting of all gas bought and sold

GAS LOSS

Cause of UFG

- Line losses (corrosion / hits / third party damage / poor workmanship) and theft
- Differences between line meters (large meters) and residential / user meters (small and great numbers)
- Discrepancies caused by the lag between the time when gas is supplied to the mains and when the gas is recorded as send out (meter reading lag)
- Correction factor estimation (pressure / temperature / composition)

- Limitation of flow measurement devices
- Inaccurate measurement because of poor operation, application, and maintenance

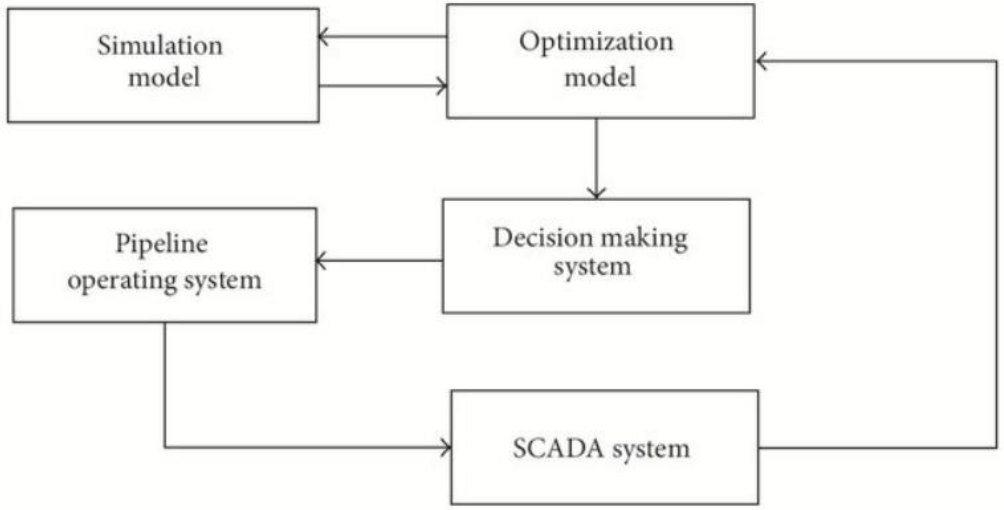
GAS LOSS

How to reduce:

Proper O&M, Better Surveillance, Awareness & Training, Adequate Instrumentation, Increase in accuracy, Adequate compensation / better estimation, Live (frequent) modeling, Data Analytics, Engineering / selection of equipment / meters, Calibration (frequency / purpose / flow)

Meters

- Age, testing and replacement policy
- Random testing for accuracy
- Temperature and pressure compensated
- Accurate meter reads
- Maintenance



Thank You!

O&M : ASME B31G ANALYSIS

- **Flow Stress**
  - 1.1 x SMYS, for plain carbon steel operating at temp. below 250°F (120°C)
    - shall not exceed SMTS
  - SMYS + 10 ksi (69 MPa), for plain carbon and low-alloy steel having SMYS not in excess of 70 ksi (483 MPa) and operating at temperatures below 250°F (120°C)
    - shall not exceed SMTS
  - $(S_{YT} + S_{UT})/2$, for plain carbon and low-alloy steel having SMYS not in excess of 80 ksi (551 MPa) reference ASME B&PV Sec II part D

- **Safety Factor**
  - A flaw or anomaly is considered acceptable where the computed failure stress is equal to or greater than the hoop stress at the operating pressure multiplied by a suitable safety factor.
  - No single safety factor that is suitable for all types of pipeline construction, for all modes of pipeline operation, or for all types of flaws or anomalies
  - B31G recommends a minimum SF equal to the ratio of the minimum hydrostatic test pressure required for the given type of pipeline construction to the MAOP, but usually not less than 1.25.

O&M : ASME B31G ANALYSIS

- **Level 2 Evaluation**
  - performed using Effective Area Method (RSTRENG method).
  - evaluations shall be carried out using a procedure similar to the Level 1, except that the Effective Area Method
  - requires several measurements of the depth of corrosion or remaining wall thickness throughout the corroded area.
  - evaluates, by iteration, all possible combinations of local metal loss, A, with respect to original material, A_0
  - detailed profile is established by obtaining several measurements
  - such measurements may be arranged in a grid pattern, or may follow a “river bottom” path through the deepest areas of metal loss
  - $n!/2(n-2)!$ iterations may be required

$$S_F = S_{\text{flow}} \left[\frac{1 - A/A_0}{1 - (A/A_0)/M} \right]$$

$$z = L^2/Dt$$

Bulging stress Magnification factor

For z <= 50 $M = (1 + 0.6275z - 0.003375z^2)^{1/2}$

For z > 50 $M = 0.032z + 3.3$

where S_{flow} from modif. B31G

Thank You!