Industry Guidance for the Development of Inspection Plans for Buried Piping

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1.0 Preface

This document provides industry guidance for the determination of reasonable assurance for structural and/or leakage integrity for buried piping. The criteria and guidelines presented in this document were developed as a consistent basis for establishment of what is necessary to provide “reasonable assurance of integrity”.

2.0 Purpose

The purpose of this document is to provide a technically based approach for development of inspection plans that establish reasonable assurance of structural and/or leakage integrity of buried piping through the application of the results of both indirect inspections and direct examinations. The approach is programmatically founded in the precepts established in the “Recommendations for an Effective Program to Control the Degradation of Buried and Underground Piping and Tanks (EPRI 1016456, Revision 1) and utility site specific program documents. This document is intended to establish reasonable assurance for scoped buried piping systems; optimizing the inspection scope, while not requiring 100% inspection.

3.0 Background

Reasonable assurance is an industry methodology used to achieve increased confidence in the capability of a structure, system or component (SSC) to perform its intended function. Reasonable assurance does not equate to absolute assurance or confidence. Rather, reasonable assurance collects appropriate data/insights/information to support the establishment of increased confidence. Situations may occur where sufficient data cannot be easily collected; in these cases, the available data may be supplemented with additional insights to bolster a technical foundation of reasonable assurance. If available information (even with supplemental insights) is insufficient to support a conclusion of reasonable assurance, then additional actions must be taken to achieve reasonable assurance. Ultimately, the establishment of reasonable assurance is the obligation of the owner. This guideline provides insights to achieve consistency among industry users to identify what actions are generally necessary to establish reasonable assurance for structural and/or leakage integrity for buried piping.

Reasonable assurance of integrity in buried piping systems containing licensed material or non-licensed material is obtained when activities such as an engineering evaluation (including a Fitness-for-Service assessment), indirect inspections of underground components, direct examination and remediation (if necessary), are performed. Such a combination of activities will provide a high level of confidence that the structural and leak integrity of the buried piping systems, will be managed and effectively maintained.

A reasonable assurance of integrity process is based on defining systems that are in scope, risk ranking these systems, and then identifying a sample of locations in these systems for inspections. It relies on engineering analyses, expert judgment, operating experience, and groundwater protection program data to determine what regions of the buried pipes are vulnerable to degradation and adequately characterizing the vulnerability so that, if necessary, appropriate corrective actions may be taken. This process is based on risk identification and inspection sampling intended to greatly reduce the potential for unacceptable leakage or failures in the most susceptible systems.

Engineering evaluation is an important part of the "reasonable assurance of integrity" process. The engineering evaluation will consider but not limited to items such as high consequence and/or likelihood areas, previous inspection results, fabrication practices, material type, backfill, coating, soil condition, water levels, water and soil chemistry, cathodic protection, operational history, industry operating experience, site operating experience and groundwater protection program data. This engineering evaluation will identify the risk of potential leakage, the most probable locations, and/or areas of likely susceptibility. The evaluation will also identify the potential consequences that could result if a leak occurred. With this information, an inspection plan can be developed and implemented that provides information regarding the condition of the structure, system or component. The inspections can be indirect in that they will provide information on the condition of the pipe remotely – from ground level or from an exposed section of pipe that is distant or remote from the pipe location of interest. Inspections include a direct examination of the pipe wall and a visual inspection of the outer surface coating to determine coating integrity. Direct examination can also be achieved using an in-line vehicle (or Pipeline Inspection Gauge "PIG") deployed with demonstrated direct examination equipment that is capable of detecting degradation that is possible at the location of interest and that is large enough to challenge structural or leakage integrity if present.

The specific inspections and examinations that are performed will be based on the type of degradation observed or expected, the susceptibility of the pipe to leakage, the consequences of a leak, and the location of the pipe. The scheduling of re-inspection and re-examination is also dependent on the engineering determination of susceptibility, consequences, and the results of the initial inspection or examination.

4.0 Terms and Definitions

4.1. **Adverse Inspection Findings** – Indications from inspections that require immediate repairs or repairs within one cycle.

4.2. **Baseline Inspections** - Inspection of new or replaced pipe or components that have not previously been involved in plant operations.

4.3. **Corrosion Rate (CR)** is the rate of corrosion occurring over a defined period of time.

4.4. **Direct Examination -** A Nondestructive Evaluation (NDE) examination where the NDE sensor(s) is in immediate contact with or in close proximity to the section of the component being examined. Results provide some degree of quantitative measurement of wall thickness or discontinuity size. Direct examinations can be performed from the interior or exterior surface. Detection and characterization capabilities vary by NDE method as well as by specific NDE technique. Examples of NDE methods include ultrasonics, eddy current, radiography, visual and various electromagnetic techniques. Visual examinations need to be supplemented with NDE or engineering judgment that addresses the condition of the pipe wall.

4.5. **Fitness-for-Service (FFS) -** is a technical evaluation of direct examination data to determine acceptable flaw size, degradation rate, remaining life, and the time to the next inspection or repair/replacement/mitigation.

4.6. **Highest Susceptible Locations** are the highest likelihood and consequence risk ranked lines, segments or zones as defined in the buried piping susceptibility analysis and risk ranking database.

4.7. **Indirect Inspection** – Survey techniques used to assess the likelihood of degradation without having direct access to the section of the component being examined. These inspections typically measure surrounding conditions that may be indicative of corrosion or damage. Results are typically qualitative and less accurate than direct examinations. Examples of indirect inspection methods include over-the-line surveys and for the purpose of this document, long range guided wave.

4.8. **Initial Inspection -** The inspection of pipe or components that have been in service but have not been previously inspected.

4.9. **Inspection Program** - A systematic evaluation of in-scope components using various techniques (e.g., ultrasonic testing (UT), radiographic testing (RT), visual testing (VT), leak testing (LT), eddy current testing (ET)).

4.10. **Lg** – is the total length of piping associated with a group of lines.

4.11. **L indirect** – is the total length of pipe associated with a group of pipe lines that have been indirectly inspected.

4.12. **Line Grouping** - is a process that may be used to optimize inspection scope and schedule duration. Lines/segments/zones are grouped based on various attributes, such as but not limited to process fluid, pipe material, coatings, depth, age, soil/backfill, etc.

4.13. **Next Scheduled Inspection (NSI)** - is the time duration until another inspection of the pipe line group is required.

4.14. **Opportunistic Inspection** – An inspection performed when buried or underground components are exposed or excavated due to another activity providing an opportunity to inspect and document the results for a program component.

4.15. **Piping Segment** - Portions of buried piping systems that are grouped together for risk ranking purposes based on similarities such as installation, manufacture, or environmental conditions. Some risk ranking methods may use other terms to refer to piping segments, such as zones.

4.16. **Post Assessment** is an assessment of all indirect and direct examination results including a FFS evaluation that will determine the projected structural and leakage integrity of a pipe.

4.17. **Remaining Life (RL)** is defined as the time period until the pipe wall thickness is no longer acceptable.

4.18. **Visual Inspections** involve direct observation by inspectors or by the use of remote visual inspection devices.

Figure 5-1 Buried Piping Inspection Reasonable Assurance (RA) Flow Chart

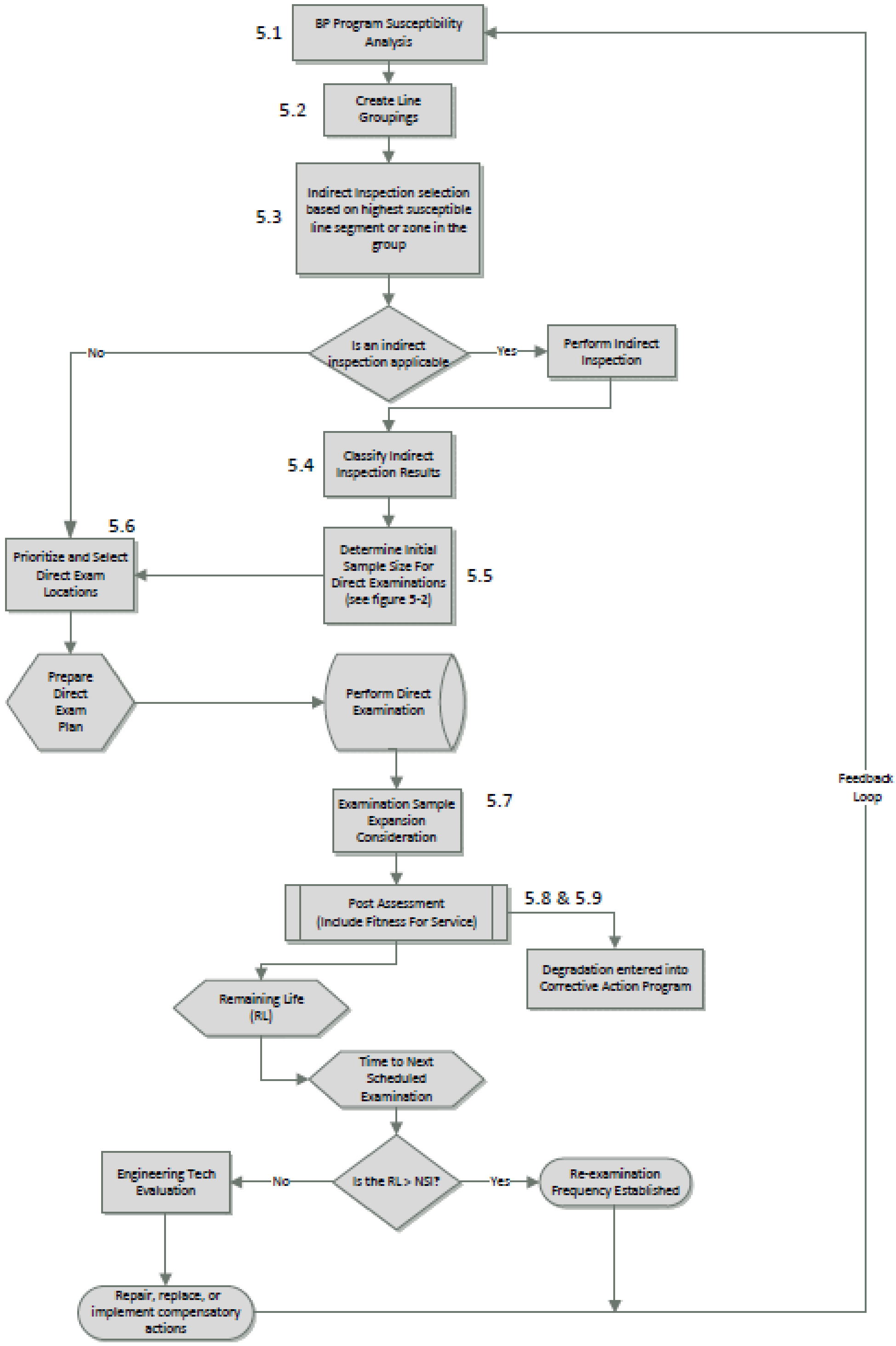
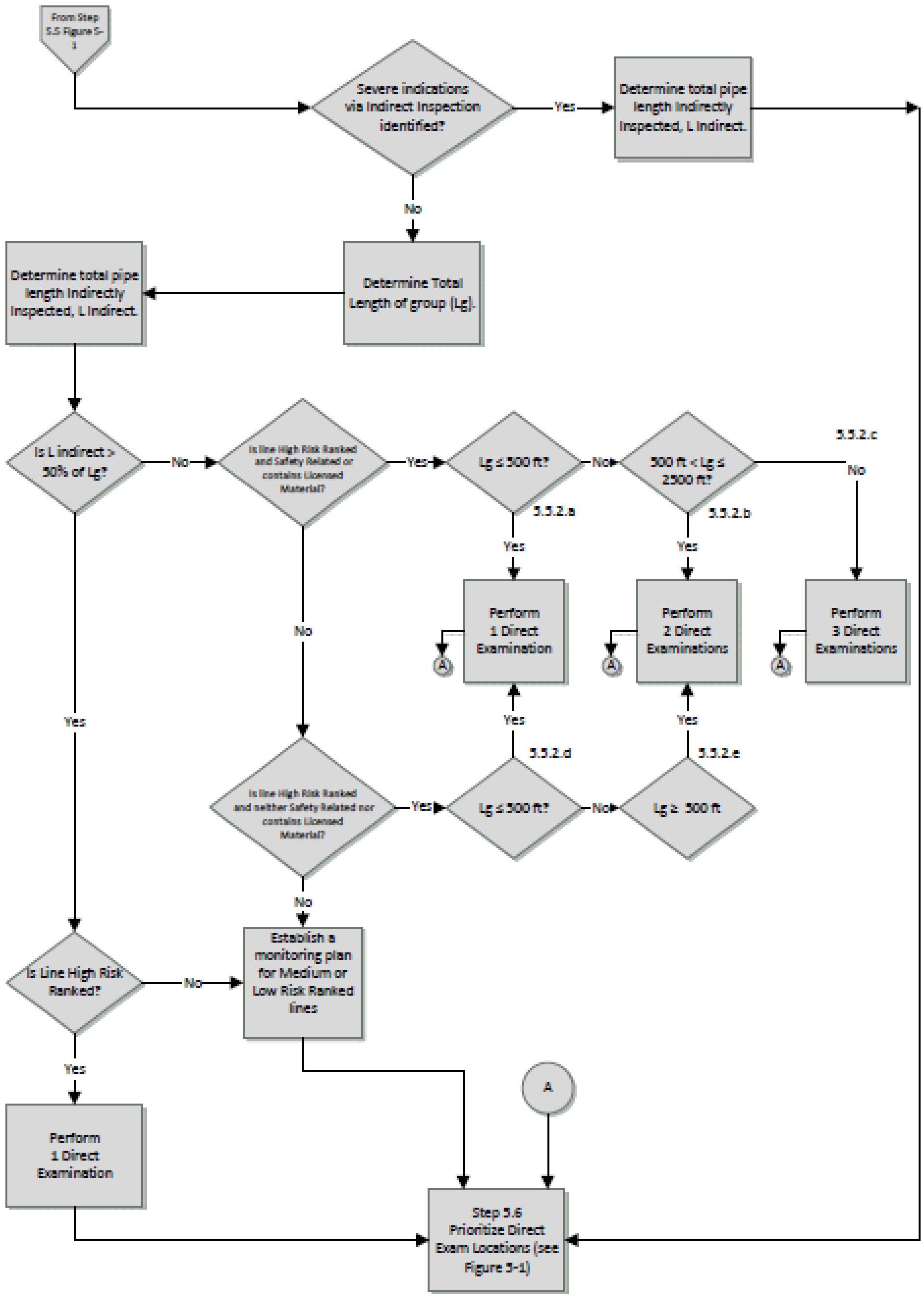


Figure 5-2 Buried Piping Inspection Reasonable Assurance (RA) Flow Chart



5.0 Buried Piping Inspection RA Flow Chart-Description

5.1 Buried Piping Program Susceptibility Analysis and Risk Ranking

1. Susceptibility Analysis and Risk Ranking are used to determine the overall likelihood and consequence of a line, segment or zone failure.
2. This evaluation is based on detailed site specific information and provides a risk assessment of all piping within the program scope.
3. The following potential exclusions from the program scope may be considered in the susceptibility and risk ranking process. The basis for the exclusion should be documented:
   a. Segments or zones constructed of materials not susceptible to the associated ID and OD degradation mechanisms like titanium and super austenitic stainless (e.g., AL6XN or 254 SMO).
   b. Segments or zones of materials fully backfilled using controlled low strength material (flowable backfill) in accordance with NACE SP0169-2007, unless the pipe is susceptible to ID degradation.
   c. Piping sections that are hydrostatically tested in accordance with 49 CFR 195 subpart E on an interval not to exceed 5 years.

5.2 Create Line Groupings

1. The purpose for the grouping of lines is to be able to extrapolate inspection results from one or more examinations to the rest of the group, optimizing the number of excavations.
2. Separate segments or zones by process fluid (e.g., Tritiated, Service Water, & Oil lines would be grouped separately; Corrosive vs. non-corrosive fluid, for instance chemical feed would be grouped separately from condensate and separately from tritiated circulating water piping)
3. Further separate or create groups of lines with similar physical attributes by the following order of importance :

   a. Material (e.g., Carbon Steel, Stainless Steel, Plastic, Fiberglass, and Aluminum would be grouped separately)

   b. Coating type/age
      i. ID coating, type/age
      ii. OD coating, type/age

   c. Line depth (the basis for this grouping is the effect of live loads, and overburden):
      i. < 10ft below grade -- Can see the effects of live loads

ii. > 10ft below grade

d. Pipe Age (e.g., Inspections on newer lines should not be used to justify reasonable assurance on older lines).

e. Location in similar soil conditions (e.g., Lines in close proximity to one another in the same underground path/fill trench, backfill)

f. Cathodic protection availability and operating history

g. Operating Conditions
   i. Temperature (e.g., lines that undergo cyclic temperature changes and/or are >100F would not be grouped with ambient temperature lines).
   ii. Operating frequency, and durations (e.g., continuous vs. infrequent/outage only)

h. Pipe joining methods (e.g., socket vs butt welds or threaded connections & could be a consideration for the adequacy of the external coating application)

4. It is not required to separate or create new groups for each category listed in 5.2.3 above.
5. Each segment or zone should be included in a Line Group.
6. Documentation is required to support the basis for each line grouping.
7. Inspections would be performed on the highest susceptible locations in each group.

5.3 Indirect Inspection

1. Indirect inspections, when feasible, are the best approach for determining the number and location of direct examinations that are required.

2. Indirect inspections are not required and the owner can go straight to direct examinations.

3. Indirect Inspection Selection is based on the highest susceptible locations in a line group.

4. Review each of the Indirect Inspection techniques per station or industry examination guidelines for determining applicable or optimum methods for each grouping or individual segments/zones.

5. Review historical cathodic protection survey data and segment or zone location accessibility in order to refine the inspection selection areas.

6. Review the Groundwater Protection Program data.

7. Indirect inspection measurements should be referenced to precise geographic locations and documented so that inspection results can be used for excavation and direct examinations. Indications from inspections should be aligned with other results, drawings and structures.

8. Verification of the indirect inspections should be done using the direct examination results. At least one direct examination will be performed in each high risk line grouping.

5.4 Classify Indirect Inspection Results

1. Criteria for classifying indirect inspection results must be established.
2. The criteria for classifying the severity of indications should take into account the indirect inspection techniques used and the conditions surrounding the pipe segment. The following general classifications may be used:
   - Severe – indications having the highest likelihood of active corrosion activity;
   - Moderate – possible pipeline corrosion activity; or
   - Minor – the lowest likelihood of active corrosion activity.
3. The capability and accuracy of the inspection method used must be considered as part of the engineering evaluation.

5.5 Direct Examination Initial Sample Size

1. When indirect inspections (for example a combination of Guided Wave and Above Ground Coating Surveys), covered greater than 50% of total (group) length including the highest susceptibility locations and where **no severe indication** (Section 5.4) is identified; one direct examination of the highest susceptible location to confirm the indirect inspection results would be required for each high risk line grouping, irrespective of the total line length. If an acceptable direct examination was achieved (i.e., Post Examination Assessment), then reasonable assurance could be demonstrated.

2. When indirect inspections covered less than 50% of total length of a pipe group and where **no severe indication** is identified:

   a. For those High Risk Ranked lines that are safety related or contain Licensed Material or are known to be contaminated, that have pipe groups with total lengths of piping less than approximately 500' (ft), then one direct examination of the highest susceptible location, with acceptable results, may be sufficient to demonstrate reasonable assurance. In selecting the location of the direct examination, consideration can be given to the accessibility of examination locations.

   b. For those High Risk Ranked lines that are safety related or contain Licensed Material or are known to be contaminated, that have pipe groups with total lengths of piping greater than approximately 500' (ft), but less than 2500' (ft), two direct examinations of the highest susceptible locations, with acceptable results, may be sufficient to demonstrate reasonable assurance. In selecting the location of the direct examination, consideration can be given to the accessibility of examination locations.

   c. For those High Risk Ranked lines that are safety related or contain Licensed Material or are known to be contaminated, that have pipe groups with total lengths of piping greater than approximately 2500' (ft), three direct examinations of the highest susceptible locations, with acceptable results, may be sufficient to demonstrate reasonable assurance. In selecting the location of the direct examination, consideration can be given to the accessibility of examination locations.

   d. For those lines that are High Risk Ranked and are not safety related, do not contain Licensed Material or are not known to be contaminated that have pipe groups with total lengths less than approximately 500 ft, one direct examination of the highest susceptible location, with acceptable results, may be sufficient to demonstrate reasonable assurance. In selecting the location of the direct examination, consideration can be given to the accessibility of examination locations.

   e. For those lines that are High Risk Ranked and are not safety related, do not contain Licensed Material or are not known to be contaminated that have pipe groups with total lengths greater than approximately 500 ft, two direct examinations of the highest susceptible locations, with acceptable results, may be sufficient to demonstrate reasonable assurance. In selecting the location of the direct examination, consideration can be given to the accessibility of examination locations. .

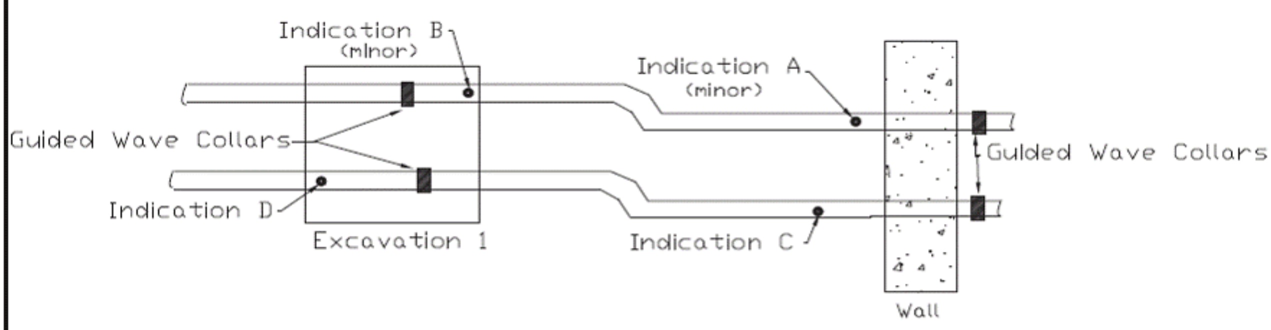
f. For those lines that are Medium and Low Risk Ranked, a monitoring plan should be established and direct examinations performed on an opportunistic basis to determine reasonable assurance.

3. For indirect inspections that indicate severe levels of corrosion activity, categorize locations for direct examination and proceed to section 5.6.

4. For indirect inspections that indicate moderate and minor levels of corrosion activity the direct examination or examinations in section 5.5.2 would be focused on the highest area of indicated degradation.

5. Where indirect inspections that evaluate wall thickness are performed at the most susceptible locations in a group, and the results of such inspections indicate NO or MINOR likelihood of corrosion activity, then confirmation of the indirect inspection results may be obtained from a direct examination of another indirect inspection location in the same group (where the same inspection technique was used). This can be allowed when accessibility issues exist for conducting a direct examination.

   Using the figure below to illustrate this concept; a guided wave shot is taken in Excavation 1 showing only “minor” indications at “B” and “D”.
   A direct exam is performed that validates these results, and the remaining life is acceptable. A second set of guided wave shots is taken through a wall penetration (highest susceptible location), showing minor indications at “A” and “C”. The pipe condition and indications at “A” and “C” would be considered validated by the direct examination completed in Excavation 1 with an acceptable remaining life. A second excavation would not be required to validate indications “A” and “C”. To provide additional assurance of pipe integrity for all of these indications; one or more of the monitoring activities listed in section 5.8-3 should be periodically performed.



5.6 Direct Examination Selection

The objective of direct examination is to assess the extent of corrosion activity for line segments selected for examination based on the risk assessment and indirect inspections, when performed. When no significant degradation is found from a direct examination the remaining service life and next scheduled inspection should be calculated using the guidance in the following sections.

1. Indirect inspections results should be used in determining the priority of direct examinations. Below is an example of criteria used for prioritizing direct examinations based on the severity of indications from the indirect inspections:

   a. Severe Indications – Initiate Direct Examination Plan with Contingencies for Mitigating Action for:

      i. Severe indications in close proximity
      ii. Severe indications in a region with multiple moderate indications
      iii. Isolated severe indications in a high risk region or area
      iv. Indications known to be actively corroding
      v. Moderate indications in a region of high risk, prior leaks or severe corrosion

   b. Moderate Indications – Scheduled Action Required
      i. Isolated severe indication in a low risk region
      ii. Groups of moderate indications
      iii. Groups of minor indications in a medium risk region
      iv. Groups of minor indications in close proximity

c. Minor Indications – Monitor
   i. All remaining indication scenarios

2. If no Indirect Inspections were performed for a group, then selection of the direct examination locations is based on the highest susceptible location of each line group considering location accessibility. Review historical cathodic protection survey data or other relevant parameters to refine the direct examination area.

3. Direct examinations resulting from excavations should include coatings inspections by a person trained and experienced in coating condition assessment.

4. At least one Direct Examination is required for each High Risk Line Group in order to establish reasonable assurance for the Group.

5. A Direct Examination at an individual excavation will assess a minimum 10 feet length of pipe, if feasible. When there is more than 1 pipeline in an excavation, each pipeline that receives an examination accounts for a separate direct examination.

5.7 Inspection Sample Expansion Considerations

When a pipe segment or zone has degradation detected by direct examination that exceeds the acceptance criteria in section 5.8 and 5.9:

1. Determine the extent of the corrosion by mapping the axial and transverse lengths and depths of the corroded area.

2. Review the indirect inspection results for the affected segment or zone and determine if additional excavation is required to perform direct examination of other areas with severe or moderate indications.

3. Determine any segments or zones that share the same corrosion susceptibility characteristics and schedule additional direct examinations. The timing of the additional examinations should be based on the severity of the degradation identified and should be commensurate with the consequence of a leak or loss of function.

4. Scope expansion must be sufficient to provide confidence that the extent of condition reasonably bounds the degradation.

5. Document the findings and actions in the appropriate corrective action program.

5.8 Post Examination Assessment

The purpose of the post assessment process is to define the inspection interval (time to Next Scheduled Inspection or NSI), assess the effectiveness of the program, and then feed the results back to the pre-assessment step to revise the risk ranking of buried pipe segments or zones as a continuous improvement process. The cumulative goal of the evaluations for a piping group is to complete a post assessment; including a fitness for service evaluation, that determines the remaining life and next scheduled inspection interval to provide quantitative reasonable assurance for that group.

1. The assessment of the examination results should be made using a Fitness-for-Service (FFS) assessment. Any degradation found during a direct examination should be appropriately documented.

2. The FFS evaluation performed will apply to all lines, segments, or zones in the group.

   a. When direct wall thickness measurement meets t_{min} & t_{meas} is >87.5% of t_{nom} no FFS evaluation is required, unless active degradation is identified.

   b. When direct wall thickness measurement meets t_{min} & t_{meas} is <87.5% of $t_{nom:}$
      i. Perform an FFS
      ii. Evaluate cause of degradation (consider all variables-backfill, coatings, installation, etc.)
      iii. Evaluate the extent of degradation (localized verses global)
      iv. Evaluate the need for scope expansion

   c. When direct wall thickness measurement does NOT meet t_{min}:
      i. Evaluate cause and extent of degradation
         - Inspection scope expansion (See section 5.7)
         - Determine the Extent of Condition
         - Repair degraded areas
         - Evaluate potential mitigation strategies
         - Enter into the corrective action program

3. Monitoring activities should be considered as part of the reasonable assurance programmatic or compensatory actions. Examples for the

justification of the scheduling/deferral of reasonable assurance direct examinations are:

- Increased Ground Water Initiative related well monitoring frequency
- Enhanced Cathodic Protection and/or Area Potential Earth Current (APEC) Surveys
- Soil Analysis
- Coating Scans
- Flow/pressure testing
- Guided Wave inspections
- Corrosion Probes
- Leak Testing (Acoustic monitoring, etc.)

5.9 Fitness for Service (FFS) Evaluation

The purpose of the FFS evaluation process is to provide guidelines for evaluating wall thickness degradation in safety and non-safety related components. Engineering should use these guidelines, or other applicable methodologies, when establishing the acceptance criteria or refining the acceptance criteria when warranted. The projected life of the component, based on these calculations, is to be used to establish the interval between examinations. An engineering technical evaluation is required for any deferral of the next scheduled examination past the remaining life date.

a) Corrosion Rate

It is recognized that for buried piping, most degradation mechanisms are not linear with time. Any corrosion rate calculated from one inspection is likely to have a large inaccuracy and could be either conservative (for inactive degradation mechanisms) or non-conservative (for recently activated mechanisms). Whenever possible, external corrosion rates should be determined by directly comparing measured wall thickness changes over a known time interval. Therefore, it is recommended to perform at least two inspections before a more accurate corrosion rate can be established.

When previous pipe wall thickness measurements or other data are not available, default corrosion or pitting rate may be used to determine re-inspection intervals. NACE recommends a default pitting rate of 16 mils/year. NACE further indicates that the default corrosion rate may be reduced by 24% (from the default 16 mils/year), provided that the Cathodic Protection (CP) levels of the pipeline segments being evaluated have had at least 40 mV of polarization, considering the voltage drop, for a significant fraction of the time since installation. If the evaluated line can potentially be subjected to an internal corrosion process, such as Flow Accelerated Corrosion (FAC), Erosion/Corrosion (E/C) or Microbiologic Influenced Corrosion (MIC), effects of internal wall loss should also be considered.

For components with multiple examinations the corrosion rate may be more refined, as outlined in equation 1 below:

$CR = (time_{meas1} - time_{meas2}) \times SF / time$……….…………Equation 1

Where:

CR = Corrosion rate, also referred to as R_{ml} in Ref. 14

$time_{meas1}$ = t_{meas} at 1st examination

$time_{meas2}$ = t_{meas} at 2nd or subsequent examination at same location

t_{meas} = The minimum measured value

SF = Safety Factor (recommend at least 10%) = 1.10

time = The length of time between the ($time_{meas1}$ and $time_{meas2}$) examinations (years)

b) Remaining Life (RL) Calculation

For the examination of a buried pipe component, the remaining life (RL) may be calculated as per Equation 2 below:

$RL = (t_{meas} - t_{min}) / CR$………………………………….Equation 2

Where:

t_{meas} = The minimum measured value from the 1st examination

t_{min} = The minimum acceptable wall thickness for the current inspection required to meet Code requirements.

CR = Corrosion Rate (mils/year). Whenever possible external corrosion rates should be calculated from direct comparison of changes in wall thickness over time. However, for the initial examination the time period of active corrosion is unknown. In the absence of a known period of time from the initiation of corrosion, a default corrosion rate (CR) of 16 mils/year may be used.

If the evaluated line can be subjected to FAC, E/C, and/or MIC, then the effects of internal wall loss should be considered.

3. Time to Next Scheduled Inspection (NSI)

   When t_{meas} is found to be less than or equal to 50% of t_{nom}, the re-examination interval should be taken as one-half the remaining life (RL) calculated in Equation 2. The examination interval may be increased if it can be determined that the corrosion mechanism is inactive, for example a coating repair has been applied. When corrosion is less than 50% of t_{nom} (i.e. t_{meas} is greater than 0.5 t_{nom}), the re-inspection interval may be taken as 75% of RL, as summarized below:

   $t_{meas} </= 0.5 \times t_{nom}$: NSI = 0.5 x RL……………………….Equation 3

   $t_{meas} > 0.5 \times t_{nom}$: NSI = 0.75 x RL………………………Equation 4

4. Mitigation or Engineering Technical Evaluation

   a) A determination should be made to either mitigate directly or to perform additional engineering technical evaluation/analysis if the remaining life does not support the period of time until the pipe will be available for the next examination (e.g., refueling outage).

   b) If more than a single line is in the group, the lines with no examination data need to be evaluated based on the examinations performed for determination of condition. Additional examination may be required based on this evaluation.

   c) A determination should be made to repair, replace or implement compensatory actions.

   d) All engineering evaluations should be performed and documented as required by station procedures.

6.0 References

1. "Recommendations for an Effective Program to Control the Degradation of Buried and Underground Piping and Tanks 1021175 (EPRI 1016456, Revision 1)
2. Radiological SSC Groundwater Initiative Risk Evaluation Criteria
3. A.P. Moser "Buried Pipe Design", McGraw Hill, 2nd Edition (Table 2.7 "Live Loads").
4. Section XI, Div. 1 Class 2 and 3 Metallic Piping Buried in a Back-Filled Trench, Inquiry, Draft "What Rules may be used to evaluate Class 2 and Class 3 metallic piping buried in a back-filled trench subjected to metal loss on the internal and external surfaces of the pipe or fitting"
5. ASME B&PV Code, Section XI
6. ASME B&PC Code, Section III
7. ASME B31.1, "Power Piping"
8. ASME Standard B31.3, "Process Piping"
9. ASME B31-G, "Manual for Determining the Remaining Strength of Corroded Pipelines"
10. American Petroleum Institute (API) Standard 510 Pressure Vessel Inspection Code: "Maintenance Inspection, Rating, Repair, and Alteration"
11. API Standard 570 Piping Inspection Code: "In-service Inspection, Rating, Repair, and Alteration of Piping Systems"
12. API Standard 653, "Tank Inspection, Repair, and Reconstruction"
13. ASME Code Case N-597-1, "Requirements for Analytical Evaluation of Pipe Wall Thinning", Section XI Div. 1.
14. ASME Code Case N-513, "Evaluation Criteria for temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping", Section XI, Div. 1.
15. API 579-2/ASME FFS-2, "Fitness-For-Service"
16. NACE Standard Practice SP0169-2007, Control of External Corrosion on Underground or Submerged Metallic Piping Systems, 2007.
17. NACE International Standard Recommended Practice, RP0502, Item No. 21097, "Pipeline External Corrosion Direct Assessment Methodology".
18. NUREG -1801, Rev. 2, Generic Aging Lessons Learned