Direct Assessment (DA) of Pipelines

Amendment Details

<table>
<thead>
<tr>
<th>Rev. No.</th>
<th>Date</th>
<th>Purpose</th>
<th>Prepared by</th>
<th>Reviewed by</th>
<th>Approved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>23.08.2016</td>
<td>First draft</td>
<td>SSV</td>
<td>RA</td>
<td></td>
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<tr>
<td>02</td>
<td>03.03.2017</td>
<td>Issued for implementation</td>
<td>CIMG</td>
<td>Panel of GMs</td>
<td>ED (O&amp;M) - CO</td>
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1.0 Preamble

1.1 Direct Assessment (DA) is an integrity assessment tool for gas and liquid pipelines designated by industry standards and is one of the pipeline integrity assessment methods prescribed by PNGRB in their Integrity Management System Regulation - 2012 the other being In-line Inspection. In the case of unpiggable pipelines, therefore, DA remains the only option available at the moment, if converting the pipeline for piggability is not feasible.

1.2 DA is a structured and iterative assessment process which envisages identifying “Most Probable Locations (MPL)” in a pipeline for the occurrence of corrosion by integrating data, performing diagnostic modeling and/or surveys, direct examination of the identified locations and finally assessment of observed corrosion damage from pipeline fitness for service point of view and other analyses.

1.3 The DA methodology is a four-step process. It requires the integration of data from historical and multiple indirect inspections, from direct pipe surface examinations, pipeline’s physical characteristics and operating history. All of these data are combined to provide a comprehensive integrity evaluation with respect to external corrosion (EC), internal corrosion (IC), and stress corrosion cracking (SCC), which are collectively known as time-dependent corrosion threats. Further, the DA methodology can prescribe a basis for re-assessment interval, confirm the absence or presence of integrity threats and identify the action(s) required for safe and reliable operation of the pipeline.

2.0 Objectives

2.1 DA is intended for Integrity assessments of the buried carbon steel Natural Gas & LPG pipelines to address the threat from external corrosion (EC), internal corrosion (IC) and stress corrosion cracking (SCC), which are time-dependent corrosion threats. The primary purpose of the DA methodology is to reduce the threat of the above mentioned time-dependent threats for reliability and safety of pipelines.

3.0 Scope

3.1 This guidance document is applicable for Integrity assessments of all buried Carbon steel Natural gas & LPG pipelines in general and specifically for those lines where Integrity Assessment cannot be carried out through In-line Inspection where they are unpiggable by design or due to prevailing low flow or any other conditions / requirements. It is strongly encouraged while conducting DA in such pipelines as above, DA may also be carried out in piggable pipelines with ILI data as it would validate the methodology and the models used in the DA process.

3.2 This document provides the guidance for minimum elements essential for carrying out
4.0 Approach & Methodology

4.1 Approach

4.1.1 DA as detailed in this document shall be conducted by the concerned RIMG or the Maintenance Base for the pipelines under their care as per their Board approved IMS document. DA comprises of the following:

External Corrosion Director Assessment (ECDA)

Internal Corrosion Director Assessment (ICDA) which further comprise (i) Wet Gas ICDA (ii) Dry Gas ICDA (iii) Liquid Pipeline ICDA (iv) Multiphase ICDA out of which one of the applicable ICDA process shall be carried out based on the fluid being handled.

Stress Corrosion Cracking Direct Assessment (SCCDA)

4.1.2 DA shall be considered completed for a pipeline only when all the above three DA processes are completed.

4.1.3 All the above DA methods involve the following four steps:

Step-1: Pre-Assessment
Step-2: Indirect Inspection
Step-3: Direct Examination
Step-4: Post-Assessment

4.1.4 In the IMS document, different pipeline networks have mentioned the time interval at which the DA shall be performed for the pipelines in their network which otherwise cannot be inspected using IILI. When taking up DA work, it would be prudent to carry out all the three DA processes simultaneously or in tandem so that the third and fourth step of DA i.e., Direct Examination and Post Assessment can be carried out in an integrated manner so that site inspections can be taken up together in a fair weather period and to provide data integration and analysis for successful completion of DA on holistic basis.

4.1.5 When it is decided to take up DA for pipelines, it can be done by completely outsourcing all the four steps job of all the three DA processes. Alternatively, a combination of in-house work and outsourced services (particularly for CP / Coating surveys and field work in day-lighting MPLs and conducting NDE at such locations are anyway outsourced) can be adopted. Since such combination provides the ideal mix considering the time & cost as well as the technical development opportunities it
provides for GAIL Engineers, this approach is highly recommended. The methodology detailed in this document also follows this principle of combining in-house work and outsourced services wherever required.

4.1.6 In case of WG-ICDA, since the process requires advanced flow assurance techniques and software tools, the same wherever required shall be outsourced until in-house expertise and resources are put in place.

4.1.7 DA shall be carried out on pipelines as per latest version of following NACE Standards (year suffixed to the standard no. is the current version):

(a) ECDA : NACE SP0502-2010
(b) ICDA : NACE SP0110-2010 (For wet Natural gas)
   NACE SP0208-2008 (For LPG)
   NACE SP0206-2006 (For dry Natural gas)
(c) SCCDA : NACE SP0204

4.1.8 All DA methods follow an identical structured process using data and information acquired from indirect pipeline survey techniques or advanced modeling as part of the overall assessment process. Additionally, the direct examination of pipelines along with all other relevant information (e.g., design, fabrication / construction and historical time-based operating data) shall be used to assess the current condition of a pipeline.

4.1.9 Each DA method will, in step-3 (direct examination), employ at least one non-destructive (NDE) inspection technique that can be used to physically inspect and assess pipelines. Additional techniques may be also used on case to case basis to get the most accurate results.

4.1.10 The procedures and guidance prescribed here utilize the Excel tools and supporting documentation which were delivered as part of the CPIMS project and are hosted in the O&M Intranet page. The procedures to follow in each of the DA cases viz., ECDA, DG-ICDA / LP-ICDA and SCCDA are described hereunder.

4.1.11 Wherever other documents are referenced hereunder as being available at O&M Intranet page, only the current document may be referred by clicking the link in the Intranet; only the online documents will be kept up-to-date.

4.1.12 **Step-1: Pre Assessment** and **Step-2: Indirect Inspection assessment** can be performed as per CPIMS Excel tools available in the O&M Portal of GAIL Intranet.

4.1.13 **Step-3: Direct Examination** can be performed as per Guidance document- CIMG-CIMG-GD-4-2015-0003: Field Verification procedure for Feature Location, Confirmation and Measurement in Buried Pipelines & **Step-4: Post Assessment** as per Guidance
document CIMG-GD-5-2016-0001: Pipeline Anomaly Management.

4.1.14 For ECDA, Indirect inspections shall be performed as per guidance document CIMG-GD-4-2016-0001: Performing CIPS, CAT and DCVG/ CAT ‘A’ Frame Survey (Using paras applicable specifically for Unpiggable pipelines). Pipeline depth survey at every 10 meters during CAT survey shall be utilized for elevation profile data requirement in ICDA.

4.1.15 DA Assessment reports shall be prepared as per Template given at Annexure A-D and reviewed by the concerned HOD-pipelines. The scanned soft copy shall also be uploaded in the O&M Portal of GAIL Intranet.

4.1.16 For carrying out the ECDA for the first time in a pipeline, if surveys have been carried out within three years, same data can be utilized provided it is established during pre-assessment step that there was no any major change in operating parameters of CP system, Coating integrity, environmental change surrounding of the pipelines etc. which may affect the protection towards External corrosion. Otherwise, fresh surveys shall be conducted.

4.2 Methodology

Methodology adopted for performing ECDA, DG-ICDA, LP-ICDA and SCCDA is explained in Sections 5.0 to 8.0.

5.0 Performing ECDA

5.1 Introduction:

ECDA is divided into following four steps having the key actions as given below:

<table>
<thead>
<tr>
<th>Key Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-assessment</strong></td>
</tr>
<tr>
<td>● Feasibility study</td>
</tr>
<tr>
<td>● Data collection</td>
</tr>
<tr>
<td>● Identification of ECDA regions</td>
</tr>
<tr>
<td>● ECDA indirect assessment tool selection</td>
</tr>
<tr>
<td><strong>Indirect Inspection</strong></td>
</tr>
<tr>
<td>● Performing Indirect Inspections from selected</td>
</tr>
<tr>
<td>minimum two nos. of complementary Tools</td>
</tr>
<tr>
<td>● Identification of critical sites, i.e. those</td>
</tr>
<tr>
<td>considered most likely susceptible to external</td>
</tr>
<tr>
<td>corrosion</td>
</tr>
<tr>
<td>● Ranking of sites for Direct examination</td>
</tr>
</tbody>
</table>
### Direct Assessment (DA) of Pipelines

**Title:** Direct Assessment (DA) of Pipelines  
**Type:** Guidance  
**Reference No.:** CIMG-GD-4-2016-0005

<table>
<thead>
<tr>
<th>Key Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Examination</strong></td>
</tr>
</tbody>
</table>
| • Excavation of critical sites  
  • Infield data collection and measurements |
| **Post Assessment** |
| • Fitness-for-purpose/service assessment  
  • Determination of re-assessment interval  
  • Evaluation of ECDA effectiveness |

#### 5.2 Preliminary work

**5.2.1** Line up contract for CIPS, CAT, DCVG or CAT- A Frame survey and Soil resistivity, for the pipelines on which ECDA is required to be conducted. For further details, Refer to CIMG Guidance document CIMG-GD-4-2016-0001: Performing CIPS, CAT and DCVG/CAT 'A' Frame Survey for this purpose, specifically as applicable for unpiggable pipelines requiring that pipeline burial depth and surface elevation information may be collected during this survey at an interval of maximum 10 m. This pipeline profile data is essentially to be collected at least for the first time which would be a critical input for ICDA.

**5.2.2** Line up contract for field verification involving earth excavation and making working pits, coating / recoating and conducting NDE such as UT, Phased Array UT, LRUT, MPT, LPT etc. Please refer to CIMG Guidance document- CIMG- CIMG-GD-4-2015-0003: Field Verification procedure for Feature Location, Confirmation and Measurement in Buried Pipelines.

**5.2.3** Collect all available pipeline asset data and survey data.

**5.2.4** Download ECDA tool from O&M Intranet Page and save it to the local working folder duly renaming it for the pipeline name & code number for the particular pipeline. Save as many copies as required for the number of pipelines. While downloading the Excel tool and saving locally, care should be given to select the Macro-Enabled Worksheet. Otherwise its functionalities may not work properly.

**5.2.5** Open the Excel Tool; Commence populating the data and performing the analysis.

#### 5.3 ECDA Procedure

**5.3.1** **Step-1: Pre-assessment:**

**5.3.1.1 Feasibility (First sheet of Excel Workbook):** The first step in the Pre-Assessment step includes the feasibility assessment comprises of some questions about the pipeline in order to determine if ECDA is applicable/feasible. A sample of such questionnaire is
5.3.1.2 **Pipeline Parameters (Second sheet of Excel Workbook):** At next step of the pre-assessment, collection / input of pipeline data is required as given below. Pipeline ID shall be the Pipeline section code as per Pipeline master data. These data also includes the data related to threat assessment this is accomplished by entering applicable data into a series of tables as follows

<table>
<thead>
<tr>
<th>Pipeline Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline ID</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start Distance (m)</th>
<th>End Distance (m)</th>
<th>Diameter (mm)</th>
<th>Wall Thickness (mm)</th>
<th>Pipe Type</th>
<th>Installed (YYYY)</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.3.1.3 **Pre-assessment (Third sheet of Excel Workbook):** In this sheet, data related to coating, pipeline equipment (valves, tees etc.), soil resistivity, soil parameters, DC / AC interference, casings, known external corrosion locations, disposition (aboveground or underground, road/river crossings etc.) are input. The type of coating is an important input for ECDA; some coatings are known to be more susceptible to external corrosion over time as the coating degrades. Should the coating be uniform along the length of the line then the start and end distances and coating need only be identified once. Should the coating scheme be mixed, the different sections should be identified in turn. The age of the coating is also an important parameter; if the precise date the coating was fitted is unknown the user should enter a conservative estimate e.g. 1st

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Are there any locations with adjacent buried metal structures?

- Yes ✓

Adjacent metal structures may be sources of stray current and/or interference; this may limit the effectiveness of above ground surveys and therefore additional care should be taken in such areas (it is noted that sources of AC/DC are a region defining parameter in this model).
January of the year fitted or the commissioning year of the pipeline. Sample of the table is given below

<table>
<thead>
<tr>
<th>Coating Type &amp; Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please state the coating type; if multiple coating types are fitted the start/end should be stated in a list format. If the coating is a single type then just the start/end of the line and type should be entered</td>
</tr>
<tr>
<td>Coating Start Distance (m)</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>50</td>
</tr>
</tbody>
</table>

5.3.1.4 Pipeline Equipment like Valves and areas containing other pipeline equipment may have the potential to act as drain points or interfere with the CP system. Pipeline equipment should be identified by distance and its type (available as a drop-down menu).

5.3.1.5 Soil resistivity is a recognized indication of the corrosivity of soil. It is recognized that any recorded soil resistivity levels are likely to be from discrete points and so the model is arranged to linearly interpolate between these discrete points. Sample of such reading is given below.

<table>
<thead>
<tr>
<th>Pipeline Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please state the locations of any pipeline equipment e.g. valves, supports etc.</td>
</tr>
<tr>
<td>Distance (m)</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>17</td>
</tr>
<tr>
<td>57</td>
</tr>
</tbody>
</table>

5.3.1.6 Areas of anaerobic soil can often limit the effectiveness of the CP system and carry the additional threat of microbial corrosion. Areas of anaerobic soil should be identified by their start and end distances and if any soil analyses have been carried out in those areas the results (SRB count) should be entered. Sample of such input is given below.

<table>
<thead>
<tr>
<th>Anaerobic Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please identify any known areas of anaerobic soil. If soil analyses have been carried out (bug count) please also state the result, otherwise this should be marked 'unknown'</td>
</tr>
<tr>
<td>Distance Start (m)</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>17</td>
</tr>
<tr>
<td>151</td>
</tr>
</tbody>
</table>

5.3.1.7 Any areas of known DC interference (e.g. from metallic structures or parallel pipelines, HVDC Transmission) should be identified by their start and end distances. Sample of such input is given
5.3.1.8 Any areas of known AC interference from HVAV Overhead Transmission power lines, Power cables etc. should be identified by their start and end distances. Sample of such input is given below.

<table>
<thead>
<tr>
<th>Start Distance (m)</th>
<th>End Distance (m)</th>
<th>AC Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>250</td>
<td>Power lines (&gt;10 KVAC)</td>
</tr>
<tr>
<td>301</td>
<td>399</td>
<td>Other AC Source</td>
</tr>
</tbody>
</table>

5.3.1.9 Casings can shield the pipe from protective CP current and are a potential source of interference or current drain. The locations of casings should be identified by their start and end distances. The most recent casing inspection should also be recorded along with the casing status i.e. isolated, electrolytic short or metallic short. Sample of such input is given below.

Table: Casings

<table>
<thead>
<tr>
<th>Start Distance (m)</th>
<th>End Distance (m)</th>
<th>Last Inspection Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>45</td>
<td>01/05/2010</td>
<td>Short metallic</td>
</tr>
<tr>
<td>220</td>
<td>263</td>
<td>01/01/2013</td>
<td>Isolated</td>
</tr>
</tbody>
</table>

5.3.1.10 Historic failures due to external corrosion can be indicative of a localized problem or at least indicate that conditions in the local area are conducive to external corrosion. Previous failures should be identified by their distance and the action following repair, i.e. repair only or full root cause analysis. Sample of such input is given below.

Table: Previous Failures due to External Corrosion

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Full Root Cause Analysis</td>
</tr>
<tr>
<td>220</td>
<td>Repair Only</td>
</tr>
</tbody>
</table>

5.3.1.11 **Region List (Fourth Sheet) for Identification of ECDA regions**: After inputting data in all the previous sheets, move to the sheet named ‘Region List’ and click the ‘Define’ button.
Upon clicking the ‘Define’ button, the Excel tool lists all the ECDA regions with Index score as per data provided and a new sheet ‘Region Chart’ showing the same in a graphical format as illustrated below.

A new ECDA region will be defined whenever there is change parameter such as Diameter, Wall Thickness, Pipe Type and Age, Coating Type & Age, Areas of Anaerobic Soil, Areas with known AC/DC interference, Crossings (Casings) etc.

**5.3.1.12 Selection of Indirect Assessment tools:**

As recommended in NACE ECDA SP 0502, minimum two nos. of complementary Indirect Inspection tools shall selected. However, for ECDA in GAIL as per this document, minimum three nos. of indirect inspection tool shall be selected as given below uniformly for all unpiggable pipelines:

(i) Close Interval Potential survey (CIPS)
(ii) Current Attenuation Test (CAT)
(iii) DCVG/CAT with “A” frame survey

As mentioned in 4.2.1.2 (a) above, the contracts for carrying out the above surveys shall have been awarded and executed earlier to starting the ECDA process using the Excel tool.

**5.3.2 Step-2: Indirect Inspection:**

**5.3.2.1 Indirect Assessment-Input Data (Sixth sheet of Excel Workbook):** Data from various surveys shall be populated in the Excel tables named as Coating Survey (DCVG), Coating Survey Results (DCVG) and so on.
For each indirect inspection method, the data shall be analyzed to identify and classify indications. The output of this process is a list of sites leading to the direct examination step.

5.3.2.2 **Site Ranking (Seventh sheet of Excel Workbook):** After inputting data in all the previous sheets as above, move to the sheet named ‘Site Ranking’ and click the ‘Rank’ button.

Upon clicking the ‘Rank’ button, the Excel tool ranks along with ECDA region with Dig Site Selection score and a new sheet ‘Site Chart’ showing the same in a graphical format as illustrated below.

In addition to the above, most probable dig site locations shall be also identified as per outcome of the CIPS, CAT & DCVG or CAT “A” frame surveys. Following the completion of at least two indirect inspection surveys, the pipeline operator shall compare the
results to determine whether they are consistent. Additional indirect inspection surveys and preliminary direct examination should be considered in case of discrepancies in comparing the integrated indirect survey results. Finally, the data that was initially collected during the pre-assessment is integrated with the results of the surveys and is utilized to refine ECDA regions and to determine the sites with the highest possibility of locating external corrosion. All such sites shall be classified as Severe, Moderate & Minor.

For an initial ECDA application, any location where unresolved discrepancies have been found between the indirect inspection results shall be placed under the “immediate action required” category. For first time applications, if there are indications where the operator is unable to estimate the prior corrosion damage or unable to determine active corrosion, then these indications should be categorized as “immediate” or “scheduled action required” or “Suitable for monitoring” as given below in the table.

<table>
<thead>
<tr>
<th>Immediate Action Required</th>
<th>Scheduled Action Required</th>
<th>Suitable for Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Severe indications in close proximity regardless of prior corrosion.</td>
<td>• All remaining severe indications.</td>
<td>• All remaining indications.</td>
</tr>
<tr>
<td>• Individual severe indications or groups of moderate indications in regions of moderate prior corrosion.</td>
<td>• All remaining moderate indications in regions of moderate prior corrosion.</td>
<td></td>
</tr>
<tr>
<td>• Moderate indications in regions of severe prior corrosion.</td>
<td>• Groups of minor indications in regions of severe prior corrosion.</td>
<td></td>
</tr>
</tbody>
</table>

### 5.3.3 Step-3: Direct Examination

**5.3.3.1** The objectives of the direct examination is to field verify the sites selected following the integration and analysis of the indirect inspection surveys and the pre-assessment. This step requires excavation to be made to expose the pipeline so that measurements can be made of the pipeline and the surrounding environment.

**5.3.3.2** As stated under Section 6.7.2 in NACE SP0502, for process validation and to determine the effectiveness of the ECDA process, at least one additional direct examination must be performed at a randomly selected location. For an initial ECDA application at least two additional sites are required, one at a random location and the other at a scheduled (if not possible then monitored) action required location.

**5.3.3.3** Final Dig Sites shall be selected in each ECDA region integrating the Dig Site score table at Para 4.2.1.3 (b) (ii) and Dig Sites as per table given hereunder as per NACE standards based on the classification of the results obtained during assessment of the various Indirect surveys report.
5.3.3.4 Further, Guidance document- CIMG- CIMG-GD-4-2015-0003: Field Verification procedure for Feature Location, Confirmation and Measurement in Buried Pipelines, shall be referred for the Direct Examination of the dig site.

5.3.4 Step-4: Post Assessment

Following shall be the part of the Post-assessment Step:

5.3.4.1 Fitness-for-purpose/service assessment

It shall be performed as per Guidance document CIMG-GD-5-2016-0001: Pipeline
Anomaly Management. It may be combined with other DA processes i.e., ICDA, SCCDA.

5.3.4.2 Determination of re-assessment interval

a) When corrosion defects are found during the direct examinations, the maximum reassessment interval for each ECDA region shall be taken as one-half the calculated remaining life. The maximum reassessment interval may be further limited by documents such as ASME B31.4, ASME B31.8, and ASME B31.8S. Different ECDA regions may have different reassessment intervals based on variations in expected growth rates between ECDA regions.

b) For features which are under scheduled/Monitored category, reassessment interval shall be as per Guidance document CIMG-GD-4-2016-0005: Pipeline Anomaly Management.

5.3.4.3 Root-Cause Analysis & Mitigation:

a) Existing root causes of all significant corrosion activity found during direct examination shall be identified. This may include inadequate CP current, previously unidentified sources of interference, or other situations that are isolated and unique.

b) If it is found that a root cause for which ECDA is not well suited (e.g., shielding by disbonded coating or MIC), the pipeline operator shall consider alternative methods of assessing the integrity of the pipeline segment.

c) The pipeline operator shall identify and perform remediation activities to mitigate or preclude future external corrosion resulting from significant root causes.

d) The pipeline operator may choose to repeat indirect inspections after remediation activities.

5.3.4.4 Evaluation of ECDA effectiveness

a) ECDA is a continuous improvement process. Through successive ECDA applications, locations at which corrosion activity has occurred, is occurring, or may occur, shall be identified and addressed.

b) Throughout the ECDA process as well as during scheduled activities and reassessments, steps shall be taken to improve the ECDA applications by incorporating feedback at all appropriate opportunities.

5.3.4.5 Reporting

ECDA reporting shall be as per template provided at Annexure-A.

6.0 Performing DG-ICDA

6.1 Introduction:
DG-ICDA is divided into following four steps having the key actions as given below:

<table>
<thead>
<tr>
<th>Key Actions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-assessment</td>
<td>• Feasibility study</td>
</tr>
<tr>
<td></td>
<td>• Data collection</td>
</tr>
<tr>
<td></td>
<td>• Identification of DG-ICDA regions</td>
</tr>
<tr>
<td>Indirect Inspection</td>
<td>• Identification of critical sites, i.e. those susceptible to water hold-up and accumulation</td>
</tr>
<tr>
<td></td>
<td>• Ranking of critical sites</td>
</tr>
<tr>
<td>Direct Examination</td>
<td>• Excavation of critical sites</td>
</tr>
<tr>
<td></td>
<td>• Infield data collection and measurements</td>
</tr>
<tr>
<td>Post Assessment</td>
<td>• Fitness-for-purpose/service assessment</td>
</tr>
<tr>
<td></td>
<td>• Determination of re-assessment interval</td>
</tr>
<tr>
<td></td>
<td>• Evaluation of DG-ICDA effectiveness</td>
</tr>
</tbody>
</table>

6.2 Preliminary work

6.2.1 Obtaining the pipeline burial depth and surface elevation information collected during the CAT survey at an interval of maximum 10 m.

6.2.2 Line up contract for field verification involving earth excavation and making working pits, coating / recoating and conducting NDE such as UT, Phased Array UT, LRUT, MPT, LPT etc. Please refer to CIMG Guidance document- CIMG-GD-4-2015-0003: Field Verification procedure for Feature Location, Confirmation and Measurement in Buried Pipelines.

6.2.3 Collect all available pipeline asset data and survey data.

6.2.4 Download DG-ICDA tool from O&M Intranet Page and save it to the local working folder duly renaming it for the pipeline name & code number for the particular pipeline. Save as many copies as required for the number of pipelines. While downloading the Excel tool and saving locally, care should be given to select the Macro-Enabled Worksheet. Otherwise its functionalities may not work properly.

6.2.5 Open the Excel Tool; Commence populating the data and performing the analysis.

6.3 DG-ICDA Procedure

6.3.1 Step-1: Pre-assessment:
6.3.1.1 **Feasibility (First & Second sheet of Excel Workbook):** On opening the program, the start page will appear as given below. Enter the information into the text fields, and click “Step 1” to begin DG-ICDA ad 2nd sheet of Excel workbook shall be created. To return to this page at any time, click the MACAW icon in the top left corner.

6.3.1.2 The first step in the Pre-Assessment step includes the feasibility assessment comprising of 8 questions about the pipeline in order to determine if DG-ICDA is applicable/feasible. A sample of such **questionnaire** is given below.

```plaintext
Does the pipeline normally contain liquids, including glycols?

Yes  The pipeline should contain normally dry gas. DG-ICDA should not be used to assess this pipeline.
```

Each questionnaire is having of answers with options of “Yes” or “No” from the drop-down list below each question. If any response suggests that DG-ICDA may not be suitable, warning text will be generated as mentioned above to advice upon the applicability of the methodology.

6.3.1.3 Once all questions have been answered, click “Continue”. If DG-ICDA is inappropriate for the pipeline, or if the feasibility assessment is incomplete, a warning will be displayed as given below.

6.3.1.4 On clicking button ‘Yes’ in the above pop up, below pop up screen will appear and same has to be verified by clicking ‘Yes’ button that all data have been collected. If this is not the case, continuation of Step 1 is not possible. On verification, third excel sheet for Pipeline data shall be created.
6.3.1.5 Pipeline Data (Third sheet of Excel Workbook): At next step of the pre-assessment, collection / input of pipeline data is required as given below.

At least 3 rows of pipeline data must be entered in the above. Chainage, elevation, outer diameter and wall thickness values must be specified on each row. It is recommended that these data are pasted into the sheet using the “Paste Data” button given at the top of the page. Blank cells should be avoided; the program will check for blank cells and will prevent continuation to Step 2 until they have been filled. If data are unavailable on a given row, they should be set equal to the equivalent parameters on an adjacent row.

6.3.1.6 ICDA Regions (Fourth sheet of Excel workbook): On clicking the right arrow button to continue, will generate a list of ICDA regions based on changes in wall thickness and diameter. These will be displayed on the next sheet and must be updated (by clicking the “Update” button, any time that pipeline data are edited. The ICDA regions output sheet will show the start chainage of each new region, and the criterion upon which the region is based. Note that the final region continues until the end of the pipeline. A sample of the sheet is given below.
6.3.1.7 Previous Digs (Fifth sheet of Excel Workbook): In this sheet, if historical excavations have been performed, these should be recorded. The “Result” column contains a drop-down box which allows the user to specify “no internal corrosion”, or a category between 1 and 4. Definitions of the categories are provided in the “Post Assessment” sheet. Once the page has been completed, click the right arrow button to continue.

<table>
<thead>
<tr>
<th></th>
<th>Start (m)</th>
<th>End (m)</th>
<th>Result</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.3.1.8 Product Data (Sixth Sheet of Excel Workbook): This page requires input of all necessary parameters relating to the gas and liquid products, i.e.

- Gas flow rate at standard temperature and pressure (kNm3 h⁻¹)
- Inlet and outlet temperatures (°C)
- Inlet and outlet pressures (bar)
- Gas and liquid compositions (mol fraction)

As a general rule, the actual operating conditions should be entered on this page. However, if no critical sites are found after running the assessment, the user may return to this page and enter those operating conditions which may be expected under process upset conditions (such as low flow).

With respect to composition, the gas can be specified from a list of typical natural gas components. Additionally, the liquid can be defined; typically this will be 100 mol% water, but for services operating near the dew point, the option is available to include condensed hydrocarbons.

The user should ensure that the mole fraction for each component is between 0 and 1, and that the total mole fraction is 1. Otherwise, the program will generate a warning.
6.3.2 Step-2: Indirect Inspection

6.3.2.1 **Critical Sites (Seventh & Eighth sheet of Excel Workbook):** On clicking “Step 2” as mentioned above, indirect inspection step shall begin and shall allow the program to run. Depending on the pipeline / product data entered, the following warning may appear during the assessment. This implies that within at least one region a critical angle does not exist between 0° - 90°.

When the assessment has completed, a message box will appear reporting the number of critical sites which have been detected. Click OK to continue to the output sheet.
6.3.2.2 Ranking of Critical sites: On clicking OK, output sheet is generated which gives the list of critical sites with following details. A sample of the list of Critical sites is given below.

- Ranking in descending order of angular exceedance,
- Start and End chainage values of the site,
- Inclination & Critical angle
- Exceedance,
- ICDA Region within which the site is located

<table>
<thead>
<tr>
<th>Rank</th>
<th>Site Start (m)</th>
<th>Site End (m)</th>
<th>Exceedance (°)</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>134.28</td>
<td>135.40</td>
<td>37.7</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3619.70</td>
<td>3621.80</td>
<td>28.5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>171.40</td>
<td>186.40</td>
<td>20.7</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>23.98</td>
<td>27.98</td>
<td>19.4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>366.30</td>
<td>370.80</td>
<td>11.0</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>2354.20</td>
<td>2372.00</td>
<td>10.8</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>2551.90</td>
<td>2556.40</td>
<td>9.5</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>504.00</td>
<td>513.60</td>
<td>8.7</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>195.00</td>
<td>209.00</td>
<td>5.0</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>1200.90</td>
<td>1213.10</td>
<td>2.8</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>87.46</td>
<td>102.46</td>
<td>0.1</td>
<td>2</td>
</tr>
</tbody>
</table>

Further on clicking the view chart button a new sheet shall be created showing the graphical representation.
6.3.3 Step-3: Direct Examination

6.3.3.1 The direct examination step in DG-ICDA includes performing excavations and conducting direct examinations of the pipeline to decide whether any metal loss from internal corrosion has occurred. The main objectives of the DG-ICDA direct examination are:

a) To determine whether internal corrosion occurs at locations selected in the previous step.

b) To use the findings to evaluate the overall condition of the DG-ICDA region.

6.3.3.2 Locations with an inclination greater than the critical angle must be examined moving downstream from the beginning of a pipeline region. Two consecutive locations must be found free from internal corrosion for the assessment to be complete. In addition, a third examination at the next location with inclination greater than the critical angle further serves as validation of the assessment.

6.3.3.3 If no inclination angles greater than critical exist, the largest angle must be examined. If corrosion is found, the next largest downstream location is chosen for analysis. If no corrosion is found, one additional (next largest) location serves as validation.

6.3.3.4 To account for low flow (i.e., if steady-state flow cannot be documented), a minimum of two inspections must be performed in sub region \( n' = 0 \), which is defined between
the beginning of the DG-ICDA region and the first site examined. If there is only one location with inclination upstream from the first site inspected, only one site must be inspected in the subregion. If there are no locations with inclinations in the subregion, no sites for that particular subregion need to be inspected.

6.3.3.5 If the pipeline has experienced bidirectional flow, the effect(s) of changing flow direction on corrosion distribution at selected sites shall be taken into account. This is in addition to treating the reverse directions as separate regions.

6.3.3.6 Further, Guidance document- CIMG- CIMG-GD-4-2015-0003: Field Verification procedure for Feature Location, Confirmation and Measurement in Buried Pipelines, shall be referred for the Direct Examination of the dig site.

6.3.4 Step-4: Post Assessment

Following shall be the part of the Post-assessment Step:

6.3.4.1 Fitness-for-purpose/service assessment

It shall be performed as per Guidance document CIMG-GD-5-2016-0001: Pipeline Anomaly Management. It may be combined with other DA processes i.e., ECDA, SCCDA.

6.3.4.2 Determination of re-assessment interval

a) Re-examine site at a prescribed frequency as determined in the post-assessment step based upon both remaining life and remaining strength pipeline calculations, to determine or assess growth rate (i.e., monitor site for corrosion growth on the actual pipe).

b) Apply a corrosion rate model based on operating conditions, gas quality, liquid composition and other key factors.

c) Perform laboratory testing on fluids based on operating conditions, gas quality, liquid composition, and other key factors to determine corrosiveness.

d) Technically justify and validate the selected method(s) of reassessment interval determination

e) Consider the distribution and uncertainty of predicted corrosion rates.

f) Demonstrate that the introduction of corrosive electrolytes is unlikely. If this can be done, the threat of future internal corrosion can be removed.

g) For features which are under scheduled/Monitored category, re-assessment interval shall be as per Guidance document CIMG-GD-5-2016-0001: Pipeline Anomaly Management.

6.3.4.3 Root-Cause Analysis & Mitigation:
a) Existing root causes of all significant corrosion activity found during direct examination shall be identified.

b) Identify and perform remediation activities to mitigate or preclude future external corrosion resulting from significant root causes.

6.3.4.4 Evaluation of DG-ICDA effectiveness

a) DA is a continuous improvement process. Through successive DG-ICDA applications, locations at which corrosion activity has occurred, is occurring, or may occur, shall be identified and addressed.

b) Throughout the DG-ICDA process as well as during scheduled activities and reassessments, steps shall be taken to improve the DG-ICDA applications by incorporating feedback at all appropriate opportunities.

6.3.4.5 Reporting

DG-ICDA reporting shall be as per template provided at Annexure-B.

7.0 Performing LP-ICDA

7.1 Introduction:

LP-ICDA is divided into following four steps having the key actions as given below:

<table>
<thead>
<tr>
<th>Key Actions</th>
<th>Pre-assessment</th>
<th>Indirect Inspection</th>
<th>Direct Examination</th>
<th>Post Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● Feasibility study</td>
<td>● Ranking of sites, with respect to relative risk from water accumulation, solids accumulation and sweet corrosion</td>
<td>● Excavation of critical sites</td>
<td>● Fitness-for-purpose/service assessment</td>
</tr>
<tr>
<td></td>
<td>● Data collection</td>
<td></td>
<td>● Infield data collection and measurements</td>
<td>● Determination of re-assessment interval</td>
</tr>
<tr>
<td></td>
<td>● Identification of LP-ICDA regions</td>
<td></td>
<td></td>
<td>● Evaluation of LP-ICDA effectiveness</td>
</tr>
</tbody>
</table>

7.2 Preliminary work
Title: Direct Assessment (DA) of Pipelines

Type: Guidance

Reference No.: CIMG-GD-4-2016-0005

7.2.1 Obtaining the pipeline burial depth and surface elevation information collected during the CAT survey at an interval of maximum 10 m.

7.2.2 Line up contract for field verification involving earth excavation and making working pits, coating / recoating and conducting NDE such as UT, Phased Array UT, LRUT, MPT, LPT etc. Please refer to CIMG Guidance document- CIMG- CIMG-GD-4-2015-0003: Field Verification procedure for Feature Location, Confirmation and Measurement in Buried Pipelines.

7.2.3 Collect all available pipeline asset data and survey data.

7.2.4 Download LP-ICDA tool from O&M Intranet Page and save it to the local working folder duly renaming it for the pipeline name & code number for the particular pipeline. Save as many copies as required for the number of pipelines. While downloading the Excel tool and saving locally, care should be given to select the Macro-Enabled Worksheet. Otherwise its functionalities may not work properly.

7.2.5 Open the Excel Tool; Commence populating the data and performing the analysis.

7.3 LP-ICDA Procedure

7.3.1 Step-1: Pre-assessment:

7.3.1.1 Feasibility (First & Second sheet of Excel Workbook): On opening the program, the start page will appear as given below. Enter the information into the text fields, and click “Step 1” to begin LP-ICDA ad 2nd sheet of Excel workbook shall be created. To return to this page at any time, click the MACAW icon in the top left corner.

7.3.1.2 The first step in the Pre-Assessment step includes the feasibility assessment comprising of 5 questions about the pipeline in order to determine if LP-ICDA is applicable/feasible. A sample of such questionnaire is given below.

7.3.1.3 Each questionnaire is having of answers with options of “Yes” or “No” from the drop-down list below each question. If any response suggests that LP-ICDA may not be
suitable, warning text will be generated as mentioned above to advice upon the applicability of the methodology.

7.3.1.4 Once all questions have been answered, click “Continue”. If LP-ICDA is inappropriate for the pipeline, or if the feasibility assessment is incomplete, a warning will be displayed as given below.

7.3.1.5 On clicking button ‘Yes’ in the above pop up, below pop up screen will appear and same has to be verified by clicking ‘Yes’ button that all data have been collected. If this is not the case, continuation of Step 1 is not possible. On verification, third excel sheet for Pipeline data shall be created.

7.3.1.6 **Weighting Factors (Third sheet of Excel Workbook):** Weighting factors must be entered by the user before running the ranking assessment. The following recommendations are made:

- Unless prior knowledge (i.e. a previous LP-ICDA assessment) is available with respect to the relative severity of the three models, each weighting factor should be set to \( \frac{1}{3} \).
- If prior knowledge is available for the pipeline, or for another similar pipeline, the weighting factors may be adjusted to reflect this knowledge.

7.3.1.7 **Region data (Fourth sheet of Excel Workbook):** A new ICDA region is defined when one of the following reference points is passed:
- Pig launcher / receiver
- Injection / delivery points
- Transition between internally coated / uncoated pipeline
- Diameter change
- Wall thickness change

As such, locations of pig traps, injection / delivery points and internally coated regions must be entered on the Region Data page. Any changes in flow rate or inhibitor efficiency which result from an operational injection / delivery point must be specified on the next sheet.

7.3.1.8 **Pipeline Data (Fifth sheet of Excel Workbook):** At next step of the pre-assessment, collection / input of pipeline data is required as given below.

At least 3 rows of pipeline data must be entered in the above. It is recommended that these data are pasted into the sheet using the “Paste Data” button given at the top of the page. Blank cells should be avoided; the program will check for blank cells and will prevent continuation to next step until they have been filled. If data are unavailable on a given row, they should be set equal to the equivalent parameters on an adjacent row.

7.3.1.9 **ICDA Regions (Sixth sheet of Excel workbook):** On clicking the right arrow button to continue, will generate a list of ICDA regions based on changes in wall thickness and diameter. These will be displayed on the next sheet and must be updated (by clicking the “Update” button, any time that pipeline data are edited. The ICDA regions output sheet will show the start chainage of each new region, and the criterion upon which the region is based. Note that the final region continues until the end of the pipeline. A sample of the sheet is given below.
7.3.1.10 **Previous Digs (Seventh sheet of Excel Workbook):** In this sheet, if historical excavations have been performed, these should be recorded. The “Result” column contains a drop-down box which allows the user to specify “no internal corrosion”, or a category between 1 and 4. Definitions of the categories are provided in the “Post Assessment” sheet. Once the page has been completed, click the right arrow button to continue.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STEP 1</strong></td>
<td><strong>Previous Digs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start (m)</td>
<td>End (m)</td>
<td>Result</td>
<td>Date</td>
</tr>
</tbody>
</table>

7.3.1.11 **Process Data (Eighth Sheet of Excel Workbook):** This page requires input of all necessary parameters relating to the process:

- Inlet and outlet temperatures (°C)
- Inlet and outlet pressures (bar)
- Water cut (vol %) and CO2 fraction (vol %)
- Solids density (kg m⁻³) and particle diameter (mm)
- Product pH
- Liquid composition

As a general rule, the actual operating conditions should be entered on this page. However, if the ranking is found to place all sites in the green risk band, the user should return to this page and enter those operating conditions which may be expected under process upset conditions (such as high temperature, low pH, large particle diameter etc.). This will highlight which threat is of greatest concern. 

With respect to composition, the liquid can be specified from a list of petroleum components. It should be ensured that the mole fraction for each component is between 0 and 1, and that the total mole fraction is 1. Otherwise, the program will generate a warning. A sample sheet is given below.
### 7.3.2 Step-2: Indirect Inspection

7.3.2.1 **Critical Sites (Ninth sheet of Excel Workbook):** On clicking “Step 2” as mentioned above, indirect inspection step shall begin and shall allow the program to run.

When the assessment has completed, a message box will appear. Click OK to continue to the output sheet. A sample assessment output sheet is shown here below.

The output sheet presents a list of critical sites, including for each site:

- Rankin
- Start and End chainage values of the site
- Water accumulation result
- Solids accumulation result
- Corrosion rate
- The ICDA Region within which the site is located, and
- Results of previous findings (cross referenced from the Previous Digs page).
Here, a calculated value of \( W > 1 \) suggests a risk of water droplet coalescence and Froude numbers (\( F \)) < 0.67 indicate a risk of water accumulation, whereas those greater than 2 indicate complete entrainment. A calculated value of \( S < 1 \) suggests a risk of solids accumulation.

### 7.3.3 Step-3: Direct Examination

7.3.3.1 At a minimum, the two locations with the greatest probability of internal corrosion within each LP-ICDA region shall be selected for direct examination. Two consecutive locations must be found free of internal corrosion to complete the assessment. For regions longer than 5 km (3 mi), sub-regions shall be established as per the applicable NACE DA standard. The two locations with the greatest probability of internal corrosion within each subregion shall then be selected for direct examination.

7.3.3.2 If there has been bidirectional flow through the pipeline, flow in the opposite direction
shall be considered as a separate LP-ICDA region, and each direction shall be treated separately.

7.3.3.3 If a region or subregion contains more than two sites with a similar highest probability of internal corrosion, additional sites shall be selected.

7.3.3.4 Site accessibility, repair history/records, and any internal leak/rupture history should be considered during site selection.

7.3.3.5 If multiple sites have the same probability for the same internal corrosion mechanism, it may be prudent to perform the first inspection at the site that is most easily accessible.

7.3.3.6 If there are locations selected in an area of replacement pipe, consideration should be given to selecting another site with a similar probability of internal corrosion.

7.3.3.7 In addition, direct examination shall be conducted in one location not identified as susceptible for internal corrosion.

7.3.3.8 When the direct examination process identifies the existence of extensive severe internal corrosion, the operator shall return to pre-assessment because the applicability of LP-ICDA is in question.

7.3.3.9 On clicking the step-3 as mentioned in above sheet, following table shall appear where the filed measurements may be recorded from Direct examination step.

7.3.3.10 Further, Guidance document- CIMG- CIMG-GD-4-2015-0003: Field Verification procedure for Feature Location, Confirmation and Measurement in Buried Pipelines, shall be referred for the Direct Examination of the dig site.
7.3.4 Step-4: Post Assessment

Following shall be the part of the Post-assessment Step:

7.3.4.1 Fitness-for-purpose/service assessment

It shall be performed as per Guidance document CIMG-GD-5-2016-0001: Pipeline Anomaly Management. It may be combined with other DA processes i.e., ECDA, SCCDA.

7.3.4.2 Determination of re-assessment interval

a) Re-examine site at a prescribed frequency as determined in the post-assessment step based upon both remaining life and remaining strength pipeline calculations, to determine or assess growth rate (i.e., monitor site for corrosion growth on the actual pipe).

b) Apply a corrosion rate model based on operating conditions, gas quality, liquid composition and other key factors.

c) Perform laboratory testing on fluids based on operating conditions, gas quality, liquid composition, and other key factors to determine corrosiveness.
d) Technically justify and validate the selected method(s) of reassessment interval determination

e) For features which are under scheduled/Monitored category, re-assessment interval shall be as per Guidance document CIMG-GD-5-2016-0001: Pipeline Anomaly Management.

7.3.4.3 Root-Cause Analysis & Mitigation:

a) Existing root causes of all significant corrosion activity found during direct examination shall be identified.

b) Identify and perform remediation activities to mitigate or preclude future external corrosion resulting from significant root causes.

7.3.4.4 Evaluation of LP-ICDA effectiveness

a) DA is a continuous improvement process. Through successive LP-ICDA applications, locations at which corrosion activity has occurred, is occurring, or may occur, shall be identified and addressed.

b) Throughout the LP-ICDA process as well as during scheduled activities and reassessments, steps shall be taken to improve the LP-ICDA applications by incorporating feedback at all appropriate opportunities.

7.3.4.5 Reporting

LP-ICDA reporting shall be as per template provided at Annexure-C.

8.0 Performing SCCDA

8.1 Introduction:

SCCDA is divided into following four steps having the key actions as given below:

<table>
<thead>
<tr>
<th>Key Actions</th>
<th>Pre-assessment</th>
<th>Indirect Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Feasibility study</td>
<td>• Identification of critical sites, i.e. those considered most likely susceptible to SCC</td>
</tr>
<tr>
<td></td>
<td>• Data collection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Identification of SCCDA regions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• SCCDA indirect assessment tool selection</td>
<td></td>
</tr>
</tbody>
</table>
8.2 Preliminary work

8.2.1 Step (a), (b) & (c) of the preliminary work remains the same as per ECDA.

8.2.2 Download SCCDA tool from O&M Intranet Page and save it to the local working folder duly renaming it for the pipeline name & code number for the particular pipeline. Save as many copies as required for the number of pipelines. While downloading the Excel tool and saving locally, care should be given to select the Macro-Enabled Worksheet. Otherwise its functionalities may not work properly.

8.2.3 Open the Excel Tool; Commence populating the data and performing the analysis.

8.3 SCCDA Procedure

8.3.1 Step-1: Pre-assessment:

8.3.1.1 Feasibility (First sheet of Excel Workbook): The first step in the Pre-Assessment step includes the feasibility assessment comprises of some questions about the pipeline in order to determine if SCCDA is applicable/feasible. This is divided into three Sections. A sample of such questionnaire is given below:

Each questionnaire is having of answers with options of “Yes” or “No” from the drop-down list below each question. If any response suggests that SCCDA may not be suitable, warning text will be generated to advice upon the applicability of the methodology. At no point will the answers to the feasibility questions preclude the user from completing the assessment; warnings are for information only. After completing all the questionnaires and if requirements are found to be satisfied for the feasibility assessment, then user should continue to next step of the pre-assessment.

If all the conditions/threats as mentioned in the questionnaire are not present for SCC
to occur, it shall be concluded that there is no any threat from SCC in the section of Pipeline and such assessment report shall be generated. However, if the conditions are present then further steps of SCCDA shall be preceded.

8.3.1.2 **Pipeline Parameters (Second sheet of Excel Workbook):** At next step of the pre-assessment, collection / input of pipeline data is required as given below. Pipeline ID shall be the Pipeline section code as per Pipeline master data. These data also includes the data related to threat assessment this is accomplished by entering applicable data into a series of tables as follows.

<table>
<thead>
<tr>
<th>Pipeline Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline ID</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pipeline Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Distance (m)</td>
</tr>
<tr>
<td>End Distance (m)</td>
</tr>
<tr>
<td>Diameter (mm)</td>
</tr>
<tr>
<td>Wall Thickness (mm)</td>
</tr>
<tr>
<td>Pipe Type</td>
</tr>
<tr>
<td>Installed (YYYY)</td>
</tr>
<tr>
<td>Grade</td>
</tr>
</tbody>
</table>

8.3.1.3 **Pre-assessment (Third sheet of Excel Workbook):** In this sheet, data related to Location of Compressor/Pumps, Above ground sections, Coating type, Maximum operating pressure, temperature, SCC History (own & foreign Pipeline if any) and Additional features shall be entered.

There is a strong correlation between the locations of pumping stations and the presence of SCC. The sites of any pumping stations within the section need to be identified by their start and end distances. If no pumping station is located within the section, then the start distance should be entered as a negative number from its location in the preceding section to the start of the section. In longer pipelines multiple pumping stations can be entered, the distance of the intermediate stations should be identified in the context of the whole length of the line. A sample of such data table is given below.
8.3.1.4 Above ground sections are not usually considered susceptible to SCC and therefore any sections above ground should be identified. It is sufficient to list the start and end distances of these sections but a small space has been left open for comments. A sample of such data table is given below:

<table>
<thead>
<tr>
<th>Distance Start (m)</th>
<th>Distance End (m)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>

8.3.1.5 There is a strong correlation between some coating types and prevalence of SCC. Should the coating be uniform along the length of the line then the start and end distances and coating type need only be identified once. Should the coating scheme be mixed the different sections should be identified in turn. Coatings are also known to degrade over time and so their age is an important parameter. If the precise date the coating was fitted is unknown, user should enter a conservative estimate e.g. 1st January of the year fitted.

<table>
<thead>
<tr>
<th>Coating Start Distance (m)</th>
<th>Coating End Distance (m)</th>
<th>Coating Type</th>
<th>Fitted (Date)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
<td>Epoxy Paint</td>
<td>01/03/2004</td>
</tr>
<tr>
<td>50</td>
<td>5000</td>
<td>Tape Wrap</td>
<td>20/05/2010</td>
</tr>
</tbody>
</table>

8.3.1.6 The operating stress is an important parameter in determining the susceptibility of the pipeline (section) to SCC. Unless otherwise stated the model will assume the same
pressure until another value is entered. A more accurate assessment will be made if a pressure profile is used with pressures at various points along the length. A representative pressure profile may be obtained from the background calculations contained in the

![MOP Table]

8.3.1.7 The operating temperature is another important factor in determining the susceptibility of the pipeline (section) to SCC. The model assumes a linear heat loss along the length of the pipeline (section) between the inlet temperature and the eventual outlet temperature. In cases where multiple compressor/pumping stations are present, the inlet/outlet temperatures should be entered for each of the intermediate stations.

![Operating Temperature Table]

8.3.1.8 Occurrences of SCC do not happen in isolation and previous failures due to SCC in a pipeline are usually an indicator that other SCC defects will be present where conditions allow. Previous failures should be identified by their distance and the type of failure i.e. during operation or hydrotest.
8.3.1.9 SCC failures in nearby pipelines (within 30 km) may be indicative of ground conditions conducive to SCC initiation. It is noted that this is a range sum and the whole section within 30 km of the failure should be identified i.e. start and end distances along with the type of failure.

8.3.1.10 Geometric features such as dents result in localised stress concentrations and can lead to isolated SCC, even where the normal operational stress is below levels normally considered as susceptible. Any known geometric features or stress raisers should be identified by their distance. The severity of the additional feature is not considered by this assessment. A sample of such input data is given below:

### Additional Features

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Geometric Feature</td>
</tr>
<tr>
<td>563</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**8.3.1.11 Region List (Fourth Sheet) for Identification of SCCDA regions:** After inputting data in all the previous sheets, move to the sheet named ‘Region List’ and click the ‘Define’ button.

A new SCCDA region will be defined whenever there is a change in the following
parameters:

- Diameter
- Wall thickness
- Disposition
- Coating type
- Coating age
- SCC history

It is noted that temperature and pressure related parameters are not used in the region definitions as these are dynamic and change almost constantly along the length of the line depending on the operating conditions. The model will define the region number, start distance and end distance along with a susceptibility index score.

<table>
<thead>
<tr>
<th>Regions</th>
<th>Define</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td>Start (m)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon clicking the ‘Define’ button, the Excel tool lists all the SCCDA regions with Index score as per data provided and a new sheet ‘Region Chart’ showing the same in a graphical format as illustrated below.

![Region Chart](image)

The sheet is designed to work with a maximum pipeline length of 50 km

8.3.1.12 Selection of Indirect Assessment tools: Following minimum three nos. of indirect inspection tool shall be selected as given below uniformly for all unpiggable pipelines:
a) Close Interval Potential survey (CIPS)
b) Current Attenuation Test (CAT)
c) DCVG/CAT with “A” frame survey

As mentioned in 4.2.1.2 (a) above, the contracts for carrying out the above surveys shall have been awarded and executed earlier to starting the SCCDA process using the Excel tool.

8.3.2 Step-2: Indirect Inspection:

8.3.2.1 Indirect Assessment-Input Data (Sixth sheet of Excel Workbook): Data from various surveys shall be populated in the Excel tables named as Coating Survey (DCVG), Coating Survey Results (DCVG) and so on.

<table>
<thead>
<tr>
<th>Coating Survey (DCVG)</th>
<th>Coating Survey Results (DCVG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance From (m)</td>
<td>Distance To (m)</td>
</tr>
</tbody>
</table>

For each indirect inspection method, the data shall be analyzed to identify and classify indications. The output of this process is a list of sites leading to the direct examination step.

8.3.2.2 Site Ranking (Seventh sheet of Excel Workbook): The result of the model is an estimated PoF (Probability of failure) expressed in units of events m-1 year-1 across all the sections of the pipeline. The result is dependent upon the severity of the threat and the severity of any indications from the indirect inspection.

After inputting data in all the previous sheets as above, move to the sheet named ‘Site Ranking’ and click the ‘Rank’ button.

<table>
<thead>
<tr>
<th>Site Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank</td>
</tr>
</tbody>
</table>

Upon clicking the ‘Rank’ button, the Excel tool ranks along with SCCDA region with Dig Site Selection score and a new sheet ‘Site Chart’ showing the same in a graphical
format. The model produces a chart showing the profile of the line and a list of the sites considered to be the most likely to contain SCC as shown below.

<table>
<thead>
<tr>
<th>Site Ranking</th>
<th>Rank</th>
<th>Start (m)</th>
<th>End (m)</th>
<th>POF</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27000</td>
<td>27100</td>
<td>7.9E-05</td>
<td>4</td>
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<tr>
<td>2</td>
<td>19000</td>
<td>19010</td>
<td>5.5E-05</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>35500</td>
<td>35510</td>
<td>4.4E-05</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10590</td>
<td>10600</td>
<td>4.1E-05</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>24200</td>
<td>24210</td>
<td>2.4E-05</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>25200</td>
<td>25210</td>
<td>2.4E-05</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>17890</td>
<td>17900</td>
<td>8.1E-06</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>37500</td>
<td>37510</td>
<td>4.4E-06</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1090</td>
<td>1100</td>
<td>3.4E-06</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2200</td>
<td>2210</td>
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<td></td>
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<td>11</td>
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<td>5300</td>
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<td>1</td>
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<td>12</td>
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<td>8700</td>
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<td>13</td>
<td>16900</td>
<td>17000</td>
<td>2.8E-06</td>
<td>2</td>
<td></td>
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<tr>
<td>14</td>
<td>13000</td>
<td>13100</td>
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<td></td>
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<tr>
<td>15</td>
<td>9600</td>
<td>9610</td>
<td>2.2E-06</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

8.3.3 Step-3: Direct Examination

a) The objectives of the direct examination is to field verify the sites selected following the integration and analysis of the indirect inspection surveys and the pre-assessment step and as per site ranking. This step requires excavation to be made to expose the pipeline so that measurements can be made of the pipeline and the surrounding environment.

b) Although no. of minimum digs is not stipulated in the NACE SP204-2015 for SCCDA, minimum one no. of Direct examination should be performed for the validation. If SCC is found at the highest ranked site, next ranked sites should be also chosen till there is no SCC indication is met.

c) Further, Guidance document- CIMG- CIMG-GD-4-2015-0003: Field Verification procedure for Feature Location, Confirmation and Measurement in Buried Pipelines, shall be referred for the Direct Examination of the dig site.

8.3.4 Step-4: Post Assessment

Following shall be the part of the Post-assessment Step:

8.3.4.1 Fitness-for-purpose/service assessment

It shall be performed as per Guidance document CIMG-GD-5-2016-0001: Pipeline Anomaly Management. It may be combined with other DA processes i.e. ECDA, ICDA.

8.3.4.2 Determination of re-assessment interval
a) When SCC defects are found during the direct examinations, the maximum reassessment interval for each SCCDA region shall be taken as one-half the calculated remaining life. The maximum reassessment interval may be further limited by documents such as ASME B31.4, ASME B31.8, and ASME B31.8S. Different SCCDA regions may have different reassessment intervals based on variations in expected growth rates between SCCDA regions.

b) For features which are under scheduled/Monitored category, re-assessment interval shall be as per Guidance document CIMG-GD-4-2016-0005: Pipeline Anomaly Management.

8.3.4.3 Root-Cause Analysis & Mitigation:

a) Existing root causes of all significant corrosion activity found during direct examination shall be identified. This may include inadequate CP current, over CP protection, Higher operating stress etc.

b) If it is found that a root cause for which SCCDA is not well suited (e.g., shielding by disbonded coating or MIC), alternative methods for assessing the integrity of the pipeline segment shall be considered.

c) Identify and perform remediation activities to mitigate or preclude future external corrosion resulting from significant root causes.

d) The pipeline operator may choose to repeat indirect inspections after remediation activities.

8.3.4.4 Evaluation of SCCDA effectiveness

a) SCCDA is a continuous improvement process. Through successive SCCDA applications, locations at which SCC has occurred, is occurring, or may occur, shall be identified and addressed.

b) Throughout the SCCDA process as well as during scheduled activities and reassessments, steps shall be taken to improve the SCCDA applications by incorporating feedback at all appropriate opportunities.

8.3.4.5 4.1.4 Reporting

SCCDA reporting shall be as per template provided at Annexure-D.
9.0 Reference Codes/Standards

a) NACE SP 0502-2010, Pipeline External Corrosion Direct Assessment Methodology
b) NACE SP0110-2010 Internal Corrosion Direct assessment for Wet Natural gas
c) NACE SP0208-2008 Internal Corrosion Direct assessment for Liquid Petroleum pipelines
d) NACE SP0206-2006 Internal Corrosion Direct assessment for Dry Gas Natural gas
e) NACE SP0204 Stress Corrosion cracking Direct assessment
f) NACE SP 0207- 2007, Performing CIPS & DC Surface Potential Gradient Survey On Buried Or Submerged Metallic Pipelines
g) NACE SP 0169-2013, Control of External Corrosion on Underground or Submerged Metallic Piping Systems
h) NACE TM0109-2009, Aboveground Survey Techniques for the Evaluation of Underground Pipeline Coating Condition
i) Guidance document CIMG-GD-4-2016-0001: Performing CIPS, CAT and DCVG/ CAT ‘A’ Frame Survey
k) Guidance document CIMG-GD-5-2016-0001: Pipeline Anomaly Management
Annexure-A

ECDA Report Template

<table>
<thead>
<tr>
<th>Pipeline Section Code</th>
<th>Pipeline Section Name</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Prepared By</th>
<th>Reviewed By</th>
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<tbody>
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<table>
<thead>
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<th>Date</th>
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</thead>
<tbody>
<tr>
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<td></td>
</tr>
</tbody>
</table>

1.0 **Pre-assessment**

1.1 Data elements collected for the segment to be evaluated.

1.2 Methods and procedures used to integrate the data collected to determine when indirect inspection tools can and cannot be used;

1.3 Methods and procedures used to select the indirect inspection tools; and

1.4 Characteristics and boundaries of ECDA regions and the indirect inspection tools used in each region.

1.5 Copy of excel sheets of Pre-assessment step from the tool.

2.0 **Indirect Inspection**

2.1 All indirect inspection actions should be recorded.

2.2 Geographically referenced locations of the beginning and ending point of each ECDA region and each fixed point used for determining the location of each measurement;

2.3 Date(s) and weather conditions under which the inspections were performed;

2.4 Inspection results at sufficient resolution to identify the location of each indication;

2.5 When data are not recorded in a (near) continuous manner, a complete description of the conditions between the locations of indications (epicenters).

2.6 Procedures for aligning data from the indirect inspections and expected errors for each inspection tool; and

2.7 Procedures for defining the criteria to be used in prioritizing the severity of the indications.

2.8 Copy of excel sheets of Pre-assessment step from the tool.

3.0 **Direct Examination**
3.1 All direct examination actions should be recorded.
3.2 Procedures and criteria for prioritizing the indirect inspection indications;
3.3 Data collected before and after excavation;
3.4 Measured metal-loss corrosion geometries;
3.5 Data used to identify other areas that may be susceptible to corrosion;
3.6 Data used to estimate corrosion growth rates;
3.7 Results of root-cause identifications and analyses, if any;
3.8 Planned remediation activities; and
3.9 Descriptions of and reasons for any reprioritizations.
3.10 Photographic records

4.0 Post-assessment
4.1 All post-assessment actions should be recorded.
4.2 Remaining life calculation results;
4.3 Maximum remaining defect size determinations;
4.4 Corrosion growth rate determinations;
4.5 Method of estimating remaining life & Results;
4.6 Reassessment intervals and scheduled activities, if any;
4.7 Criteria used to assess ECDA effectiveness and results from assessments.
4.8 Data from periodic assessments;
4.9 Feedback-Assessment of criteria used in each step of the ECDA process; and Modifications of criteria.
Annexure-B

DG-ICDA Report Template

<table>
<thead>
<tr>
<th>Pipeline Section Code</th>
<th>Pipeline Section Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepared By</td>
<td>Reviewed By</td>
</tr>
<tr>
<td>Date</td>
<td>Date</td>
</tr>
</tbody>
</table>

1.0 **Pre-assessment**

1.1 Data elements collected for the segments.

1.2 Methods and procedures used to integrate data, prioritize segments, and select dig sites.

1.3 Characteristics and boundaries of DG-ICDA regions Methods and procedures used to select the indirect inspection tools; and

1.4 Copy of excel sheets of Pre-assessment step from the tool.

2.0 **Indirect Inspection**

2.1 Geographically referenced locations of the beginning and ending point of each DG-ICDA region and each fixed point used for determining the location of each measurement.

2.2 Procedures for determining accuracy of inclination profiles.

2.3 Procedures for defining the criteria to be used in prioritizing the severity of the indications.

2.4 Copy of excel sheets of Pre-assessment step from the tool.

3.0 **Direct Examination**

3.1 Data collected before and after excavation.

3.2 Measured metal loss corrosion geometries.

3.3 Data used to identify other areas that may be susceptible to corrosion.

3.4 Data used to estimate corrosion growth rates.

3.5 Planned mitigation activities.

3.6 Descriptions of and reasons for any selections of additional sites or reprioritizations.
### Direct Assessment (DA) of Pipelines

<table>
<thead>
<tr>
<th>Title</th>
<th>Direct Assessment (DA) of Pipelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Guidance</td>
</tr>
<tr>
<td>Reference No.</td>
<td>CIMG-GD-4-2016-0005</td>
</tr>
</tbody>
</table>

3.7 Photographic records

4.0 Post-assessment

4.1 Remaining life calculation results.

4.2 Maximum remaining flaw size determinations.

4.3 Corrosion growth rate determinations.

4.4 Method of estimating remaining life.

4.5 Reassessment intervals, including technical justification and operator’s validation of selected method of reassessment; and any scheduled activities

4.6 Criteria used to assess DG-ICDA effectiveness and results from assessments

4.7 Criteria used to select reassessment intervals and the intervals selected.

4.8 Monitoring Records

4.9 Feedback
### Direct Assessment (DA) of Pipelines

<table>
<thead>
<tr>
<th>Title</th>
<th>Direct Assessment (DA) of Pipelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Guidance</td>
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</table>

### Annexure-C

**LP-ICDA Report Template**

<table>
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<th>Pipeline Section Code</th>
<th>Pipeline Section Name</th>
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<td>Prepared By</td>
<td>Reviewed By</td>
</tr>
<tr>
<td>Date</td>
<td>Date</td>
</tr>
</tbody>
</table>

#### 1.0 Pre-assessment
1.1 Data elements collected for the segments.
1.2 Methods and procedures used to integrate data, prioritize segments, and select dig sites.
1.3 Characteristics and boundaries of LP-ICDA regions. Methods and procedures used to select the indirect inspection tools; and
1.4 Copy of excel sheets of Pre-assessment step from the tool.

#### 2.0 Indirect Inspection
2.1 Geographically referenced locations of the beginning and ending point of each LP-ICDA region and each fixed point used for determining the location of each measurement.
2.2 Procedures for defining the criteria to be used in prioritizing the severity of the indications.
2.3 Copy of excel sheets of Pre-assessment step from the tool.

#### 3.0 Direct Examination
3.1 Data collected before and after excavation.
3.2 Measured metal loss corrosion geometries.
3.3 Data used to identify other areas that may be susceptible to corrosion.
3.4 Data used to estimate corrosion growth rates.
3.5 Planned mitigation activities.
3.6 Descriptions of and reasons for any selections of additional sites or reprioritizations.
3.7 Photographic records.
4.0 Post-assessment

4.1 Remaining life calculation results.

4.2 Maximum remaining flaw size determinations.

4.3 Corrosion growth rate determinations.

4.4 Method of estimating remaining life.

4.5 Reassessment intervals, including technical justification and operator’s validation of selected method of reassessment; and any scheduled activities

4.6 Criteria used to assess LP-ICDA effectiveness and results from assessments

4.7 Criteria used to select reassessment intervals and the intervals selected.

4.8 Monitoring Records

4.9 Feedback
### SCCDA Report Template

<table>
<thead>
<tr>
<th>Pipeline Section Code</th>
<th>Pipeline Section Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepared By</td>
<td>Reviewed By</td>
</tr>
<tr>
<td>Date</td>
<td>Date</td>
</tr>
</tbody>
</table>

#### 1.0 Pre-assessment

1.1 Data elements collected for the segments.

1.2 Methods and procedures used to integrate data, prioritize segments, and select dig sites.

1.3 Feasibility outcome as per SCC Threat.

1.4 Methods and procedures used to select the indirect inspection tools; and

1.5 Copy of excel sheets of Pre-assessment step from the tool.

#### 2.0 Indirect Inspection

2.4 Documentation regarding the analysis used to identify data needs and selection of specific indirect inspection techniques.

2.5 Data elements collected for the segments to be evaluated.

2.6 Methods and procedures used to integrate data, prioritize segments, and select dig sites.

2.7 Procedures for defining the criteria to be used in prioritizing the severity of the indications.

2.8 Copy of excel sheets of Pre-assessment step from the tool.

#### 3.0 Direct Examination

3.1 Data collected for field site verification.

3.2 Data collected prior to coating removal.

3.3 Data collected after coating removal.

3.4 Results of analysis of cracking, if found.
| 3.5 | Results of assessment of severity of cracking, if found. |
| 3.6 | Photographic records |

4.0 Post-assessment

4.10 Whether mitigation was required, the type of mitigation selected, and the justification for the selection.

4.11 Criteria used to select reassessment intervals and the intervals selected.

4.12 Scheduled activities, if any.

4.13 Criteria used to assess SCCDA effectiveness and results from assessments.