STANDARD OPERATING PROCEDURE FOR INTEGRITY ASSESSMENT OF PETROLEUM & NATURAL GAS PIPELINES

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FOR RESTRICTED
CIRCULATION ONY

Guidelines for Integrity Assessment of Cross Country Pipelines

Oil Industry Safety Directorate

Government of India

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RIGHT TO INFORMATION

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PREAMBLE

The mode of transportation of petroleum products and crude oil through pipelines is eco-friendly and safe compared to other modes of transportation. Being a closed system, handling & transit losses are minimum hence pipeline is also considered as the most efficient mode of transportation.

Cross-country pipelines are the lifelines of energy security of our country. For effective transportation of petroleum products, a huge network of pipeline spread across the length and breadth of the country has been built over the years. Nevertheless, there are inherent hazards associated with transportation of hydrocarbons through pipeline from leaks, spills, fires etc.

There is no denying the fact that pipelines laid out in public spaces and their ageing pose safety risks. Moreover, about 33% of pipelines in the country are operating for more than 25 years. To mitigate these risks, it is essential that structured guidelines are drawn for assessing the health of these assets.

I am happy to note that Oil Industry Safety Directorate (OISD) in association with Industry members and experts in the field has developed these guidelines, for piggable as well as non-piggable pipelines, in a matrix format which would enable the Operators to monitor health of these pipelines right from inception stage.

The guidelines would also facilitate the operators in taking informed decisions on continuing operation of ageing assets including residual life, assessment of these pipelines under varying operating conditions, without compromising on the process safety requirements.

I am sure that the matrix would be beneficial and provide necessary guidance to the Pipeline Operators.

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(Saurabh Chandra)

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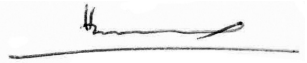
FOREWORD

Some of the cross-country pipeline assets of Oil Industry in India are more than 50 years old. These national assets have been through a natural ageing process. Consequently, the inspection & maintenance required for such cross-country pipelines is more stringent than that for an asset operating within its design life. This, coupled with feedback from some major accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review and systematise the existing practices in vogue for operating and maintaining the ageing cross-country pipelines.

With this in view, the Oil Industry Safety Directorate (OISD) has put its efforts to the above stated cause. In this regard, for the development of this guideline / matrix, for piggable and non-piggable pipelines, OISD has brought together a number of nominated industry experts and consultants to frame these guidelines on the subject of "GUIDELINES FOR INTEGRITY ASSESSMENT OF PIGGABLE CROSS COUNTRY PIPELINES".

This document has been prepared by OISD based on the accumulated knowledge and experience of industry members and the pertinent OISD standards and international codes and practices. This will serve as a ready reckoner for the industry while dealing with their ageing cross-country pipelines. This document is meant to be used as a supplement and not as a replacement for existing codes and practices. Suggestions are invited from the users after it is put into practice to improve the document further.



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Oil Industry Safety Directorate

STANDARD OPERATING PROCEDURE FOR INTEGRITY ASSESSMENT OF PETROLEUM & NATURAL GAS PIPELINES

Contents

SOP FOR INTEGRITY ASSESSMENT OF PETROLEUM & NATURAL GAS PIPELINES

1. Purpose

The purpose of the procedure is to assess health and integrity of old operative & ageing pipelines (beyond design life), residual life assessment and jobs to be undertaken by operators for repair of damages/ defects with the objective to prevent incident and sustain pipeline operation.

2. Scope

This procedure/ guideline is applicable to cross country pipelines transporting crude/ petroleum products /Natural Gas /LPG.

3. Definition :

All definition / explanatory notes mentioned herein below shall be used for this standard.

Cross country Pipeline:

Cross country pipeline means all pipelines located beyond the boundary of any facility including pipelines after separator (exploratory well) and its associated facilities, which are required for transportation of liquid hydrocarbon from one point to another excluding piping within the Refinery/ Separation and / or Processing plant up to plant isolation valves.

Coating:

A material applied to a pipeline / structure to separate it from the environment for preventing corrosion.

CP: Cathodic Protection

A technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

CIPL: Close Interval Potential Logging is technique for finding coating defect.

Consequence:

Means impact on the public, employees, property and environment due to pipeline failure.

Design Pressure:

The maximum internal pressure which the pipeline can be subjected to as determined by design procedure applicable to materials and locations involved.

DCVG: Direct Current Voltage Gradient is technique for coating survey.

Earthing:

Earthing is provision of a safe path of electrical current to ground in order to protect structures, plant and equipment from the effects of stray electrical current and electrostatic discharges.

Electrical Resistance (ER) /Electrochemical Noise Technique (ECN)/Linear Polarization Technique (LPR) probes measure corrosion rates.

IPS: **Intelligent Pigging Survey** is pipeline inspection tool.

LSAW : **LSAW** steel pipe is the abbreviation of Longitudinally Submerged Arc Welding steel pipe

MPY : Mils penetration per year (MPY) is a unit of measurement equal to one thousandth of an inch. It is used to gauge a coupon's corrosion rate.

Maximum Allowable Operating Pressure (MAOP):

The maximum pressure at which the pipeline is allowed to operate. MAOP may be less than or equal to the design pressure.

Maximum Operating Pressure (MOP):

The highest pressure at which the pipeline is operated during a normal operating cycle corresponding to a declared pipeline capacity.

Operating Pressure:

It is the pressure corresponding to a particular flow rate at which pipeline is operated. Operating pressure may be less than or equal to MAOP.

Operating Company:
Shall mean individual, partnership, corporation or public agency/organization or any other entity that operates cross country pipeline.

QRA: QRA is abbreviation of Quality Risk Assessment.

Right-of–User (RoU) / Right-of-Way (RoW):
Through PMP Act'1962 or in accordance with the agreement with the land owner or agency to lay and operate the cross country liquid hydrocarbon pipeline.

Specified Minimum Yield Strength (SMYS):
It is the minimum yield strength specified by specification or standard under which material is purchased from the manufacturer.

Sectionalizing Valve (SV):
Valve (MOVs / HOVs) used in the cross country pipeline system for isolation of a particular pipeline section whenever required. This valve is also referred as main Line valve (MLV).

SCADA: Acronym for **supervisory control and data acquisition**, a computer system for gathering and analyzing real time data.

Terminal Station / Receiving Station / Receipt Terminal:
Terminal / Receiving station / Receipt terminal is the last station on the pipeline used for receipt of liquid hydrocarbon

UT: Ultrasonic Thickness Meter is commonly used for pipe thickness.

4. Reference documents (latest versions)
4.1 OISD standards –141, 214 and 226
4.2 API RP 1160 (Managing System Integrity for Hazardous Liquid Pipelines)
4.3 ASME B31.4 (Pipeline Transportation Systems for Liquids and Slurries)
4.4 ASME B31.8 (Gas Transmission and Distribution Piping Systems)
4.5 ASME B31.8S (Managing System Integrity of Gas Pipelines)
4.6 ASME 31G (Manual for determining the Remaining Strength of Corroded Pipelines)

5. General
An Operator with an ageing asset shall determine extended life beyond initial design limits and ensure future integrity. In this regard operators must first of all conduct baseline survey against which the performance of the pipeline can be judged. This includes a smart pig run, a review of operating records, etc. It has to be understood that an accurate assessment depends on good quality data collected over the life of the pipeline.

6. Integrity Threat Classification
Following are the critical monitoring/inspection, which are essential to assess the health and the integrity of old and ageing the pipelines:

a) External corrosion
b) Internal corrosion
c) Stress corrosion cracking

7. TYPES OF DAMAGING AGENTS

- Third-Party Damage
- Corrosion Related
- Equipment
- Incorrect Operation
- Weather Related
- Manufacture
- Construction
- Environment

After the completion of initially estimated design life of the cross country pipeline, the following monitoring / Assessment of pipeline integrity have to be carried out within one year, using the appropriate methods:

- In-Line Inspection,
  - o Rate of corrosion as calculated by corrosion probe, coupon, sensor placed in the pipeline
  - o Pig residue shall be chemically examined
  - o Intelligent pigging through a high-resolution tool
  - o Records pertaining to inspections, such as external or internal line conditions
- Pressure Test
- Review of CP system
- Review of records of Leak , burst & repair history
- Direct Assessment, or
- Other new technology.

8. Types of defects detected:-

1. External Metal Loss & Internal Metal Loss
2. Leaks, Cracks (including stress corrosion cracking), Arc Burns
3. Girth Weld Flaws
4. Pipeline manufacturing defects such as pipe weld defects, ovelity, leminations etc.
5. Dents
   - o Dents with Stress Concentrators
   - o Plain Dents
   - o Double Dents
   - o Dents that Affect Welds
6. Gouges
7. Wrinkle Bends / Buckles
8. Previous Repairs
9. Mill-Related Anomalies

9. Assessing Defects and Damage In An Ageing Pipeline System

Any reported defects in the pipeline can be assessed using **fitness-for-purpose** methods. The analysis and any resulting repair depend upon:

i. defect severity: location, depth, length, orientation,
ii. financial/strategic value of pipeline,
iii. threat to environment & public relations,
iv. regulatory/legal/insurance considerations,
v. failure consequences.

10. Matrix For Integrity Assessment Of Piggable And Non-Piggable Petroleum & Natural Gas Pipelines :

The matrix for integrity assessment of petroleum and natural gas pipeline has been prepared with the objective of assessing the health of the pipeline during its life cycle as well as assessment of residual life prior to deciding to continue beyond the design life. This will give a guideline to the industry to incorporate in their respective SOPs with the ultimate objective of minimizing failures and sustain pipeline operations.

PART-I

MATRIX FOR INTEGRITY ASSESSMENT OF PIGGABLE (PART-I) PETROLEUM & NATURAL GAS PIPELINES

Type of Test/Analysis	New pipeline/ Construction & commissioning Stage	During design life span (25 years)	Beyond design life (25 years)
1	2	3	4
1. Feed Quality Analysis w.r.t. CO_2, H_2S, Cl, S, moisture/ water, condensate, pH value etc., Remarks /Actions	To be analysed prior to design. Any deviation w.r.t. design should be analysed and corrective action taken w.r.t (i) source control (ii) corrosion inhibitor dosing (iii) odourant dosing (iv) Pipe metallurgy	To be analysed once in a year. Any deviation w.r.t. design or change in service should be analysed by management to take corrective action(s) like : (i) design review, (ii) additional protection for internal corrosion substantiated by IPS results or (iii) Change in pipe metallurgy	To be analysed once in a year. (i) Past and recent data shall be used for detail analysis as well deciding pipeline condition for future use.
2. Geometric pigging Remarks /Actions	Geometric pigging should be carried out (prior to hydro testing) after cleaning of pipeline using foam pig and cleaning pig, to identify ID, dents, pipeline bend condition etc., in the entire pipeline etc., • Deviations should be corrected prior to commissioning • If the pipeline comm-issioning after pressure testing is anticipated to be delayed beyond six (6) months, pipeline shall be preserved using corrosion inhibitors or by filling the line with non-flammable non-toxic gas and at a positive pressure	NA	NA
3. Scrapper pigging	NA	The foam pig should not be used in place of scrapper pig. The frequency of cleaning will be as per OISD-STD-141, 226 and 214 as under: (i) Non ATF Petroleum Product Pipelines - once in six months. (ii) ATF pipelines also carrying other petroleum products – once in three months. (iii) Dedicated ATF Pipelines – once in a year. (iv) Crude Oil Pipelines – once in three months. (v) Two phase / multiphase flow – once in a year (or more frequently if there is significant liquid hold-up) (vi) For dry gas - once in 5 years span (vii) LPG - once in a year	The foam pig should not be used in place of scrapper pig. The frequency of cleaning will be as per OISD-STD-141, 226 and 214 as under: (i) Non ATF Petroleum Product Pipelines - Once in six months. (ii) ATF pipelines also carrying other petroleum products - once in three months. (iii) Dedicated ATF Pipelines – once in a year. (iv) Crude Oil Pipelines – once in three months. (v) Two phase / multiphase flow – once in a year (or more frequently if there is significant liquid hold-up) (vi) For dry gas - once in 5 years span (vii) LPG - once in a year

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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, Fe_2O_3, Si, S,H_2O, pH value, SRB, sulphates, carbonates,….,		The quantity of muck and residue analysis of each pigging should be compared and a trend should be analysed w.r.t. the tendency of corrosion / deterioration of pipeline. If there is an increase in quantity of muck /corrosion product, other corrosive indications, such as sulphur, pH, H_2S etc. the pigging frequency should be increased and corrosion rate should be determined. Increased trend in corrosion product is the signal that feed quality to be analysed immediately to ascertain the corrosivity.	
5. Internal Corrosion Monitoring		# Corrosion monitoring facilities (corrosion coupons and ER probes), electrochemical noise technique (ECN probes) or Linear polarization technique (LPR probes), UT sensors etc., shall be installed in liquid / Natural Gas/LPG pipelines in line with OISD-STD-141/OISD-STD-226/OISD-STD-214. For wet natural gas line also the corrosion coupon & probes at appropriate locations shall be provided for assessing internal corrosion rate.	
Remarks /Action		• If the rate of corrosion is more than 1 MPY, suitable doses of corrosion inhibitor shall be injected to mitigate the internal corrosion and a corrosion rate monitoring program should be implemented • The wet natural gas should be considered corrosive and inhibitor dosing is must since beginning along with monitoring of effectiveness of corrosion inhibitor. • Internal corrosion data should be cross verified with IP results and fitness assessment details to decide for pipe repair / replacement. • If internal corrosion rate is more **than 5 MPY**, next IPS should be suitably advanced to assess the health of the line.	• If the rate of corrosion is more than 1 MPY, suitable doses of corrosion inhibitor shall be injected and a corrosion rate monitoring program should be implemented. • The wet natural gas should be considered corrosive and inhibitor dosing should continue since beginning along with monitoring of effectiveness of corrosion inhibitor • Internal corrosion data should be cross verified with IP results and fitness assessment details to decide for pipe repair / replacement. • If internal corrosion rate is more than 5 MPY, next IPS shall be suitably advanced to assess the health of the line.
6. Intelligent Pigging Survey	# In this IPS the internal inspection tools shall be capable of detecting corrosion, stress corrosion cracking (only for oil pipelines), **illegal fittings intending for pilferage** and deformation anomalies including dents, gouges, grooves, previous repairs, **Mill-Related Anomalies and weld cracks**. # The decision of using weld crack detection tools shall lie on the individual pipeline operator based on the condition of seam weld and girth weld and on the basis of the last IPS carried out as stated above.		
Remarks /Action	• IPS to be done at the earliest not later than 10 years of commissioning intending to create base line data.	• Frequency of Instrument/ Intelligent pigging shall, in no case, be more than 10 years.	• Within one year immediately after completion of design life, IPS shall be carried out & subsequently frequency shall be decided based on the findings and not later than eight

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	• Defects detected with IPS to be corrected. • Further, this data is useful for future risk assessment.	• Defects detected with IPS to be corrected within recommended time. • Following are the types of repairs that could be carried out depending on the type of defect or thickness loss data collected from IPS: a. Replacement b. Mechanical leak clamp c. Grind repair d. "Direct deposition weld" e. Type B, pressurized sleeve or Type A, reinforcing sleeve f. Composite sleeve g. Epoxy filled sleeve h. Annular filled saddle • **The kind of repair to be carried out in lined with ANSI B 31.4 (2012 edition) /API 1160 (refer table 9.2 on summary of commonly used pipeline repairs)**	(8) years interval. However, if any operator has carried out IPS during last five (5) years, then the same shall also be considered and next IPS shall be carried out based on the findings of the last IPS but not later than eight (8) years interval. • For oil & gas pipelines remaining life can be assessed as per Table 3 of ASME B31.8S. • Further, this data should be analysed for fit for purpose & future use.
7. Cathodic protection, monitoring, upgrading and effectiveness testing. REMARKS	• In case, permanent Cathodic Protection is not available within six (6) months from the start of pipeline laying, sacrificial anode based Temporary CP to be ensured. This should be made permanent within six months. • Permanent CP system design to ensure continuous power availability through battery backup at designated locations along ROW.	# Monitoring of effectiveness of installed Permanent CP units. # Pipe to soil potential for entire pipeline(polarized) needs to be maintained in the **band of (-) 0.85 volts to (-) 1.20 volt with respect to copper/copper sulphate half-cell.** • PSP readings at feeding points shall be monitored fortnightly. • The PSP reading (ON potential) at the TLPs for entire pipeline to be taken once in a quarter and survey results shall be plotted graphically to identify and locate cathodic holidays/ un-protected strech of pipeline. • Instant PSP off potential along with ON PSP readings at test lead points of entire pipeline shall be taken once in a year. • Current consumption data to be analysed - yearly and current consumption of each pipeline, pipeline sections (CP to CP) to be compared with previous Current consumption data and results to be analysed	**All activities mentioned in column 3, to be carried out.** **Additional CP monitoring to be done are as under:** • Instant PSP OFF potential reading along with ON PSP at Test Lead point (TLP) of entire pipeline shall be taken up **every six months.** • Current consumption data / current density data/ protection level of the line etc., to be analysed for each pipeline, annually and remedial measures such as strengthening of impressed current CP station should be taken up based on the findings. • Based on analysis of old and recent data regarding health of CP station and coating condition, refurbishment of coating

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1	2	3	4
		and remedial measures based on finding to be taken/ recorded. • Cathodic protection rectifiers - once 3 months. • All protective devices shall be inspected once in 3 months. • Interference bonds - once a year. • Polarization cells - every three (3) months. • At the crossing location of one pipeline with other pipeline, current and PSP data shall be taken once in 3 months. • Ensure continuous power availability for CPs.	shall be taken up.
8. Coating survey (CAT/ DCVG/ CIPS) REMARKS	# Impressed Current CP system, following coating surveys are recommended: I. CIPL ["On" & "Off"] II. Pearson Survey/ CAT Survey/ DCVG Survey III. Coating conductance survey at CP Stations & midway between CP stations. IV. Casing & Carrier short surveys. • One month after Commissioning of **permanent CP in the pipeline.**	• Once in 5 years. • As per the identification of damage of the coating, repair should be taken up immediately	• **Coating Survey :** Within one year immediately after completion of design life, Pearson/ CAT/DCVG Survey to be carried out for the entire pipeline. • Based on above results and overall analysis, if required large scale coating reconditioning program or upgradation of CP unit should be planned. • Subsequent, coating survey & CP survey shall be carried out as per column 3
9. Soil Testing REMARKS		# If any industrial effluent is flowing over the ROW/ROU or any environmental change is noticed on the ROW, or there is any significant increase in current density, the soil samples shall be tested for determining the efficacy of the existing coating and wrapping of the pipeline.	• Within one year immediately after completion of design life, Soil resistivity survey shall be carried out. • After that, Soil resistivity test shall be carried out once in ten years in line with clause no. 5.15 of OISD-STD-188.

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Type of Test/Analysis	New pipeline/ Construction & commissioning Stage	During design life span (25 years)	Beyond design life (25 years)
1	2	3	4
		• During patrolling the line walker to take note of the any environmental changes or any industrial effluent entering the ROW. • Based on this report, soil investigation needs to be planned. • Soil resistivity test shall be carried out once in ten years in line with clause no. 5.15 of OISD-STD-188.	• Correlate that soil resistivity results with PSP/CAT/DCVG/CIPS/IPS results. • Previous data shall be used for risk analysis etc.,
10. Regular line patrolling		# Each operating company shall maintain a periodic pipelines patrol program. • Road and railway crossings shall be inspected at least once in 3 months. • Water body crossings shall be inspected at least twice a year i.e. prior to and after monsoon or flash flood for exposure. • Line Walk by company official at least once in a year for entire length of pipeline shall be carried out after the monsoon. **LIQUID PIPELINES** • Rail/Road Bridge, Suspended crossings shall be inspected once in 3 months to check supports/structures and anti-corrosion coatings where pipe exits/enters ground. • Ground / Aerial Patrolling of ROW - twice in a week (urban areas and non-urban areas) to observe surface conditions, leakage, any construction activity, encroachments, washouts and any other factors affecting the safety and operation of pipeline. **GAS PIPELINE** • Patrolling of ROU/ROW shall be carried out once in 30 days for location class 3 and 4 and once in 90 days (once in a quarter) for location class 1 and 2 to observe surface conditions, leakage, construction activity, encroachments, soil washouts and any other factors affecting the safety and operation of the pipeline. • Villages / public along the right of away shall be adequately made aware of the possible consequence of gas leaks and this shall be included as a part of regular audit.	
11. Inspection of leak detection system		# Installation of application software for leak detection to be ensured.	
		• Proper functioning of leak detection system shall be re-checked. • Effectiveness of the operation to be checked once in a year	• History of leak data and nos. with type of repair shall be used for upgrading /replacement of leak detection system.
12. Inspection of communication and control system REMARKS		# Installation of dedicated communication system, control system, safety interlock and SCADA to be ensured. • Proper functioning of communication system, control system and safety interlocks shall be re-checked and ensured	

MATRIX FOR INTEGRITY ASSESSMENT OF PIGGABLE (PART-I) PETROLEUM & NATURAL GAS PIPELINES			
Type of Test/Analysis	New pipeline/ Construction & commissioning Stage	During design life span (25 years)	Beyond design life (25 years)
1	2	3	4
		• Need to be upgraded, if functionality is found poor. • Base data and nos. with type of repair shall be used for replacement / upgradation of communication system.	
13. Pressure testing (Hydro testing) REMARKS	# The minimum test pressure shall be as 1.25 times the internal design pressure (MAOP) for a minimum period of 24 hours.	# This pressure tests to be conducted once in 5 years in line with respective OISD codes. • **For liquid pipelines :** The minimum test pressure shall be 1.25 times the maximum operating pressure (MOP) for a minimum period of 24 hours. • **For Gas/LPG Pipelines :** 1.25 times the maximum operating pressure (MOP) for a minimum period of 24 hours for location class 1 and 2. • 1.40 times the internal design pressure (MOP) for a minimum period of 24 hours for location class 3 and 4. **Note:** In case operator prefers alternative methods other than hydro test to establish the integrity of the pipeline, it must be demonstrated by the pipeline operator that the alternative selected by him is equivalent to hydro test for establishing the integrity of the pipeline. Further, while selecting alternative (to hydro test) methods pipeline operator has to establish reasons for not choosing hydrostatic testing.	# Based on data collected throughout the design life of the pipeline, a decision is to be taken by the operator to conduct pressure test (hydro test) of the entire pipeline/section of pipeline. The following data should be considered: a. Review of records of leak , burst & repair history b. Rate of corrosion as calculated by corrosion coupons placed in the pipeline. c. Intelligent pigging through a high-resolution tool • Based on pressure test (hydro test) results pipeline repair/ replacement action to be taken. **Note:** In case operator prefers alternative methods other than hydro test to establish the integrity of the pipeline, it must be demonstrated by the pipeline operator that the alternative selected by him is equivalent to hydro test for establishing the integrity of the pipeline. Further, while selecting alternative (to hydro test) methods pipeline operator has to establish reasons for not choosing hydrostatic testing.
14. Risk assessment	Quantitative Risk Assessment to be carried out at the design stage with special focus of high consequence area and risk should be identified with fatality frequency curve. Measures should be taken to bring down the risk to acceptable level.	# Quantitative Risk Assessment (QRA) to be carried out once in 5 years to identify the risk considering the actual population and effect at high risk area or low risk area has become high risk area due to increase in population and permanent settlements. The risk reduction measures should be implemented. A few examples are :	# Based on QRA data and actual growth of population if the risk is not possible to be reduced, a rerouting plan to be considered. **# Risk assessment shall be carried out after completion of design life as per ASME B31.4 & ASME B31.8, ASME B31.8S, API 1160, ASME 31G.** **# The inputs (cumulative for the design life) to be considered for risk analysis are :**

MATRIX FOR INTEGRITY ASSESSMENT OF PIGGABLE (PART-I) PETROLEUM & NATURAL GAS PIPELINES			
Type of Test/Analysis	New pipeline/ Construction & commissioning Stage	During design life span (25 years)	Beyond design life (25 years)
1	2	3	4
REMARKS		1. Design change w.r.t. pipe thickness in view of increase in consequence 2. Distance of sectionalising valves to be reduced and make it remotely operable. 3. Rehabilitation wherever possible. # A thorough data collected during the design life of pipeline needs to be preserved for integrity /risk assessment. # The methods of integrity assessment shall be one or combination of following: a. Internal inspection tools (e.g. Intelligent Pigging) for detecting corrosion and defects including dents, gouges, grooves. b. Pressure testing to be done once at 1.25 times the MOP and held for a period of 24 hours. • The frequency of data collected shall be as per detail mentioned above. • **Integrity assessment intervals to be in line with ASME B31.8S**	• Results of previous integrity assessment, • Coating type and condition • Leak history • Repair history • Cathodic protection history # Remaining strength of pipelines can be assessed in line with ASME 31G. # Thereafter, the operator shall evaluate /get evaluated from competent agency the complete risk of operating the pipeline beyond its design life and submit **Fitness-for-Service certificate** to OISD specifying the allowable future operation period and conditions implying safe operation.
15. Fatigue Testing (for ERW and LSAW pipes)			Based on failure history cases of fatigue failure in any of the pipeline/pipeline sections, failure Fatigue test shall be carried out to establish fatigue strength of LSAW and ERW seam pipe.
16. Design conformity Test		If there exists a gap between current requirement vis-à-vis original design, a design conformity test, covering integrity assurance is to be conducted. Subsequent corrective measures, if any, to be taken.	

PART-II

MATRIX FOR INTEGRITY ASSESSMENT OF NON-PIGGABLE (PART-II) PETROLEUM & NATURAL GAS PIPELINES

Type of Test/Analysis	New pipeline/ Construction & commissioning Stage	During design life span (25 years)	Beyond design life (25 years)
1	2	3	4
1. Feed Quality Analysis w.r.t. CO_2, H_2S, Cl, S, moisture/ water, condensate, pH value etc., Remarks /Actions	To be analysed prior to design. Any deviation w.r.t. design should be analysed and corrective action taken w.r.t (i) source control (ii) corrosion inhibitor dosing (iii) odourant dosing (iv) Pipe metallurgy	To be analysed once in a year. Any deviation w.r.t. design or change in service should be analysed by management to take corrective action(s) like : (i) design review , (ii) additional protection for internal corrosion substantiated by IPS results, if possible or (iii) Change in pipe metallurgy	To be analysed once in a year. (i) Past and recent data shall be used for detail analysis as well deciding pipeline condition for future use.
2. Internal Corrosion Monitoring	# Corrosion monitoring facilities (corrosion coupons and ER probes), electrochemical noise technique (ECN probes) or Linear polarization technique (LPR probes), UT sensor etc., shall be installed in liquid/ Natural Gas/ LPG pipelines in line with OISD-STD-141/OISD-STD-226/OISD-STD-214. For wet natural gas line also the corrosion coupon & probe at appropriate locations shall be provided for assessing internal corrosion rate.		
	• Provision for installation of probe/coupon should be ensured at initial stage.	• If the rate of corrosion is more than 1 MPY, suitable doses of corrosion inhibitor shall be injected and a corrosion rate monitoring program should be implemented • The wet natural gas should be considered corrosive and inhibitor dosing is must since beginning along with monitoring of effectiveness of corrosion inhibitor. • If internal corrosion rate is more **than 5 MPY**, next IPS should be advanced to assess the health of the line.	• If the rate of corrosion is more than 1 MPY, suitable doses of corrosion inhibitor shall be injected and a corrosion rate monitoring program should be implemented. • The wet natural gas should be considered corrosive and inhibitor dosing should continue since beginning along with monitoring of effectiveness of corrosion inhibitor • Internal corrosion data shall be cross verified with IP results and fitness assessment details to decide for pipe repair / replacement.
3. Internal Corrosion Direct Assessment (ICDA) To be carried out in line with OISD-GDN-233, NACE SP-0206-2006, NACE SP-0208-2008,NACE SP-0110 –2010	• Internal Corrosion Direct Assessment to be done not later than 10 years of commissioning intending to create base line data. • Defects detected with ICDA to be corrected.	• Frequency of Internal corrosion direct assessment shall, in no case, be more than 10 years. In place of ICDA, if possible, IPS tool for non-piggable pipeline, which gives complete wall thickness measurements, can be used and internal corrosion phenomenon/ rate can be measured. • Defects detected with ICDA to be corrected within recommended time.	• Within one year immediately after completion of design life, ICDA shall be carried out & subsequently frequency shall be decided based on the findings and not later than 8 years interval. However, if any operator has carried out ICDA during last five (5) years, then the same shall also be considered and next ICDA shall be carried out based on the findings of the last ICDA but not later than eight (8) years interval.

MATRIX FOR INTEGRITY ASSESSMENT OF NON-PIGGABLE (PART-II) PETROLEUM & NATURAL GAS PIPELINES			
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1	2	3	4
			• In place of ICDA, if possible, IPS tool for non-piggable pipeline, which gives complete wall thickness measurements, can be used and internal corrosion phenomenon/rate can be measured. • Further, this data should be analysed for fit for purpose & future use. • Safe operating pressure shall be assessed as per ASME B31G. • For oil & gas pipelines remaining life can be assessed as per Table 3 of ASME B 31.8S.
4. Cathodic protection, monitoring, upgrading and effectiveness testing.		# Monitoring of effectiveness of installed Permanent CP units. # Pipe to soil potential **(polarized potential) needs to be maintained in the band of (-) 0.85 volts to (-) 1.20 volt with respect to copper/copper sulphate half-cell.**	**All activities as mentioned at column 3** **and** **Additional requirements are as under:**
REMARKS	• In case, permanent Cathodic Protection is not available within 6 months from the start of pipeline laying, sacrificial anode based Temporary CP to be ensured. This should be made permanent within six months. • Permanent CP system design to ensure continuous power availability thru battery backup at designated locations along ROW.	• PSP readings at feeding points shall be monitored fortnightly. • The PSP reading (ON potential) at the TLPs for entire pipeline to be taken once in a quarter and survey results shall be plotted graphically to identify and locate cathodic holidays. • Instant PSP off potential readings at test lead points of entire pipeline shall be taken once in a year. • **Current consumption data** - once in a year • Cathodic protection rectifiers - **once 3 months**. • All protective devices shall be inspected once in 3 months. • Interference bonds - once a year. • **Polarization cells - every three (3) months.**	• Current consumption data/ current density data/ protection level of the line etc., to be analysed for each pipeline (half yearly) and remedial measures such as strengthening of impressed current CP station may be taken up based on the findings. • Based on analysis of old and recent data regarding coating holiday refurbishment of coating shall be taken up.

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		• At the crossing location of one pipeline with other pipeline, current and PSP **data shall be taken once in 3 months**. • Ensure continuous power availability for CPs	
5. Coating survey (CAT/ DCVG/ CIPS) REMARKS	# Impressed Current CP system, following coating surveys are recommended: V. ClPL ["On" & "Off"] VI. Pearson Survey/ CAT Survey/ DCVG Survey VII. Coating conductance survey at CP Stations & midway between CP stations. VIII. Casing & Carrier short surveys.		
	• One month after Commissioning of permanent CP in the pipeline.	• Once in 5 years. • As per the identification of damage of the coating repair should be taken up immediately	• All activities as per column 3 • Based on overall analysis, if required large scale coating reconditioning program or upgradation of CP unit should be planned. • Within one year immediately after completion of design life, External Corrosion Direct Assessment (ECDA) shall be carried out on the basis of the results of CAT/ DCVG/ CIPL survey and as per NACE SP-0502-2010.
6. Soil Testing REMARKS		# If any industrial effluent is flowing over the ROW/ROU or any environmental change is noticed on the ROW, or there is any significant increase in current density, the soil samples shall be tested for determining the efficacy of the existing coating and wrapping of the pipeline. • During patrolling the line walker to take note of the any environmental change or any industrial effluent entering the ROW. • Based on this report, soil investigation needs to be planned. • Soil resistivity test shall be carried out once in ten years in line with clause no. 5.15 of OISD-STD-188.	• Within one year immediately after completion of design life, Soil resistivity survey shall be carried out. • After that Soil resistivity test shall be carried out once in ten years in line with clause no. 5.15 of OISD-STD-188. • Previous data shall be used for risk analysis etc.
7. Regular line patrolling		# Each operating company shall maintain a periodic pipelines patrol program.	

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		• Road and railway crossings shall be inspected at least once in 3 months. • Water body crossings shall be inspected at least twice a year i.e. prior to and after monsoon or flash flood for exposure, **LIQUID PIPELINES** • Rail/Road Bridge, Suspended crossings shall be inspected once in 3 months to check supports/structures and anti-corrosion coatings where pipe exits/enters ground. • Ground / Aerial Patrolling of ROW - twice in a week (urban areas and non-urban areas) to observe surface conditions, leakage, any construction activity, encroachments, washouts and any other factors affecting the safety and operation of pipeline. • Line Walk by company official at least once in a year for entire length of pipeline shall be carried out after the monsoon. • Villagers / public along the right of way shall be adequately made aware of the possible consequence of hydrocarbon leaks and this shall be included as a part of regular audit. • Round the clock patrolling by Line walkers or alternative security surveillance system shall be implemented where the pipeline location is vulnerable from pilferage point of view.	
		GAS PIPELINE • Patrolling of ROU/ROW shall be carried out once in 30 days for location class 3 and 4 and once in 90 days (once in a quarter) for location class 1 and 2 to observe surface conditions, leakage, construction activity, encroachments, soil washouts and any other factors affecting the safety and operation of the pipeline. • Line Walk by the official of the company at least once in a year shall be carried out after the monsoon. The latest techniques like satellite imaginary, helicopter etc. can be used for patrolling. • The operating company shall analyse the existing pipeline for new anticipated external loads, when the pipeline is to be crossed by a new road or railroad. The operating company shall install mechanical reinforcement, structural protection, or suitable pipe, in case the design parameters considered are exceeding in order to ensure redistribution of the external loads acting on the pipeline. • Villages / public along the right of way shall be adequately made aware of the possible consequence of gas leaks and this shall be included as a part of regular audit.	
8.Pressure testing (Hydro testing)	**A) For liquid pipelines :** The minimum test pressure shall be 1.25 times the internal design pressure (MAOP) for a minimum period of 24 hours. **B) For Gas Pipelines :** 1.25 times the internal design pressure (MAOP) for a minimum period of 24 hours for location class 1 and 2.	# This pressure tests to be conducted once in 5 years in line with respective OISD codes. • **For liquid pipelines :** The minimum test pressure should be 1.25 times the maximum operatingpressure (MOP) for a minimum period of 24 hours.	# Based on data collected throughout the design life of the pipeline, a decision to be taken by the operator to conduct pressure test (hydrotest) of the entire pipeline. The following data should be considered: a. Review of records of Leak , burst &repair history b. Rate of corrosion as calculated by corrosion

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	1.40 times the internal design pressure (MAOP) for a minimum period of 24 hours for location class 3 and 4. • This pressure testing is to be completed before commissioning of pipelines.	• **For Gas/LPG Pipelines :** The minimum test pressure should be 1.25 times the maximum operating pressure (MOP)for a minimum period of 24 hours for location class 1 and 2. 1.40 times the internal design pressure (MOP)for a minimum period of 24 hours for location class 3 and 4. **Note :** Hydrostatic testing shall be the preferred method of establishing integrity of the pipeline, all efforts shall be made to carry out hydrostatic testing as per prescribed frequency at a suitable pressure corresponding to the operating pressure of the line. In case hydrostatic testing is not feasible due to valid constraints (to be established with reasons), as an alternative In-line Inspection (ILI) shall be done in such lines using suitable technology e.g., MFL, UT etc., Necessary modifications for insertion and withdrawal of ILI tool shall be made in such non-piggable pipelines at the time of undertaking ILI.	coupons placed in the pipeline c. Intelligent pigging (ILI) through a high-resolution tool if it has been carried out. • If required, pressure test (hydrotest)may be carried out within one year of completion of design life. • Based on pressure test (hydrotest)results pipeline repair/ replacement action to be taken. **Note :** Hydrostatic testing shall be the preferred method of establishing integrity of the pipeline, all efforts shall be made to carry out hydrostatic testing as per prescribed frequency at a suitable pressure corresponding to the operating pressure of the line. In case hydrostatic testing is not feasible due to valid constraints (to be established with reasons), as an alternative In-line Inspection (ILI) shall be done in such lines using suitable technology e.g., MFL, UT etc., Necessary modifications for insertion and withdrawal of ILI tool shall be made in such non-piggable pipelines at the time of undertaking ILI.
9.Risk assessment	Quantitative Risk Assessment to be carried out at the design stage with special focus on high consequence area and risk should be identified with fatality frequency curve. Measures should be taken to bring down the risk to acceptable level.	# Quantitative Risk Assessment (QRA) to be carried out once in 5 years to identify the risk considering the actual population and effect at high risk area or low risk area has become high risk area due to increase in population and permanent settlements. The risk reduction measures should be implemented. A few examples are : 1. Design change w.r.t. pipe thickness in view of increase in consequence 2. Distance of sectionalising valves to be reduced and make it remotely operable. 3. Rehabilitation wherever possible.	# Based on QRA data and actual growth of population if the risk is not possible to be reduced, a rerouting plan to be considered for reviewing the location class. **# Risk assessment shall be carried out after completion of design life as per ASME B31.4 & ASME B31.8, ASME B31.8S, API 1160, ASME 31G.** # The inputs (cumulative for the design life) to be considered for risk analysis are : • Results of previous integrity assessment, • Coating type and condition • Leak history • Repair history • Cathodic protection history

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		# A thorough data collected during the design life of pipeline needs to be preserved for integrity / risk assessment. # The methods of integrity assessment shall be one or combination of following: a. Internal inspection tools (e.g. Intelligent Pigging) for detecting corrosion and defects including dents, gouges, grooves. b. Pressure testing should be done once at 1.25 times the MOP and held for a period of 24 hours. • The frequency of data collected shall be as per detail mentioned above. • **Integrity assessment intervals to be in line with ASME B31.8S**	**# Remaining strength of pipelines can be assessed in line with ASME 31G.** • Thereafter, the operator shall evaluate /get evaluated from competent agency the complete risk of operating the pipeline beyond its design life and submit Fitness-for-Service certificate to OISD specifying the allowable future operation period and conditions implying safe operation.
10. Fatigue Testing (for ERW and LSAW pipes)			If there is seam failure case, fatigue test shall be carried out to establish fatigue strength of LSAW and ERW seam.
11. Design Conformity Test		If there exists a gap/change between current requirement vis-à-vis original design/ service condition, a design conformity test (confirming suitability for the same), covering integrity assurance is to be conducted. Subsequent corrective measures, if any, to be taken.	