Internal Corrosion Monitoring of Pipelines
1.0 Preamble

1.1 Internal Corrosion Monitoring is an integral part of the Corrosion Management System of Pipelines which in turn is a critical component of the overall Pipeline Integrity Management System. Corrosion monitoring is particularly essential when carbon steel is used under potentially corrosive conditions. Even for corrosion resistant materials (CRAs), corrosion monitoring is useful.

1.2 Corrosion Monitoring mainly serves the following purposes:

- Integrity verification of piping or pipelines, at various intervals of time over the life of the pipeline
- Verification of effectiveness and optimizing corrosion control and mitigation strategies, such as corrosion inhibitors.
- Risk-based inspection planning system.
- Remaining Life estimation and extension.
- Lower operating costs:
  - Reduces maintenance/inspection costs
  - Minimizes unscheduled shutdowns
- Assessment of an impact from operational changes/upsets.

2.0 Objectives

2.1 The objective of the Corrosion Monitoring are manifold:

- To establish a balance between the corrosion control and replacement costs;
- To provide valuable information and time to take corrective action.
- To measure of effectiveness of the corrosion control efforts and costs.

2.2 This document seeks to provide guidance on the minimum monitoring points, locations, and methodologies for an effective monitoring program.

3.0 Scope

3.1 The scope of this document is limited to monitoring internal corrosion (general and/or localized corrosion). It does not specifically cover other damage mechanisms such as fatigue, cracking or erosion. Microbial monitoring is also not covered in this document for which Guidance Document CIMG-GD-5-2016-0007 may be referred.
3.2 The scope of this document is further limited to Internal Corrosion Monitoring of pipelines only and for station piping, vessels etc., a separate document CIMG-GD-4-2016-0007 may be referred.

3.3 The scope of this document is limited to three monitoring techniques: Mass Loss (ML), electrical resistance probe (ER) and permanently installed Ultrasonic transducer (PUT). The ML and ER probe measure corrosion rate of probes whereas PUT measures the wall loss of the pipe itself. Both ML and ER probes provide time-averaged corrosion rate of the probes and PUT provides loss of wall thickness of the pipeline or pipe.

3.4 The objective of this document is to provide the minimum basic set of requirements for the selection and installation of the corrosion monitoring equipment in the GAIL pipeline network. It is not intended to be an ultimate guide for every individual pipeline or every individual case. These basic and minimum requirements shall apply to all the GAIL transmission gas pipelines that are ordinarily deemed to be “dry”, i.e., free of liquid water. However, if the pipelines have a history of increased or increasing trend of degradation caused by internal corrosion, those pipelines shall be prioritized and investigated on a case to case basis. Such investigation process should include full corrosion evaluation leading to the root cause finding and to the development of the list of actions. The process may lead to, inter alia, a more advanced or rigorous corrosion monitoring, e.g. a change of the sensitivity of monitoring technique and its components, change in monitoring intervals (both in time and distance), use of a more robust monitoring technique, use of extended analysis coupons, change in Condition Monitoring Locations (CML) or creation of additional locations. The process shall encompass the multi-discipline activity between the qualified and experienced personnel practising corrosion /material sciences, flow assurance, pipeline engineering, production chemistry and other specialisations.

3.5 Notwithstanding the various assertions of this document, it must be recognised that all monitoring techniques are point monitors, i.e., the monitor corrosion rate at the point where they are placed. Further most of them measure only general corrosion rate, whereas almost all incidences happen due to pitting corrosion (PR).

4.0 Approach & Methodology

4.1 Approach

4.1.1 Internal Corrosion occurs by various mechanisms and is influenced by numerous factors. The mode of monitoring required is related to type of the mechanism(s) and to the multiplicity and the severity of the factors responsible for internal corrosion in pipelines. Out of all the factors, the quality of fluid and the corrosivity of the medium are the most important ones. Accordingly, the pipelines handling dry gas where robust
processing and treatment facilities exist and operate continuously with infrequent outages may require a less stringent monitoring as opposed to gas flowing from regional gas gathering / collecting stations where pre-treatment is minimal. Furthermore, the pipeline type i.e., whether it is piggable or unpiggable is also important to take into account when designing a corrosion monitoring system. The pipes may be pigged for cleaning purposes or for inspection (commonly known as intelligent pigging or inline inspection (ILI)). The correlation between the ILI data and the corrosion monitoring in the piggable pipeline helps understanding the corrosion degradation mechanisms, understanding the performance of the corrosion monitoring system, as well as understanding the performance of the overall corrosion management program.

4.1.2 A fit-for-purpose and robust Corrosion Monitoring System shall always be implemented into the design and construction of the pipeline system; however, where it has not been, it shall be retrofitted in to the existing pipelines in accordance with the requirements of this guidance document.

4.1.3 It is recommended that the probes, coupons and ancillary equipment & services in installation may be undertaken by GAIL sites directly from manufacturers. For services in monitoring and change of coupons etc., GAIL sites may line up rate contracts for extended periods (typically two years) from competent services providers having experience in monitoring / maintenance of corrosion monitoring equipment of different manufacturers.

4.2 Methodology
4.2.1 A location on pipeline or piping which is selected for monitoring internal corrosion shall be designated as ‘Condition Monitoring Location (CML)’.

4.2.2 An overview of all the corrosion monitoring techniques available can be found in NACE International Publication 3T199. However, the following internal corrosion monitoring techniques shall be employed in GAIL pipeline networks, unless otherwise required in specific cases following in-depth studies:

a) Mass Loss Coupon  
b) Electrical Resistance (ER) Probe  
c) Permanently attached Ultrasonic Transducer

4.2.3 The detailed description, types available, selection criteria, guidelines for installation, maintenance of the monitoring systems are given in the Appendices at the end of this document with reference to the relevant NACE standards and standard practices.

4.2.4 Coupons and/or probes installed in GAIL pipeline systems shall be of retrievable type
with standard 2” Access fittings and tools. The access kit consisting of retriever tool and service valve kits shall have pressure rating of minimum 3600 psi and all components /materials shall comply with NACE MR-0175 material specification.

4.2.5 Condition Monitoring Locations (CML)

4.2.5.1 Dry gas Pipelines (Water dew point ≤ 0\(^{\circ}\) C) and HC dew point depression (HC dew point ≤ 10\(^{\circ}\) C)

a) As a minimum, all the pipelines 4” in diameter & above and between 50 and 100 Km in length, shall have at least one CML at the start of the ‘pipeline’. For pipelines over 100 Km of length, there shall at the least be one CML at the start and one at the end. ‘Pipeline’ refers to the complete pipeline of the same diameter irrespective of the number of sections (scraper launcher to receiver) it may comprise.

b) Any pipeline section emanating from a ‘gas source’, shall have at least one CML at the concerned Despatch Terminal for the source. Gas source shall mean all the external sources from where gas is sourced as well as GAIL’s process plants at which the gas quality is altered. If multiple pipelines emanate from such terminal, it may be sufficient to select a CML for one of the pipelines, provided that there is no change in quality of gas flowing into such pipelines.

c) Any secondary pipelines or pipeline sections branching out the main dry gas pipeline may not require a separate CML if they are less than 50 Km and if their risk profiles are not significantly different from that in the main pipeline. Otherwise, one CML at the start or end of the pipeline shall be provided.

d) Additional CML may be identified and selected at locations of high corrosion rates identified through repetitive cycles of Direct Assessment or ILI. This may provide the basis for a worst case assessment for other pipelines in the region.

4.2.5.2 LPG Pipelines & Other gas pipelines

a) For LPG pipelines and other gas pipelines (gas quality other than that mentioned in 4.2.5.1), CML shall be at the start and end of each ‘pipeline’ section if the pipeline length is more than 50 Km.

b) For the pipelines shorter than 50 Km, one CML at the start of the pipeline shall be sufficient.

c) No separate CML is required in such short pipelines as in (b) above, if the pipelines are connected to the other pipelines where CMLs have already been provided.
d) In isolated clusters or network of small length pipelines, one CML for every cumulative length of 50 Km of pipelines shall be provided (i.e., one CML for cumulative length up to 50 Km, 2 CML for pipeline cluster above 50 Km but up to 100 Km, and so on). In such cases CML shall be selected at the start of such pipeline sections with largest diameter / lowest velocity.

e) Any pipeline section emanating from a ‘LPG / gas source’, shall have at least one CML at the concerned Despatch Terminal for the source. LPG / Gas source shall mean all the external sources from where gas is sources as well as GAIL’s process plants. If multiple pipelines emanate from such terminal, it may be sufficient to select a CML for one of the pipelines, provided that there is no change in quality of gas flowing into such pipelines.

f) Additional CML may be identified and selected at locations of high corrosion rates identified through repetitive cycles of Direct Assessment or ILI. This may provide the basis for a worst case assessment for other pipelines in the region.

4.2.5.3 **Essential requirements with regard to CML and the coupon / ER probe placement**

a) A CML can be located on the mainline portion of the pipeline whether above underground or aboveground. Where such implementation is not feasible, CML can also be selected on any piping connection to such mainlines subject to the condition that the mainline flow takes place through such piping.

b) Each Condition Monitoring Location (CML) shall have a minimum of one Mass Loss Coupon and one ER probe with a minimum separation distance of 1.5 times the pipe diameter on which it is installed, between the two.

c) The Mass Loss coupon in general shall be flush disc type 1.25” diameter x 1/8” thickness with one mounting hole of ID 0.312”. The material of the coupon shall be same or as close to the pipe grade in which it is intended to be installed.

d) The ER probe in general shall be flush type with strip type element. For pipelines emanating from gas/LPG sources where the fluid is treated for moisture removal, the ER probe at the first CML shall be a High Sensitivity type (Refer to Appendix B for specifications for High Sensitivity ER probes).

e) All the Mass Loss Coupons and ER Probes shall be high pressure retrievable type. An access fitting assembly for retrieval and re-insertion of the probes and coupons under pressure shall be provided.

f) Access fittings for ER probe and Mass Loss coupons shall be fitted at 6 o’clock orientation of the pipeline / piping. Where for whatsoever reasons, if the same
cannot be installed at 6 ‘O’ Clock position and further provided that the same is being installed in an unpiggable pipeline and piping section, installation of probe / coupon may be done at 12 ‘O’ Clock position with extended stem for the probe / coupon to reach the bottom of the pipeline / piping without actually touching the bottom surface. In such cases, in order that the extended stem is rigid enough to withstand the induced forces and vibration caused by the pipeline fluid velocity, ‘Wake Frequency’ calculation and validation shall be performed.

g) Where a CML is in buried section of pipelines, the same shall be provided with an Access Vault with sufficient clearance from bottom of pipe for accessing the location of the probe fitting for data collection and retrieval. The vault shall be a RCC construction with sealed and secure covers for preventing ingress of water, extraneous matter or unauthorized access inside the vault.

h) In the areas where an Access Vault cannot be constructed, a Permanently attached Ultrasonic Transducer (PUT) with the buried terminal boxes may be considered. The ER probes in other locations may also be substituted with PUT if required. However, the Mass Loss coupons shall not be substituted with PUT.

i) If, as a result of a corrosion assessment or an in-line inspection, Top of Line Corrosion (TLC) is evident, an additional CML may be considered at the 12 o’clock position.

4.2.6 Access Fitting Assembly for Corrosion Coupons / Probes

4.2.6.1 The access fitting shall be the 2” NB, flare weld Access Fitting Assembly (non-tee), carbon steel (CS) body, and the acme thread outlet with the solid plug assembly (mass loss coupons) and hollow plug assembly (ER Probes), along with the heavy duty protective CS cover complete with essential spares. The height of the access fitting in general shall be 5.25”. The pressure rating shall be 6000 psi and the design temperature from -29 to 65°C.

4.2.6.2 The access fitting shall be designed for rust free operation and protection shall be provided to the threads for service life.

4.2.6.3 The Access fittings should be compatible with the ER Probe / Corrosion Coupons made by different manufacturers.

4.2.7 Retriever and Service Valve Kit

4.2.7.1 A compatible retrieval tool shall be procured along with service valve kit at the time of installation.

4.2.7.2 A Retrieval kit complete with repair & seal kit for ER probes & coupon with holders
and service valve kit, complete with blanking plug, extension lever, brass hammer, spare face-to access fitting O-ring, heavy duty field service box, essential repair and seal kit, shall be kept at Pipeline Maintenance Bases. Rating shall be minimum 900 Class.

4.2.7.3 The retriever and service valve kits shall be compatible with both the probe & coupon designs.

4.2.7.4 Service Valve shall be of double block & bleed type for safe de-pressurization with compact design complying with API 6D, API 6FA and API 607 as a fire safe unit.

4.2.8 Installation

4.2.8.1 Unless provided in the original design of the pipeline system, the Mass-Loss Coupons and ER probes shall preferably be retrofitted into the selected Condition Monitoring Location (CML) during shutdowns/turnarounds. However, if it is not possible, then hot-tapping may be used to install the equipment when the pipeline is under pressure subject to the satisfactory risk assessment being carried out in advance.

4.2.8.2 The selected CML location shall be thoroughly inspected by NDT to ensure the remaining wall thickness is sufficient and meets all the requirements for the new fitting. The hot tapping shall be carried out in accordance with the vendor’s approved procedure, all the welding works shall comply with the approved Welding Procedure Specification (WPS) followed by NDT examination, per API-1104 - Standard for Welding Pipelines and Related Facilities.

4.2.8.3 The pipeline with the installed access fitting shall be hydro-tested. In case of hot-tapping, the fitting shall be tested with the hot tapping machine installed.

4.2.8.4 Installation of the probes / coupons shall be accomplished by the trained personnel using approved procedures as recommended by the reputable and certified vendor and in compliance with all the safety regulations and requirements.

4.2.8.5 The installation details of the probes / coupons shall be recorded by Pipeline Maintenance Base / RIMG, in the formats given in the Appendices for respective monitoring technique and uploaded in the Web application deployed in GAIL O&M Intranet Portal.

4.2.9 Frequency of Monitoring

4.2.9.1 ER probes shall be provided with a battery operated data logger as a minimum. If online monitoring is required both data logger and transmitter may be provided (in such cases, an integrated transmitter cum data logger in one device may be used when available). In data logger, data reading frequency shall be set to a minimum of once
**Title**
Internal Corrosion Monitoring of Pipelines

**Type**
Guidance

**Reference No.**
CIMG-GD-5-2016-0006

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every day in case of standard sensitivity probe & once every hour in case of High Sensitivity type and the data from the logger shall be downloaded once a month. The batteries of the data logger shall be inspected, checked and, if necessary, replaced at the time of downloading the data into a Hand Held Unit (HHU). At locations where neither data logger nor transmitter is feasible, readings can be directly taken by an HHU. The frequency of such monitoring shall be at least once in a fortnight.

4.2.9.2 The mass loss coupons shall be retrieved once every six months. However, the monitoring interval may be varied subject to changes in the pipeline process conditions, inspection and monitoring history, corrosivity of the medium or the requirements to focus the monitoring on a specific corrosion mechanism. Such deviation in the frequency and the rationale for such change in frequency of coupon retrieval should be recorded. New coupons shall be installed every time for the next monitoring period.

4.2.10 Data Management

4.2.10.1 A web application for managing and analysing Corrosion Monitoring Data is available on the Intranet – Corporate O&M portal and can be accessed through the Corrosion Management group icon.

4.2.10.2 In order to facilitate management of corrosion monitoring data over an online database, each CML shall have its unique identification number and tag as below:

<table>
<thead>
<tr>
<th>Network Code</th>
<th>Maintenance Base</th>
<th>Equipment Category</th>
<th>CML Serial Number</th>
<th>Equipment Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>106</td>
<td>01</td>
<td>50</td>
<td>01</td>
<td>Mass Loss coupon = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ER Probe = 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PAUT=3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Designated spot for periodical Thickness measurement = 4</td>
</tr>
</tbody>
</table>

* For eg., KG Basin, Tatipaka Base, first CML of the base, Mass Loss Coupon type and first mass loss coupon in the base, is considered

Table 1: Scheme for coding of Corrosion Monitoring Equipment.

4.2.10.3 After designating the CML, coupon, probe / PUT id, the same shall be visually represented in the field by means of metal tags or stencilling on the pipe and mapped in the intranet portal. The CML shall also be mapped to the pipeline or pipeline section
Id(s) for which it is intended.

4.2.10.4 Each CML shall be allocated with a summary information sheet detailing the CML ID tag, monitoring technique used and the basic details of the probe / coupon / transducer as illustrated in Table 2.

<table>
<thead>
<tr>
<th>S No</th>
<th>Parameter</th>
<th>Details to be provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Corrosion Monitoring Location Id</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Station Name (where CML is located)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CML Location in Station (Describe the location of CML; line number or distance upstream / downstream of reference Valve and Valve ID etc.)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CML Orientation on pipe (w.r.t Flow Direction)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Pertains to Pipeline or Pipeline Section</td>
<td>Pipeline / Pipeline Section</td>
</tr>
</tbody>
</table>

*Mention below the pipelines covered by the above CML; Add rows depending on numbers of Pipelines represented.*

|     | Pipeline/ Pipeline Section Code              |                                                             |
|     | Pipeline/ Pipeline Section Name             |                                                             |
|     | Pipeline/ Pipeline Section Code             |                                                             |
|     | Pipeline/ Pipeline Section Name             |                                                             |

*Mention below the Corrosion Monitoring Equipment installed in the CML*

|     | Corrosion Coupon Id                         |                                                             |
|     | Coupon SAP Id (if available)                |                                                             |
|     | ER Probe Id                                 |                                                             |
|     | ER Probe SAP Id (if available)              |                                                             |
|     | PUT Id                                      |                                                             |
|     | PUT SAP Id (If available)                   |                                                             |

Table 2: Corrosion Monitoring Location Summary Information Sheet

4.2.10.5 The date and the time of installation and retrieval of each corrosion monitoring device (ER probe / ML Coupon / PUT) from each CML shall also be recorded in the formats, given in the Appendices.
4.2.10.6 The acquired data from coupon retrieval, ER Probe and PUT shall be uploaded in the Web application in the O&M Intranet Portal at the end of each monitoring period for further processing and analysis.

4.2.11 Analysis and Action

4.2.11.1 The mass-loss corrosion coupons allow the direct estimate of the Mass Loss occurred over the exposure period. The lost weight can then be converted to general corrosion rate. Pitting rate can be estimated separately (ref NACE SP-0775-2013).

4.2.11.2 The severity of corrosion shall be categorized using the corrosion rate bands given in Table 3 (reference NACE SP-0775-2013).

<table>
<thead>
<tr>
<th>General Corrosion Rate and Pitting Rate and the Associated Risk Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Low</td>
</tr>
<tr>
<td>Moderate</td>
</tr>
<tr>
<td>High</td>
</tr>
<tr>
<td>Severe</td>
</tr>
</tbody>
</table>

Table 3: Categorisation of Carbon Steel General and Pitting Corrosion Rates

4.2.11.3 The data from ER probe and /or UT Transducer does not give absolute readings of corrosion rate and shall only be used to establish and monitor the trend of corrosion rate changes with time.

4.2.11.4 Analysis of ER probe reading trends shall include evaluating the rate and variations. Variations shall be looked into closely to correlate with any operational upsets.

4.2.11.5 After analysis of corrosion monitoring data for a minimum period of one year and based on the category determined according to the average general corrosion rate or pitting rate, appropriate action shall be considered as below. For establishing the category, worst case scenario should be considered. For instance, if the general corrosion rate is in low category and pitting rate is in moderate category, for the purpose of using Table 3, the category should be considered moderate. The list of actions and responses to the corrosion rate measured over the monitoring interval is shown in Table 4.
<table>
<thead>
<tr>
<th>Category (ref Table 3)</th>
<th>Action</th>
<th>Action to be completed within</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Continue Monitoring</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Moderate</td>
<td>Continue Monitoring;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Investigate the causative factors of the increasing(ed) corrosion rates.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benchmark the monitoring results against the alternative inspection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>data (current and historic) and the latest corrosion modelling results.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>review process parameters, identify any changes, review any upset</td>
<td></td>
</tr>
<tr>
<td></td>
<td>conditions that might have occurred.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review the risk assessment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amend the pipeline corrosion management plan if necessary.</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Continue Monitoring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform root cause analysis.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benchmark the monitoring results against the other inspection data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and the latest corrosion modelling results, review process parameters,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>identify any changes, review any upset conditions that might have</td>
<td></td>
</tr>
<tr>
<td></td>
<td>occurred.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identify the remedial action:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Review the performance and effectiveness of the existing corrosion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>management system, if present (e.g. corrosion inhibition)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Design and set up the new corrosion management system: water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>removal, dehydration, corrosion inhibition, biocide injection.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Perform remaining life calculation, update the risk assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Update the pipeline corrosion management plan and the RBI system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Continue with corrosion monitoring and inspection programs to verify</td>
<td></td>
</tr>
<tr>
<td></td>
<td>that the corrosion management system performs as intended.</td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td>Fast track the actions identified in the ‘High’ category.</td>
<td>Within 30 days</td>
</tr>
</tbody>
</table>

Table 4. List of Actions and Responses to the Monitored Corrosion Rates
<table>
<thead>
<tr>
<th>Title</th>
<th>Internal Corrosion Monitoring of Pipelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Guidance</td>
</tr>
<tr>
<td>Reference No.</td>
<td>CIMG-GD-5-2016-0006</td>
</tr>
</tbody>
</table>

**Reference**

- OISD-STD-188 : Corrosion Monitoring of Offshore & Onshore Pipelines
- NACE-SP0106-2006 : Control of Internal Corrosion in Steel Pipelines and Piping Systems
- NACE 3T199 : Techniques for Monitoring Corrosion and Related Parameters in Field Applications
- NACE-SP0775-2013 : Preparation, Installation, Analysis, and Interpretation of Corrosion Coupons in Oilfield Operations.
- ASTM G96 : Standard Guide for Online Monitoring of Corrosion in Plant Equipment (Electrical and Electrochemical Methods)
Mass Loss Coupons

1.0 Introduction

1.1 Mass-Loss coupons are the metal test specimens exposed to the corrosive medium for a specified period of the test. They are manufactured in variety of shapes from the same material as the pipeline under examination. The pre-weighed coupons are placed through the appropriate fittings into the pipeline or a vessel in direct contact with process environment.

2.0 Principle

2.1 Mass-loss coupons are small test specimens of metal that are exposed to an environment of interest for a period of time to determine the reaction of the metal to the environment. The coupon is retrieved at the end of the test period and any remaining corrosion products mechanically and/or chemically removed.

2.2 The mass loss calculated by noting the difference between the weight of the coupon prior to installation and weight after retrieval & cleaning divided by the area of exposure gives the general corrosion rate:

\[
\text{Corrosion Rate in mm/y} = \frac{(\text{Mass Loss in grams}) \times 3.65 \times 10^6}{A \times d \times t}
\]

where:

A – total surface area of the coupon exposed to the corrosive environment (mm²)

d – density of corroding metal (g/cm³)

t – time (days)

2.3 The maximum pitting rate (PR) is calculated separately from the mass loss coupons, as below:

\[
\text{PR (mm/y)} = \frac{\text{depth of the deepest pit (mm) \times 365}}{\text{exposure time (days)}}
\]

3.0 Types & Selection

3.1 Though several types of coupons are available, only the Flush-Disc type shall be employed for general application in GAIL pipeline systems. Other type(s) of coupons may be used if required subsequent to a specific Corrosion Assessment in a particular pipeline section.
3.2 Flush type disc shall have tapering for stainless steel fastener mounting with nylon insulation. The size of the coupon shall be 1 1/4” diameter and 3 mm thick.

3.3 Coupons shall be delivered in ground, 120 grit finish, free of contaminants, shall be certified for weight and dimension, packed individually in moisture proof sealed Vapor Corrosion Inhibitor (VCI) bags suitable for storage for minimum one year.

3.4 All the coupons shall be suitable for mounting with high pressure access system for online retrieval.

4.0 Access Fitting

4.1 The access fitting material shall be compatible with the pipeline material and size.

4.2 The access fitting shall be the 2” NB, 5 ¼” in height, flare weld Access Fitting Assembly (non-tee) with Integral Branch Reinforcement per ASME B31.3, carbon steel (CS) body, and the acme thread outlet with the solid plug assembly in AISI-316, along with the heavy duty protective CS cover complete with essential spares. The pressure rating shall be 6000 psi and the design temperature from -29 to 204°C.

4.3 The access fitting shall be designed for rust free operation and protection shall be provided to the threads for service life.

4.4 The Access fittings should be compatible with Corrosion Coupons made by different manufacturers.
4.5 The fitting assemblies shall have the protective covers to protect external thread and the external seal area from damage.

5.0 Plug and Coupon Holder

5.1 All the coupons shall use the solid plug assembly in the access fitting.

5.2 Sealing shall be achieved by Viton ‘O’ ring and Teflon primary packing suitable for temperature of -29°C to 204°C.

5.3 All Disc Coupon Holder Assemblies shall be fixed type (of suitable dimensions for identified CML) made of AISI 316 conforming to NACE MR 0175 and MR 0103, attaching to the bottom of the Solid Plug Assembly of the Access Fitting Assembly by means of a left-hand threaded nut.

5.4 When attached, the assembly shall securely lock into place by a set screw. The attaching nut replaces the Solid Plug Nut component of the Solid Plug Assembly and also serves as the primary packing retainer. Coupon attachment shall be by a single flat head machine screw-type with Teflon® insulation.

6.0 Purchase Information

6.1 Procurement of Mass Loss Coupons shall be made only from reputed manufacturers with proven industry expertise and experience.

6.2 The following are some of the manufacturers / suppliers of coupons.

(a) Alabama Specialty Products Inc (Metal Samples), USA
Title: Internal Corrosion Monitoring of Pipelines

Type: Guidance

Reference No.: CIMG-GD-5-2016-0006

6.3 The template at Appendix-D shall be used to provide and obtain technical confirmation on the required coupon.

6.4 Coupons shall be weighed up to 0.1 mg precision, provided with a unique serial number and packed in moisture proof VCI bag.

6.5 Coupon weight data sheet supplied with each order shall furnish the specific details of each coupon as to material composition, weight in grams to 0.1 mg and its identifiable serial number.

6.6 Inspection and Tests: The Manufacturer & Contractor shall perform all inspection and tests as per the requirements of this specification and the relevant codes, prior to shipment from their Works. Such inspection and tests shall include, but not limited to, the following:

6.6.1 All assemblies and components shall be 100% visually inspected & hydro tested and test certificates for the same shall be provided.

6.6.2 Dimensional checks shall be carried out as per the approved drawings.

6.6.3 Chemical composition and mechanical properties including hardness shall be checked as per relevant material standards and this specification.

6.6.4 All butt welds of pressure containing parts shall be examined 100% by radiography. Acceptance limits shall be as per ASME B31.4 / ASME B31.8. Welds, which cannot be inspected by radiographic methods, shall be checked by ultrasonic or magnetic particle methods. Methods of examination shall be as per ASME Section VIII Div.1 Appendix 12 and Appendix 6 respectively.

6.6.5 All forgings shall be wet magnetic particle inspected on 100% of forged or extruded surfaces. Method and acceptance shall comply with MSS-SP-53. The end section of the components to be welded shall be 100% ultrasonically tested for lamination type defects for a distance of 50 mm from the ends prior to being prepared. The presence of any discernible defects shall be cause for rejection.

6.6.6 All fillet welds of thickness less than 6 mm shall be examined 100% by Magnetic Particle Inspection and 6 mm shall be examined 100% by angle probe UT. Acceptance criteria for
MPT and UT shall be as per ASME Sec. VIII Div.1 Appendix 6 and Appendix 12 respectively.

6.6.7 The hydro test water shall be clean and fresh water. Test procedure and Inspection & Test Plan (ITP) shall be submitted to GAIL for review and approval.

6.6.8 GAIL may elect to appoint its own or authorised Inspector to perform stage wise inspection and witness tests at Manufacturer's Works prior to shipment. Manufacturer shall give reasonable notice of time and shall provide, without charge, reasonable access and facilities required for inspection by GAIL. Inspection and tests performed/witnessed by the GAIL shall in no way relieve the Manufacturer's/Contractor’s obligation to perform the required inspection and tests.

6.6.9 Manufacturer shall submit the following certificates:

6.6.9.1 Test certificates relevant to the chemical analysis and mechanical properties including hardness of the materials used for the manufacture as per relevant material specification.

6.6.9.2 Test reports on non-destructive testing.

6.6.9.3 Test certificates for hydrostatic tests.

6.6.9.4 Test reports of heat treatment carried out.

6.6.9.5 Dimensional & Visual check report.

6.6.9.6 Surface preparation and painting, marking report.

6.6.9.7 Inspection release note.

6.6.10 **Painting, Marking and Shipment**

6.6.10.1 After all inspection and test required have been carried out; surface shall be thoroughly cleaned, freed from rust and grease and applied with sufficient coats of corrosion resistant paint.

6.6.10.2 Each assembly shall be tagged with the tag number stamped legibly on the edge of the inlet flange using die stamps with characters at least 12 mm high.

6.6.10.3 The assembly shall be fitted with a stainless-steel nameplate, attached to the body with stainless steel wire. At least the following information shall be clearly stamped on the plate:

a) Manufacturer's name

b) Rating

c) Material Body/plug etc

d) P. O. Number and Tag No’s.
6.6.10.4 All necessary precautions shall be taken for adequate protection of the assemblies during shipment and storage.

7.0 Installation

7.1 The step-by-step procedure for the coupon installation into the holder fitting shall be provided by the designated vendor / contractor including the technical specification of the retrieval tool, service valve, the necessary drawings, construction, operation, maintenance and the associated safety measures when carry out the works. The contractor shall perform installation, servicing and maintenance of the fittings, retrieval tool and the service valves.

7.2 The coupon installation and retrieval under pressure is hazardous. They require thorough risk assessment procedures, specialized equipment and the work shall only be performed by suitably trained and certified contractor personnel in compliance with all the safety regulations and quality control procedures.

7.3 New coupons will be received individually packaged complete with Washers in the moisture proof bags.

7.4 Before opening the container, the serial number of the coupon and initial weight of the coupon (as indicated by the coupon supplier) must be noted. If the container does not indicate either of them, the coupons must not be installed and the coupons/container should be returned back to the vendor. Coupons shall be extracted from the container and handled using lint free gloves or clothes, disposable plastic gloves, coated tongs or coated tweezers. The coupons shall always be held by their edges.

7.5 The coupons with requisite washers should be mounted on their selected holders while preventing any form of surface contamination in process.

7.6 If the coupon is being installed into a new CML, the access fitting assembly must be installed first. The work (either by hot tapping or during shut-down or isolation from the main process stream) is carried out by the approved contractor in accordance with the vendor’s installation and welding procedures. A post-welding quality inspection shall be carried out following installation.

7.7 Service valve and retriever shall be used for insertion and retrieval of the coupons under system pressure.

7.8 The insertion and retrieval shall only be carried out by the trained personnel by the vendor in accordance with the approved installation procedure and all the safety requirements.

7.9 The change-over of the coupons or any other service that requires its retrieval under pressure shall be carried out through a two-inch double block and bleed service valve.
<table>
<thead>
<tr>
<th>Title</th>
<th>Internal Corrosion Monitoring of Pipelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Guidance</td>
</tr>
<tr>
<td>Reference No.</td>
<td>CIMG-GD-5-2016-0006</td>
</tr>
</tbody>
</table>

7.10 The size of the retriever is governed by the length of stroke required. The stroke is defined as the distance the solid or hollow plug assembly and its longest tool or attachment must travel from its seated position within the access fitting body through the service valve allowing the service ball valve to be closed.

7.11 The access fitting requires periodic inspection and maintenance: cleaning, repairs to the internal threads, grease replacement, O-rings and protective covers. All the maintenance shall be performed by the approved contractor and in accordance with the approved procedure over the prescribed intervals.

8.0 Retrieval, Cleaning & Weighing

8.1 The coupon retrieval shall be carried out by the approved contractor in accordance with the approved procedure. The retrieval under high pressure is a hazardous procedure; it involves a number of stages, specialized equipment and shall be carried out by a specialist contractor with adequate level of experience and expertise.

8.2 The retrieved coupons shall not be reused.

8.3 Serial number of the retrieved coupon (if visible) shall be noted and matched with the data on the corrosion coupon report including the installation date.

8.4 The following activities shall be performed on retrieval of the coupon from service:

8.4.1 Photograph of coupons shall be taken before and after cleaning.

8.4.2 Immediately upon retrieval, coupons shall be visually examined on site by an experienced corrosion engineer/professional for colour, presence of scale, slime, foreign material, erosion, mechanical damage or any other relevant information. Two rules must always be adhered to, when retrieving coupons or samples: a) protect all the evidence, and b) collect all the evidence.

8.4.3 If microbiological tests are required (as determined by the experienced corrosion engineer/professional), sample of deposits from coupon or a sterile swab of the coupon (if deposit of discernible quantity is not found) shall be taken with due care. The sample shall then be inoculated in the culture medium and transported on ice to the microbiological laboratory for analysis as soon as possible. Further information on the microbiological monitoring and analysis of the liquid and solid samples is given in CIMG-GD-5-2016-0007.

8.4.4 The corrosion engineer/professional should decide whether Scanning Electron Microscopy (SEM) or Energy Dispersive Spectroscopy (EDS) is required as mentioned in 9.1.5. If it is decided to carry out SEM or EDS analysis, the coupon must not be cleaned off the corrosion products.

8.4.5 Moisture, if any, may be removed from the coupons by gently blotting with tissue paper.
or a clean soft cloth. Avoid disturbance caused to any surface films or deposits.

8.4.6 Coupon may be placed into the moisture proof envelope and shipped immediately to a laboratory for analysis. If any changes that occur (changes in appearance, e.g. colour) while handling the coupon on air, they shall be noted and recorded.

8.4.7 Upon the arrival at the laboratory, coupons shall be cleaned by immersing in a suitable hydrocarbon solvent, such as clean benzene. This shall be done long enough to remove any oil or paraffin deposits. Coupons shall then be rinsed in isopropyl alcohol or acetone and dried in a gentle dry air stream. The safety measures when handling flammable (acetone and isopropyl alcohol) and both flammable and toxic carcinogen (benzene) chemicals shall be adhered to.

8.4.8 Coupon shall be kept immersed 15% inhibited Hydrochloric acid (HCl) for one to two minutes to remove scale and/or corrosion products. The HCl solution shall contain a corrosion inhibitor to protect the steel from corrosion (refer to NACE SP0775-2013, Section 2.3 for the recommended formulations). Repeated immersion or a slightly more acidic solution may be required to clean severely coated coupons. Ultrasonic bath can be used to accelerate the cleaning process.

8.4.9 Coupon shall be cleaned in saturated sodium bicarbonate (NaHCO₃) solution for one minute to neutralize the acid and rinse in isopropyl alcohol or acetone immediately thereafter. The safe working practices with highly flammable isopropyl alcohol and acetone shall be adhered to.

8.4.10 The coupons shall be visually examined and then weighed to 0.1 milligrams.

8.4.11 Mass loss shall be compared with coupon weight sheet data for differential.

8.4.12 Calculate corrosion rate from the mass loss using equation equation given in 2.2 and 2.3.

8.4.13 Pit depths may be measured with a depth gauge or micrometer caliper with sharp pointed probes. A microscope calibrated for depth measurement may also be used. (Depth of deepest pit – in mils, inches, or micrometers – times (x) 365 and divided by exposure time in days will give an effective calculation of pitting rate).

9.0 Evaluation, Analysis and Reporting

9.1.1 The general corrosion rate shall be calculated using equation (1) in paragraph 2.2

9.1.2 The pitting rate shall be calculated using equation (2) in paragraph 2.3

9.1.3 The qualitative analysis shall include the surface morphology assessment for pitting, etching as well as the relative indication of severity

9.1.4 The quantitative analysis shall include the measurement of the pit depths/widths as well
as the number of pits per unit area.

9.1.5 Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) may be used for qualitative assessment of coupon surfaces at high magnifications, typically up to 2000X. EDS may be used to identify the elemental composition of embedded particles or scale. The SEM and EDS assessments are carried out separately from optical microscopy. These studies may be required in cases where high corrosion rates are observed.

9.1.6 After each installation / retrieval, the following information shall be recorded in the CMS application in O&M Intranet Portal:

<table>
<thead>
<tr>
<th>Corrosion Coupon Record</th>
</tr>
</thead>
</table>
a) CML Location Details
| Station Name | CML Tag |
| Coupon Tag    | Coupon SL No |

b) Coupon Particulars

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Date, dd/mm/yyyy</td>
<td>Installation Mass, g</td>
</tr>
<tr>
<td>Removal Date, dd/mm/yyyy</td>
<td>Removal Mass, g</td>
</tr>
<tr>
<td>Mass loss after cleaning, mg</td>
<td>Avg. Corrosion Rate (mpy)</td>
</tr>
<tr>
<td>Deepest Corrosion Pit, µm</td>
<td>Pitting Rate (mpy)</td>
</tr>
<tr>
<td>Description of deposit before cleaning</td>
<td></td>
</tr>
<tr>
<td>Analysis of Report</td>
<td>(Attach Report)</td>
</tr>
<tr>
<td>Description of coupon after cleaning (e.g., etch, pitting, erosion, etc.)</td>
<td>(Attach Photograph)</td>
</tr>
<tr>
<td>Remarks</td>
<td></td>
</tr>
</tbody>
</table>
Appendix-B

**Electrical Resistance Probes**

1.0 Introduction

1.1 The electrical resistance (ER) technique is an indirect intrusive corrosion monitoring technique that relies on changes in electrical resistance of the corroding/eroding element.

2.0 Principle

2.1 When immersed in corrosive/erosive medium, the element (wire, strip or a tube of metal) corrodes or erodes, its cross-sectional area decreases in a predictable manner thereby making it more difficult for electric current to pass through. This leads to increase in electrical resistance of the element, given by Poullet’s law:

\[ R = \rho \times \frac{L}{A} \]

Where:

- \( R \) – Electrical resistance (\( \Omega \))
- \( L \) – Element’s length (m)
- \( A \) – Cross sectional area (m\(^2\))
- \( \rho \) – Resistivity (\( \Omega \times m \)) of the probe element, constant

2.2 The corrosion rate is calculated using equation:

\[ C = \frac{P \times 365 \times (S_2 - S_1)}{\Delta T \times 1000} \]

Where:

- \( C \) – corrosion rate expressed in mils/year (1 mil = 0.0254 cm)
- \( P \) – “probe life” (expressed in mils) or probe span, a constant depending on the type of probe
- \( S_2 \) and \( S_1 \) – instrument readings, metal loss (mils), related to “A” (Vendor should provide details on converting “A” to “instrument readings”).
- \( \Delta T \) – lapse time between the two readings \( S_1 \) and \( S_2 \)

3.0 Types and Selection

3.1 Though a variety of types of ER probes are available, Flush mounted -Strip element type of the ER probe shall be employed for the GAIL transmission pipeline systems in both piggable and unpiggable pipelines for standard speed & sensitivity applications, unless otherwise
required as a result of corrosion assessment for specific cases. In case of high speed and sensitivity requirements, vendor may specify a type other than strip type.

3.2 In special cases, a different type of ER Probe may be called for, on the basis of Corrosion Assessment, which may be selected upon such study and requirement.

3.3 The probe shall be retrievable type, capable of being inserted or retrieved at the pressures up to 200 bar and temperatures up to 200 °C.

3.4 The probe element shall have appropriate thickness and life span (that is, the half of the element thickness) and be sufficiently sensitive to be able to detect any change in a corrosion rate as per the intended service.

3.4.1 For applications, other than that specified in 4.2.5.3 (d) of this Guidance document, standard sensitivity probes may be employed.

3.4.2 In cases where high sensitivity probes are required (Refer 4.2.5.3 (d) of this Guidance Document), the probe shall be capable of detecting change of 0 to 0.25 mm/y (i.e., 0 to 10 mpy) within one hour.

3.5 All the probes shall be installed with a sleeve or an adaptor to ensure that the connector is clean.

3.6 The material of the probe element shall be suitable for the pipeline material grade.

3.7 Service valve and retriever shall be used for insertion and retrieval of the probes under system pressure.

3.8 The insertion and retrieval shall only be carried out by the trained personnel by the vendor in accordance with the approved installation procedure and all the safety requirements.

4.0 Access Fitting

4.1 The access fitting material shall be compatible with the pipeline material and size.
4.2 The access fitting shall be the 2” NB, 5 ¼” in height, flare weld Access Fitting Assembly (non-tee) with Integral Branch Reinforcement per ASME B31.3, carbon steel (CS) body, and the acme thread outlet with hollow plug assembly in AISI-316 complete with essential spares. The pressure rating shall be 6000 psi and the design temperature from -29 to 204°C.

4.3 The access fitting shall be designed for rust free operation and protection shall be provided to the threads for service life.

4.4 The Access fittings should be compatible with ER probes made by different manufacturers.

4.5 The fitting assemblies shall have the protective covers to protect external thread and the external seal area from damage.

5.0 Plug and Probe Assembly

5.1 All the probes shall use the hollow plug assembly in the access fitting.

5.2 Sealing shall be achieved by Viton ‘O’ ring and Teflon primary packing suitable for temperature of -26°C to 204°C.

The Probe Assemblies shall be fixed type (of suitable dimensions for identified CML) made of SS 316 conforming to NACE MR 0175 and MR 0103, attaching to the bottom of the Hollow Plug of the Access Fitting Assembly by means of a hollow plug nut and bore sealing nut with packings & seals.
6.0 Hand Held Unit (HHU)

6.1 A Hand Held Corrosion monitoring instrument shall be available at all Maintenance Bases capable of reading all the ER probe data in their region.

6.2 HHU shall be provided with splash-proof enclosure with sealed membrane keyboard and shall be suitable for both standard and High Speed / Sensitivity type ER probes.

6.3 The resolution of the meter shall be minimum 0.1 probe divisions (0.01% probe span) for standard speed & sensitivity type with repeatability of ±1 division (0.1% of probe span).

6.4 The HHU shall have capability to recognize the installed probes by Tag ID and shall have adequate storage suitable for reading directly from probe as well as downloading from Field Data Loggers. It shall have user-friendly interface to transfer data to a Windows PC in CSV format as a minimum.

6.5 Data transfer shall be achieved through Intrinsically safe RS 232 protocol at 9600 Baud Rate.

6.6 The HHU shall be Intrinsically Safe and compliant with UL/ULc (IEC) AEx and Ex ib IIC T4 / ATEX EEx ib IIC T4 / CE (EMC).

7.0 Field Data Logger

7.1 A Field Data Logger shall be primary mode of data acquisition from an ER Probe. Only where the same is not feasible or otherwise the probe is connected to Remote Control Room through a Transmitter, shall it become necessary to use Hand Held Unit (HHU) directly to acquire the data.

7.2 Field Data Logger shall be provided with NEMA 4X Enclosure suitable for Operating Temperature: -40°F to +158°F (-40°C to +70°C).

7.3 The resolution of the Data Logger shall be compatible with the type of ER Probe installed; In specific case of High Speed / High Resolution ER probes, the Data Logger shall have a minimum resolution of 18 bit.

7.4 Battery capacity shall be designed for a minimum of 6 months with dual sensor data measured at the rate of 1 reading/hr.

7.5 The Data Logger shall be certified for Hazardous Area under UL/ULc Class 1, Zone 1, Ex and AEx ib IIC T4* (Class 1, Div. 2, A, B, C, D, T4) with Battery Pack.

8.0 Data Transmitter

8.1 ER Probe data transmitter may be considered on a case-to-case basis if required based on feasibility.

8.2 The transmitter shall be of Two-wire type providing 4-20 mA output with a resolution of ±0.1% for rapid response, compatible with the ER probes installed. In case of High Speed /
High Sensitivity ER Probes, suitable transmitter of higher resolution (minimum 18 bit) and response shall be required.

8.3 It shall be provided with a Switchable Probe Selector to easily adjust between different probe types. The transmitter shall be compatible for use with modern PLC / DCS type central control with 24 V power supply through Intrinsically safe Barriers suitable for Zone 1.

8.4 The transmitter shall be CE/ATEX/IECEx compliant and be supplied in stainless steel enclosure to NEMA 7 and IP 66/ NEMA 4X specification.

9.0 **Purchase Information**

9.1 Procurement of ER probes shall be made only from reputed manufacturers with proven track record.

9.2 The following are some of the manufacturers / suppliers of coupons.

(a) Alabama Specialty Products Inc (Metal Samples), USA
(b) Cosasco systems, USA
(c) Caproco Ltd., Canada
(d) Teledyne Cormon Ltd, UK
(e) CorrOcean ASA, Norway / Roxar / Emerson Process Management India Pvt. Ltd.
(g) Korosi Specindo, Indonesia.

9.3 The template at Appendix-E shall be used to provide and obtain technical confirmation on the required coupon.

9.4 ER Probes shall be provided with a unique serial number and packed in moisture proof VCI bag.

9.5 **Inspection and Tests:** The Manufacturer & Contractor shall perform all inspection and tests as per the requirements of this specification and the relevant codes, prior to shipment from their Works. Such inspection and tests shall include, but not limited to, the following:

9.5.1 All assemblies and components shall be 100 % visually inspected & hydro tested and test certificates for the same shall be provided.

9.5.2 Dimensional checks shall be carried out as per the approved drawings.

9.5.3 Chemical composition and mechanical properties including hardness shall be checked as per relevant material standards and this specification.

9.5.4 All butt and repair welds of pressure containing parts shall be examined 100% by radiography. Acceptance limits shall be as per ASME B31.4 / ASME B31.8. Welds, which
cannot be inspected by radiographic methods, shall be checked by ultrasonic or magnetic particle methods. Methods of examination shall be as per ASME Section VIII Div.1 Appendix 12 and Appendix 6 respectively.

9.5.5 All forgings shall be wet magnetic particle inspected on 100% of forged or extruded surfaces. Method and acceptance shall comply with MSS-SP-53. The end section of the components to be welded shall be 100% ultrasonically tested for lamination type defects for a distance of 50 mm from the ends prior to being prepared. The presence of any discernible defects shall be cause for rejection.

9.5.6 All fillet welds of thickness < 6 mm shall be examined 100% by Magnetic Particle Inspection and 6 mm shall be examined 100% by angle probe UT. Acceptance criteria for MPT and UT shall be as per ASME Sec. VIII Div.1 Appendix 6 and Appendix 12 respectively.

9.5.7 The hydro test water shall be clean & fresh water. Test procedure shall be submitted to GAIL for review and approval.

9.5.8 GAIL’s own or authorised Inspector may also perform stage wise inspection and witness tests at Manufacturer's Works prior to shipment. Manufacturer shall give reasonable notice of time and shall provide, without charge, reasonable access and facilities required for inspection by GAIL. Inspection and tests performed/witnessed by the GAIL shall in no way relieve the Manufacturer’s/Contractor’s obligation to perform the required inspection and tests.

9.5.9 Manufacturer shall submit the following certificates:

9.5.9.1 Test certificates relevant to the chemical analysis and mechanical properties including hardness of the materials used for the manufacture as per relevant material specification.

9.5.9.2 Test reports on non-destructive testing.

9.5.9.3 Test certificates for hydrostatic tests.

9.5.9.4 Test reports of heat treatment carried out.

9.5.9.5 Dimensional & Visual check report.

9.5.9.6 Surface preparation and painting, marking report.

9.5.9.7 Inspection release note.

9.5.9.8 Certification for use in hazardous area shall be as follows

a) Certificates from statutory authorities like BASEEFA, FM, PTB, UL, and CENELEC etc. for items of foreign origin, and from CMRI etc. for items of Indian origin.

b) Approval certificate from PESO (Petroleum Explosive Safety Organizer) / CCE (Chief Controller of Explosives) for items to be installed in India, irrespective of country of
origin and the same is mandatory. In case PESO (Petroleum Explosive Safety Organizer) / CCE certificate is not available at the time of quotation, bidder shall confirm that the certificate shall be furnished before shipment.

c) Approval certificate from BIS (Bureau of Indian Standards) for all flameproof instruments of Indian origin.

9.5.10 Painting, Marking and Shipment

9.5.10.1 After all inspection and test required have been carried out; surface shall be thoroughly cleaned, freed from rust and grease and applied with sufficient coats of corrosion resistant paint.

9.5.10.2 Each assembly shall be tagged with the tag number stamped legibly on the edge of the inlet flange using die stamps with characters at least 12 mm high.

9.5.10.3 The assembly shall be fitted with a stainless-steel nameplate, attached to the body with stainless steel wire. At least the following information shall be clearly stamped on the plate
   a) Manufacturer's name
   b) Rating
   c) Material Body/plug etc
   d) P. O. Number and Tag No’s.

9.5.10.4 All necessary precautions shall be taken for adequate protection of the assemblies during shipment and storage.

10.0 Installation / Retrieval & re-installation

10.1 In the event that the corrosion monitoring system is to be retrofitted on the pipeline operating under pressure, a hot tap kit shall be used. The detailed procedure for hot-tapping shall be obtained from the supplier.

10.2 The change-over of the probes or any other service that requires its retrieval under pressure shall be carried out through a two-inch double block and bleed service valve.

10.3 The retrieval under pressure shall be performed using a retriever kit. The retrievers shall be compatible with the double block and bleed service valve.

10.4 The size of the retriever is governed by the length of stroke required. The stoke is defined as the distance the solid or hollow plug assembly and its longest tool or attachment must travel from its seated position within the access fitting body through the service valve allowing the service ball valve to be closed.
11.0 Data Acquisition and Transfer

11.1 The minimum basic requirement for all the GAIL pipelines is the manual ER probe interrogation. An HHU shall be used for reading and downloading data directly from the probe or downloading stored data from the designated data logger. Manual probe interrogation can be upgraded to an automatic online data logging and transmission subject to feasibility, operability and risk assessments of individual pipeline cases.

11.2 Data from ER probes captured by the data logger shall be downloaded at regular intervals, which is unless otherwise specified on a monthly basis. The same shall be transferred to personal computer and uploaded in the Corrosion Monitoring Application of Corporate O&M Intranet Portal for analysis and interpretation on a monthly basis, unless otherwise specified.

11.3 The data loggers / transmitters shall be compatible with the associated ER probe and be able to support the measurements of corrosion rate at the required resolution.

11.4 The device shall be rated explosion-proof.

11.5 The data logger shall be closely coupled to the probe. This can be achieved with a short connecting adaptor that allows the data logger to be effectively mounted on top of the ER probe. If it is not possible, the transmitter can be installed alongside the fitting with a short cable.

11.6 If the pipeline is subject to vibration or its temperature exceed the data logger rating, the device can be mounted on a separate post and connected to the probe via a short cable.

12.0 Evaluation, Analysis and Reporting

12.1 ER Probe data should primarily be used to establish and monitor trends and analyse reasons for deviation from norm if any. The same may also be used to verify and adjust effectiveness of Corrosion Mitigation measures such as chemical intervention or cleaning pigging. It is recognised that corrosion rate from ER Probe data may not correlate with that of Corrosion Coupon installed at the same or nearby CML. However, the corrosion rate obtained from the 6 month period (or other frequency of Mass Loss coupon retrieval) ER probe should be compared with that of Mass Loss coupon and the results documented.

12.2 Data shall be uploaded in the Corrosion Monitoring Application in Corporate O&M Intranet Portal in the following format.
### Internal Corrosion Monitoring of Pipelines

**Title**
Internal Corrosion Monitoring of Pipelines

**Type**
Guidance

**Reference No.**
CIMG-GD-5-2016-0006

---

#### ER Probe Monitoring Record

**a) CML Location Details**

<table>
<thead>
<tr>
<th>Station Name</th>
<th>CML Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER Probe Tag</td>
<td>ER Probe SL No</td>
</tr>
<tr>
<td>ER Probe Life</td>
<td>Expected Replacement Date, dd/mm/yyyy</td>
</tr>
</tbody>
</table>

**b) ER Probe Data**

<table>
<thead>
<tr>
<th>Installation Date, dd/mm/yyyy</th>
<th>Record Retrieval Date, dd/mm/yyyy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Time</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where is the type (handheld unit (HHU) or field data logger) of ER probe data acquisition captured?
Permanently Mounted Ultrasonic Transducers

1.0 Introduction

1.1 Ultrasonic Testing (UT) or Examination utilizes high sensitivity ultrasonic technology to provide noninvasive monitoring of corrosion and erosion in the pipelines.

1.2 The ultrasonic monitoring of the fixed CML can be carried out by the permanently installed ultrasonic transducers (PUT) that enable continuous monitoring or hand held ultrasonic transducers (HUT) in series of successive measurements. The other available UT methods, such as the automated ultrasonic testing (AUT) methods or Guided Wave Ultrasonic Testing (GWUT) are the methods that are primarily used to scan the areas of the pipeline for defects. As they are not strictly fixed to the same CML of the pipeline, they are typically classified as inspection methods rather than monitoring methods. They are non-permanent methods and require human intervention.

1.3 PUT is advantageous for monitoring for corrosion at the isolated and remote CML such as pipeline low points, as they provide more accurate measurements than HUT because the exact location of the probe remains constant. The sensitivity of the UT probes limits the minimum change in the wall loss thickness that can be detected.

1.4 After the PUT sensors are attached to the pipeline underground, the attachment areas can be re-coated and the excavation backfilled. The cable is run to the above ground test post. Data can be downloaded from the test post using an HHU.

2.0 Principle

2.1 The ultrasonic examination is based on the principles of piezoelectricity. Applied AC electrical current generates vibration and ultrasound waves (frequency in the 2 – 10 MHz range) that are transmitted and received by the sensor. PUT utilizes fixed sensors, hence it is only able to monitor for corrosion at a fixed CML. The UT waves traverses a region where there is a change in material properties, such as the decrease of thickness in corrosion, the directly transmitted signal is modified and the change of receiving signal can provide good information about the corrosion development across the transmitting and receiving path.

2.2 The basic components of the ultrasonic monitoring system are the sensor and the data logger. The sensor is a multi-element, flexible, self-adhesive ultrasonic transducer or an array of transducers that is permanently bonded to the pipeline section to be monitored at the identified CML, i.e. where corrosive/erosive activity has historically taken place or is anticipated. A calibration sensor, an identification chip and a temperature sensor are typically built into the sensor unit and the one or a few discrete ultrasonic transducers are
each accessed by means of a small-integrated control module. A self-adhesive tape provides ultrasonic coupling and, once installed, the sensor can be coated in any conventional insulating or proofing material used to protect the pipeline.

2.3 A data logger is used to interrogate the sensors and can display inspection data in terms of wall thickness or rectified and un-rectified waveform display (A-scans) on a built-in LCD screen. It can store data records from up to a certain number of sensors (depending on a manufacturer and a model) before uploading to a PC is required via a communication bus. Measurement data can then be viewed on a PC.

3.0 Ultrasonic Sensor Types and Specifications for the GAIL NG and LPG Pipelines

3.1 Ultrasonic sensors shall have a minimum resolution of 0.1 mil (0.0025 mm), be able to operate in the range of pipeline wall temperatures between -40 and 150 °C and the minimum pipeline wall thickness 3 mm.

3.2 The sensor shall be “smart” to allow for electronic tagging and shall have adequate temperature compensation capability

3.3 The sensor shall have adequate size to provide low attenuation and sufficient penetration power for the pipeline CML where it is installed.

3.4 The sensor shall be capable of recognizing both general and localized corrosion.

3.5 Any internal noise from probes shall not interfere with interpretation of results.

4.0 Installation

4.1 PUT shall be installed in the CML of the underground pipelines where regular access for the probe/coupon interrogation and servicing is difficult or impossible. It shall only be installed as a “last resort” into those CML, where neither Mass Loss coupon, nor the ER probe is practicable to install.

4.2 The sensors shall be oriented in the pipeline circumference in the position where corrosion is predicted to occur. For example, if corrosion is expected to occur only at the bottom of the pipeline, 5 sensors shall be installed at the 3 o’clock, 5 o’clock, 6 o’clock, 7 o’clock and 9 o’clock positions. If top of line condensation is expected in the pipe causing the likelihood of corrosion caused by condensed water, additional probes shall be installed in the 11, 12 and 1 o’clock positions, making a total number of probes 8 per CML.

4.3 The vendor shall provide the PUT sensor calibration procedure prior to the installation, including the type of calibration instrument or device, the couplant type, the couplant life (if the couplant dries up, no useful data can be obtained from PUT) specification, service life and the associated maintenance and replacement instructions.
4.4 The connection between the sensors on the buried pipeline and the above ground test post shall be provided by a heavy duty, reliably insulated cable and be able to withstand variations of temperature, soil composition changes, etc. The connectivity check shall be performed after installation before backfilling.

4.5 PUT shall be installed on the exterior of the pipeline surface, on the bare steel. Any coating shall be removed prior to installation and re-coated after installation in accordance with all the applicable quality procedures. The contact surface shall be free from irregularities, grit, corrosion product (scale), etc. that could interfere with free movement of the probe or impair the transmission of ultrasonic waves. Maintaining a good contact between the transducer and the pipe surface throughout the service is imperative for long-term effective performance of PUT. The sensor shall be attached using the transfer adhesive, assisted by the magnetic shell of the sensor. The specification of all the components shall be provided by the manufacturer.

4.6 The reliability of attachment of PUT to the pipeline wall shall also be verified by calibration with a different sensor at the time of installation. The wall thickness of the CML where PUT is to be installed should be determined by handheld ultrasonic transducer (HUT). Then the PUT should be installed and the wall thickness is determined. The results shall be compared and must not deviate by more than 10%. This will establish the baseline wall thickness that will be used as a reference point for the future.

4.7 Contract personnel installing the PUT system must possess valid level II in Certification Scheme for Welding and Inspection Personnel (CSWIP), Personnel Certification in Non-Destructive Testing (PCN) or ASNT (American Society of Non-Destructive Testing) Technical Certification Program (ACCP) or National or international central certification programs accredited by ISO 17024.

5.0 Wall Thickness Data Acquisition and Transfer

5.1 The data acquisition equipment shall be via a Hand Held Unit (HHU) device incorporating a data logger for manual downloading of the data from the above ground test post and transfer to the personal computer for analysis and interpretation.

5.2 The frequency of data collection is once in 3 – 6 months. The results should be compared with those from ML or ER probe installed in that CML location to verify meaningfulness, accuracy, consistency, and reliability of HHT.

5.3 In the piggable pipelines, the data from PUT shall be correlated with ILI data to verify meaningfulness, accuracy, consistency and reproducibility. For the unpiggable pipelines, the PUT data shall be correlated with the ICDA findings.
5.4 In the event of the increasing corrosion activity in at the CML of unpiggable pipelines or poor data correlation, the CML shall be excavated for further investigation. The assessment will be required using HUT or GWUT to identify the corrosion spread.

5.5 Data from PUT data logger shall be uploaded in the Corrosion Monitoring Application in Corporate O&M Intranet Portal. The format for upload shall be as per table given below:

**PUT Transducer Monitoring Record**

<table>
<thead>
<tr>
<th>a) Pipeline &amp; CML Location Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Name</td>
</tr>
<tr>
<td>PUT Tag</td>
</tr>
<tr>
<td>PUT S No</td>
</tr>
<tr>
<td>PUT S No</td>
</tr>
<tr>
<td>PUT S No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b) PUT Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>PUT Readings, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>#1   #2   #3   #4   #5   #6   #7   #8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Data Sheet for Mass Loss Coupon and/or Accessory Parts**

**Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GAIL Requirement</th>
<th>Vendor Confirmation / Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 CML Id</td>
<td>GAIL to specify</td>
<td></td>
</tr>
<tr>
<td>1.2 Pipeline #1 Code &amp; Name</td>
<td>GAIL to specify pipeline(s) represented by the above CML</td>
<td></td>
</tr>
<tr>
<td>1.3 Pipeline #2 Code &amp; Name</td>
<td>GAIL to specify pipeline(s) represented by the above CML</td>
<td></td>
</tr>
<tr>
<td>1.4 CML Pipe NB, Inches</td>
<td>GAIL to specify</td>
<td>CML Orientation GAIL to specify</td>
</tr>
<tr>
<td>1.5 CML Pipe Grade</td>
<td>GAIL to specify</td>
<td>CM Pipe Thickness, mm GAIL to specify</td>
</tr>
<tr>
<td>1.6 Design Pressure of CML pipe</td>
<td>GAIL to specify</td>
<td>Vendor to note for all required components</td>
</tr>
<tr>
<td>2.1 Coupon Size</td>
<td>1.25&quot;OD x 1/8&quot; Thick</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.2 Coupon Material</td>
<td>Equivalent to Pipe Grade at 1.5 above</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.3 Type</td>
<td>Flush Disc, Retrievable</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.4 Mounting</td>
<td>One Hole, 0.312&quot; ID</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.5 Finish</td>
<td>Ground, 120 Grit</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.6 Coupon Weight</td>
<td></td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>3.1 Type</td>
<td>Retrievable, Flush Disc Holder, Fixed Length</td>
<td></td>
</tr>
<tr>
<td>3.2 Body Material</td>
<td>AISI 316</td>
<td></td>
</tr>
<tr>
<td>3.3 Weight</td>
<td>For information</td>
<td>Vendor to Specify</td>
</tr>
<tr>
<td>3.4 Extended Stem Required?</td>
<td>GAIL to specify (If CML located at 12 'O' Clock)</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>3.5 Wake Frequency Calculation required</td>
<td>GAIL to specify (If CML located at 12 'O' Clock)</td>
<td>Vendor to provide &amp; Certify calculation,</td>
</tr>
<tr>
<td>4.1 Type</td>
<td>Solid Plug</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>4.2 Material</td>
<td>AISI 316</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>4.3 Sealing</td>
<td>Viton 'O' Ring and Teflon Primary Packing</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>4.4 Coupon Attachment</td>
<td>Single single flat head machine screw-type</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>4.5 Plug Weight</td>
<td>For information</td>
<td>Vendor to Specify</td>
</tr>
<tr>
<td>5.1 Mounting</td>
<td>Flare Weld with integral branch reinforcement</td>
<td></td>
</tr>
<tr>
<td>5.2 Type</td>
<td>Non Tee, High Pressure Retrievable</td>
<td></td>
</tr>
<tr>
<td>5.3 Size</td>
<td>2&quot; x 5 1/4&quot; Height</td>
<td></td>
</tr>
<tr>
<td>5.4 Material</td>
<td>ASTM A 105</td>
<td></td>
</tr>
<tr>
<td>5.5 Rating</td>
<td>6000 psi</td>
<td></td>
</tr>
<tr>
<td>5.6 Connection</td>
<td>Internal ACME thread</td>
<td></td>
</tr>
<tr>
<td>5.7 Retaining Cover</td>
<td>High Pressure (10000 psi) with Gauge &amp; Bleed</td>
<td></td>
</tr>
<tr>
<td>6.1 Test Pressure</td>
<td>1.5 Times Design Pressure</td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

1. If only Coupon is being procured, strike out all other sections (Holder, Access Fitting etc)
2. Temperature Rating of all components shall be -15°C to 204°C
4. Holder Sizing shall be done by vendor
5. Coupons shall be packed individually and packaging shall be suitable for minimum one year before use
6. Sub Parts mentioned in the datasheets are indicative; Vendor to supply all necessary components and spares for making the unit complete.
## CML Details

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GAIL Requirement</th>
<th>Vendor Confirmation / Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 CML Id</td>
<td>GAIL to specify</td>
<td></td>
</tr>
<tr>
<td>1.2 Pipeline #1 Code &amp; Name</td>
<td>GAIL to specify pipeline(s) represented by the above CML</td>
<td></td>
</tr>
<tr>
<td>1.3 Pipeline #2 Code &amp; Name</td>
<td>GAIL to specify pipeline(s) represented by the above CML</td>
<td></td>
</tr>
<tr>
<td>1.4 CML Pipe NB, Inches</td>
<td>GAIL to specify</td>
<td>CML Orientation: GAIL to specify</td>
</tr>
<tr>
<td>1.5 CML Pipe Grade</td>
<td>GAIL to specify</td>
<td>CM Pipe Thickness, mm: GAIL to specify</td>
</tr>
<tr>
<td>1.6 Design Pressure of CML pipe</td>
<td>GAIL to specify</td>
<td>Vendor to note for all required components</td>
</tr>
</tbody>
</table>

## ER Probe

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GAIL Requirement</th>
<th>Vendor Confirmation / Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Probe Type</td>
<td>High Pressure Flush, Retrievable</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.2 Probe Material</td>
<td>AISI 316</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.3 Probe Length</td>
<td>Vendor to calculate as per details given</td>
<td>Vendor to Specify</td>
</tr>
<tr>
<td>2.4 Extended Probe Length Required?</td>
<td>GAIL to specify (If CML located at 12 'O' Clock)</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.5 Wake Frequency Calculation required?</td>
<td>GAIL to specify (If CML located at 12 'O' Clock)</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.6 Element Material</td>
<td>Equivalent to Pipe Grade given at 1.5 above</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>2.7 Element thickness</td>
<td>10 Mils (for 5 Mils useful life)</td>
<td>Vendor to Specify</td>
</tr>
</tbody>
</table>

## Plug

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GAIL Requirement</th>
<th>Vendor Confirmation / Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Type</td>
<td>Hollow Plug</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>4.2 Material</td>
<td>AISI 316</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>4.3 Sealing</td>
<td>Viton 'O' Ring and Teflon Primary Packing</td>
<td>Vendor to Confirm</td>
</tr>
<tr>
<td>4.4 Plug Weight</td>
<td>For information</td>
<td>Vendor to Specify</td>
</tr>
</tbody>
</table>

## Access Fitting

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GAIL Requirement</th>
<th>Vendor Confirmation / Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Mounting</td>
<td>Flare Weld with integral branch reinforcement</td>
<td></td>
</tr>
<tr>
<td>5.2 Type</td>
<td>Non Tee, High Pressure Retrievable</td>
<td></td>
</tr>
<tr>
<td>5.3 Size</td>
<td>2&quot; x 5 1/4&quot; Height</td>
<td></td>
</tr>
<tr>
<td>5.4 Material</td>
<td>ASTM A 105</td>
<td></td>
</tr>
<tr>
<td>5.5 Rating</td>
<td>6000 psi</td>
<td></td>
</tr>
<tr>
<td>5.6 Connection</td>
<td>Internal ACME thread</td>
<td></td>
</tr>
</tbody>
</table>

## Testing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GAIL Requirement</th>
<th>Vendor Confirmation / Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Test Pressure</td>
<td>1.5 Times Design Pressure</td>
<td></td>
</tr>
</tbody>
</table>

---

* Condition Monitoring Location (CML) is the location on GAIL Pipeline / Piping where Access Fitting for Probe / Coupon shall be installed.

1. If only Probe is being procured, strike out all other sections (Holder, Access Fitting etc).
2. Temperature Rating of all components shall be -15°C to 204°C.
4. Probe Assembly Sizing shall be done by vendor.
5. Probes shall be packed individually and packaging shall be suitable for minimum one year before use.
6. Sub Parts mentioned in the datasheets are indicative; Vendor to supply all necessary components and spares for making the unit complete.
7. Hend Held Unit, Data Logger and/or Transmitter as per technical specifications shall be supplied (if applicable) as per Purchase Order.