XI.M41 BURIED AND UNDERGROUND PIPING AND TANKS (11AUG2010 Draft)

Comment/Basis:

XI.M41 – 1 Program Description, Element 2 item b (Table 2b), Element 4 item c (Table 4b), and element 4 item e. (Table 4d) - Recommend deleting "underground" environment and associated sections in element 2 and element 4. "Underground" environment is defined as below grade, but contained within a tunnel or vault such that they are in contact with air and are located where access for inspection is restricted. Detection of aging effects for underground components exposed to air environments is managed by AMP XI.M36 External Surfaces Monitoring of Mechanical Components (see element 4) which requires that surfaces that are not readily visible during plant operations are inspected when they are made accessible and at such intervals that would ensure the components intended function is maintained. The external surfaces program is the appropriate program due to the relatively benign environment of air. XI.M41 is not appropriate since it is primarily directed at components in a soil environment and the corresponding inspections are overly restrictive and the preventive actions regarding coating, cathodic protection and backfill are not appropriate. Clarification to be added to XI.M36 that requires the identification of the underground components, their materials, coatings and inspection amount and frequencies to ensure intended functions are maintained. NOTE: Due to the changes required to incorporate this comment it is not shown in AMP markup

Add sentence to describe that the aging management of buried fire protection components are managed by system flow and pressure testing on a bi-annual frequency in accordance with XI.M27 such that the need for notes in Element 2 item a.ii., Element 4 item b.ix, Element 4 item c.ix, Element 6 item g in regards to this testing are not needed.

XI.M41 – 2 Element 2 Table 2a and Element 4 Table 4a and associated notes – HDPE should be listed in Element 2 item a as a material that does not require aging management in a soil environment and be deleted from the tables and associated footnotes in Element 2 and Element 4.

Cracking can be caused by chemical aging. PE molecular chains may be broken down by temperature plus exposure to ozone, ultraviolet radiation, or oxidative chemicals. Carbon black is added to HDPE for protection from ultraviolet radiation. Ultraviolet radiation exposure is not an issue for buried HDPE pipe. Piping system design temperatures are well below the oxidation induction temperature requirement of 220C.

Slow crack growth is the predominant failure mode for HDPE. This failure mode is addressed by material testing required by ASTM D-3350, *Standard Specification for Polyethylene Plastics Pipe and Fittings Materials*. PENT Testing performed under ASTM D-3350 measures resistance of HDPE to slow crack growth and test results can be correlated to material service life. HDPE materials used in nuclear safety class applications are required to as a minimum meet ASTM classification 445574C. PENT testing for materials assures that slow crack growth is not a failure mode during the design life of the piping. Crack growth occurs at a very slow rate and this condition cannot be observed by field inspection.

HDPE does not absorb water according to Plastic Pipe Institute technical report PPI TR-19, *Chemical Resistance of Thermoplastic Piping Materials* based on testing performed at temperatures up to 140 degrees F. HDPE is not subject to water absorption and subsequent osmotic blistering that can occur with other polymeric materials. There is no color change in response to water absorption with HDPE.

XI.M41 – 3 Element 2 item a.ii., Element 4 item b.ix, Element 4 item c.ix, Element 6 item g. – Delete this item. This item is redundant to periodic NFPA 25 flow testing of fire mains as described in AMP XI.M27, Fire Water Systems. The NFPA 25 flow and pressure testing is performed at plant-specific intervals determined by engineering evaluation of the fire protection piping to ensure that degradation will be detected before the loss of intended function. NFPA (2008) section 7.3.1 requires that underground and exposed piping shall be flow tested to determine the internal condition of the piping at minimum 5 year intervals. A frequency of every six months is excessive for determining the capability of the system to provide proper pressure and flows. This flow test along with additional NFPA and XI.M27 testing and continuous system pressure monitoring using jockey fire pump operation would detect a significant loss of pressure boundary without flow testing at the specified frequency. Recommend revising 6 month flow testing frequency to a maximum of once every two years which significantly exceeds existing NFPA requirements. In addition, a change should be made to the Program description to eliminate need for these additional notes.

XI.M41 – 4 Element 2 Table 2a footnote 2 – For consistency with Table 2b footnote2, also include the following sentence in Table 2a footnote2: “Other coatings may be used if justification is provided in the LRA.”

XI.M41 – 5 Element 2 Table 2a footnote 4 – Revise this footnote to specify that “operation and maintenance” of the cathodic protection system is in accordance with NACE SP0169-2007 section 10. Revise the third sentence of the footnote to indicate that cathodic protection equipment need not be 10 CFR 50 Appendix B qualified or within the scope of license renewal. Parts “a” and “b” of footnote 4 should be clarified to indicate that either is acceptable for not providing cathodic protection.

XI.M41 – 6 Element 2 Table 2a footnote 5 and 6 – Revise this footnote to clarify that for purposes of initial and subsequent inspections, backfill not meeting this standard is acceptable if inspections of piping within the scope of license renewal do not reveal evidence of mechanical damage to pipe coatings due to backfill. Add similar note for footnote 6.

XI.M41 – 7 Element 2 Table 2a footnote 9 – Add a new footnote to read: “AWWA C-105 provides a standard for determining if the ductile iron should be coated and/or CP-protected (primarily based upon soil conditions)". DIPRA and NBS studies point to > 95% of all soils being compatible with and non-corrosive to ductile iron.

XI.M41 – 8 Element 2 Table 2b footnote 3 – Delete footnote 3 and the requirement for providing coatings for stainless steel and aluminum underground piping.

Stainless steel and aluminum piping are highly corrosion resistant materials in an air environment and not typically coated. The aging evaluation process would evaluate the aggressive nature of the environment to identify aging and the appropriate aging management requirements. Coatings are not the only solution for managing aging due to an aggressive environment. Periodic inspections as noted in element 4.c. or other preventative measures (e.g. stopping the source of the leak/aggressive environment) could be used to detect and manage aging.

XI.M41 – 9 Element 4 item b.iv. – Revise to read "visual inspections may be supplemented". Surface and/or volumetric examinations should be optional if significant indications are observed and the decision is made to repair or replace the piping based on the visual indications. Recommend significant indications be defined as aging resulting in pitting or surface corrosion.

XI.M41 - 10 Element 4 item b.vi and item c.vi – This requirement should be deleted. Not crediting shared/common piping systems for multiple unit sites will penalize multiple unit sites with additional inspections that are not required by a single unit site and provides no significant additional assurance of the integrity of the coating based on the common systems, materials and environments including soil conditions. For example, 14,000 feet of buried FRP common fire protection piping (1% of length for other polymer piping) at a 3 unit site will require 420 feet of pipe to be inspected rather than 140 feet at a single unit site.

XI.M41 – 11 Element 4 item b.x and item c.x.. – Revise this item to allow either hydrostatic testing (option A) or internal inspections (option B) to be used in lieu of the inspections noted in Table 4a. Both methods will provide evidence of a loss of pressure boundary function. Delete need for staff approval. NRC will have opportunity to review the qualified method credited during audits. Delete word precisely since it is undefined. In addition 49 CFR 195 is a transportation pipeline standard that requires test pressures well above system operating pressures that may not be achievable for these systems. It also requires use of water or gas test mediums which would not be possible for fuel oil lines. Recommend pressure or inservice leak testing using ASME requirements.

XI.M41 – 12 Element 4 Table 4a footnote 2 and Table 4c footnote 2 – Delete the reference to NACE SP0169-2007 through footnote 2 and just reference element 2 Table 2a. Element 2 Table 2a and its associated footnotes identifies the coating, backfill, and cathodic protection preventative measures acceptable to the staff. Identifying applicability of backfill, coating and cathodic protection preventative measures to both NACE SP0169-2007 and Table 2a is confusing and redundant. Note that several of the element 2 table 2a footnotes also allow the use of NACE RP0285-2002.

XI.M41 – 13 Element 4 Table 4a footnote 2 item C & D and Table 4c footnote 2 item C & D – Revise these items to specify cathodic protection system 90% operation is based on the previous five years of operation or the time since the piping was last inspected. Monitoring/trending required by element 5 that is associated with five years worth of cathodic protection system operation at 90% should also provide an indication of the effectiveness of the system and/or coatings. Also, plant records might not be available to support 90% operation for the piping under consideration was installed.

XI.M41 – 14 Element 4 Table 4a footnote 2 item D and Table 4c footnote 2 item D – Correct a typo to delete "at" in the second sentence so that it reads: "…operated in accordance with NACE SP0169-2007 for ~~at~~ less than 90%...".

XI.M41 – 15 Element 4 Table 4a footnote 2 item F – This preventative action category is confusing with criteria C, D and E in direct contradiction to each other. Is the intent of item F to specify coatings, backfill, and cathodic protection are not provided?

XI.M41 – 16 Element 4 Table 4a footnote 3.b and 3.c. and Table 4b footnote 2.b and 2.c.– Editorial changes

XI.M41 – 17 Element 4 Table 4a footnote 5 and Table 4b footnote 4 – Revise to read "Hazmat pipe normally contains…."

XI.M41 – 18 Element 4 Table 4a footnote 6. – Editorial changes

XI.M41 – 19 Element 4 item c.iv – Delete volumetric examinations to detect internal corrosion. Internal aging management is performed by another AMP and is not part of the Buried and Underground Piping and Tanks AMP.

XI.M41 – 20 Element 4 item c.vii and item e.vi.– Delete this item. How can manual examinations be performed if the piping/tank is restricted access?

XI.M41 – 21 Element 4 Table 4b footnote 2. – Delete excavations this footnote applies to underground pipe not buried pipe.

XI.M41 – 22 Element 4 Table 4c footnote 4 & 5 and Table 4d footnote 3 & 4 – Delete pipe this footnote applies to HDPE tanks.

XI.M41 – 23 – Element 4 item d.iv. and item e.iv. – If the tank is volumetrically inspected internally, the required number of inspection locations of the tank surface area should be in accordance with API standard 1631 which specifies an exam where the internal tank cylinder wall shall be initially divided in 3 foot square (9 ft^2) sections. Tank ends (heads) shall be divided into four equal quadrants and each quadrant then divided into 3 foot square (9 ft^2) sections. Any remaining areas less than 3 ft by 3 ft in size shall be considered to be additional sections. Any sections with thickness readings of 75% or less of the original metal thickness shall be subdivided into 9 subsections and require additional gauging at the center of each subsection.

XI.M41 – 24 – Element 4 item f.iv. – Delete the requirement for doubling of the sample size and revise item f.iii. to require an evaluation of the degradation to determine extent and size of the expansion sample. Doubling of the sample size with no basis could likely result in unnecessary inspections depending on the cause of the degradation, may not be possible in many cases and in some cases doubling may not be enough.

XI.M41 – 25 – Element 6 item b – Currently the only inspector certification related to visual inspection of buried pipe coatings is NACE CIP (Coating Inspector Program

Level III. There are no qualifications for buried piping coating inspections at this time. Recommend revising this item to include an equivalent qualified coatings inspector.

XI.M41 – 26 - Element 4 item iii - Added that inspection locations should be selected based on risk instead of susceptibility to degradation to maintain some consistency with the Industry Initiative 09-14.

XI.M41 – 27 - Table 4b inspections are excessive when compared to the inspections in 4a for hazmat piping. For example in 4b for steel 5% is required for hazmat underground and only 2% is required for buried coated hazmat steel piping in table 4a. The potential for corrosion of these components in an air environment is significantly less than soil if both are coated and there is no basis for the percentages shown for steel and copper and aluminum hazmat. Recommend deleting the Hazmat Column and let inspections for code class cover all piping without percentages. There is no basis for percentages. When the piping is contained in a vault or tunnel the risk is much lower for it to get in to the environment than buried components.

XI.M41 – 28 - Element 1, Scope of Program - For some plants, buried pipe is encased in concrete or backfilled in controlled low strength material (CLSM)/flowable fill (a flowable, self-leveling and self-compacting cementitious material used in place of traditional compacted fill) with trade name such as Fillcrete. CLSM has been found to be beneficial in reducing corrosion (compared to typical compacted fill) when pipes are completely embedded in CLSM. The reduced permeability of CLSM can reduce the ingress of chlorides, and the microstructure of CLSM can improve corrosion resistance through changes in the pH and resistivity of the pore solution. CLSM provides more protection against corrosion initiation and propagation when metallic structures are completely embedded in CLSM compared to compacted sand. The above results included in a study presented in *Development of a Recommended Practice for Use of Controlled Low-Strength Material in Highway Construction.* Report 597 (2008), indicated that corrosion activity for steel pipe coupons completely embedded in CLSM was significantly lower (i.e. negligible) than that embedded in sand. This study can be found at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_597.pdf. NUREG-1801 line items VII.J.AP-3 and 19 show no aging effects for carbon or stainless steel exposed to concrete. These factors present a strong argument for insignificant corrosion susceptibility and lack of need for excavation.

Add that piping encased in concrete or CLSM (flowable fill) is not in scope of the program.

XI.M41 BURIED AND UNDERGROUND PIPING AND TANKS (11AUG2010 Draft)

Program Description

This is a comprehensive program designed to manage the aging of the external surfaces of buried and underground piping and tanks and to augment other programs which manage the aging of internal surfaces of buried and underground piping and tanks. It addresses piping and tanks composed of any material, including metallic, polymeric, cementitious and concrete materials. This program manages aging through preventive, mitigative and inspection activities. It manages all applicable aging effects such as loss of material, cracking, and changes in material properties.

Depending on the material, preventive and mitigative techniques include: the material itself, external coatings for external corrosion control, the application of cathodic protection and the quality of backfill utilized. Also, depending on the material, inspection activities include electrochemical verification of the effectiveness of cathodic protection, non-destructive evaluation of pipe or tank wall thicknesses, hydrotesting of the pipe, and visual inspections of the pipe or tank from the exterior as permitted by opportunistic or directed excavations.

With, in some cases, the assistance of this program, management of aging of the internal surfaces of buried and underground piping and tanks is accomplished through the use of other aging management programs (e.g. Open Cycle Cooling Water (AMP XI.M20), Treated Water (AMP XI.M21A), Internal Inspection of Miscellaneous Piping and Ducts (AMP XI.M38), Fuel Oil Chemistry (AMP XI.M30), Fire Water System (AMP XI.M27) or Water Chemistry (AMP XI.M2). Additionally, this program does not address selective leaching. The selective leaching program (AMP XI.M33) is applied in addition to this program for applicable materials and environments. For buried fire protection components the aging effects of the external surfaces are managed by XI.M27 “Fire Water System” including periodic system flow testing at a frequency of once every two years.

The terms “buried” and “underground” are fully defined in Chapter IX of the GALL Report. Briefly, buried piping and tanks are in direct contact with soil or concrete (e.g., a wall penetration). Underground piping and tanks are below grade, but are contained within a tunnel or vault such that they are in contact with air and are located where access for inspection is restricted.

Evaluation and Technical Basis

1. ***Scope of Program*****:** This program is used to manage the effects of aging for buried and underground piping and tanks constructed of any material including metallic, polymeric, cementitious and concrete materials. The program addresses aging effects such as loss of material, cracking, and changes in material properties. Typical systems in which buried and underground piping and tanks may be found include service water piping and components, condensate storage transfer lines, fuel oil and lubricating oil lines, fire protection piping and piping components (fire hydrants), and storage tanks. Corrosion of piping system bolting within the scope of this program is managed using this program. Piping encased in concrete or controlled low strength material/flowable fill is not in scope of this program. Other aging effects associated with piping system bolting are managed through the use of the Bolting Integrity Program (AMP XI.M18).

2. *Preventive Actions:* Preventive actions utilized by this program vary with the material of the tank or pipe and the environment (air, soil, or concrete) to which it is exposed. These actions are outlined below:

a. Preventive Actions, Buried Piping and Tanks

i. Preventive actions for buried piping and tanks are conducted in accordance with Table 2a and its accompanying footnotes

~~ii. Fire mains are installed in accordance with National Fire Protection Association (NFPA) Standard 24. Preventive actions for fire mains beyond those in NFPA 24 need not be provided if the system undergoes a periodic flow test in accordance with NFPA 25 as described in program element 4 of this AMP.~~

Table 2a, Preventive Actions for **Buried** Piping and Tanks

Material[1]	Coating[2]	Cathodic Protection[4]	Backfill Quality
Titanium			
Super Austenitic Stainless[8]			
Stainless Steel	X[3]		X[5, 7]
Steel[9]	X	X	X[5]
Copper	X	X	X[5]
Aluminum	X	X	X[5]
Cementitious or Concrete	X[3]		X[5, 7]
Polymer			X[6]

1. Materials classifications are meant to be broadly interpreted; e.g., all alloys of titanium which are commonly used for buried piping are to be included in the titanium category. Material categories are generally aligned with P numbers as found in the ASME Code, Section IX. Steel is defined in chapter IX of this report. Polymer includes polymeric materials as well as composite materials such as fiberglass.

2. When provided, coatings are in accordance with Table 1 of NACE SP0169-2007 or Section 3.4 of NACE RP0285-2002. Other coatings may be used if justification is provided in the LRA.

3. Coatings are provided based on environmental conditions (e.g., stainless steel in aggressive high chloride containing soil environments). If coatings are not provided, a justification is provided in the LRA.

4. Operation and Maintenance of cathodic protection is ~~in accordance~~ consistent with NACE SP0169-2007 section 10 or NACE RP0285-2002. The system monitoring interval discussed in section 10.3 of NACE SP0169-2007 may not be extended beyond one year. The equipment used to implement cathodic protection need not be 10 CFR 50 Appendix B qualified or within the scope of license renewal. Cathodic protection need not be provided if either of the following conditions are met:

a. Soil resistivities > 20,000 ohm cm. If this condition is met, inspections in Table 4a are conducted in accordance with Table 4a footnote 2 item C.

b. Corrosion rates, based on at least 5 years of data, which indicate that minimum design wall thickness for the buried pipe or tank will not be reached within the period of extended operation. The corrosion rates may be based on measurements taken from actual uncoated pipe or may be approximated for coated piping, which is assumed to contain flaws in the coating, from bare metal coupons of similar material exposed, on site, to soil of similar conditions (e.g., resistivity, ionic content, moisture content, etc). Multiple corrosion measurements are necessary when a length of pipe passes through varying soil types. If this condition is met, inspections in Table 4a are conducted in accordance with Table 4a footnote 2 item D.

5. Backfill is consistent with SP0169-2007 section 5.2.3. The staff considers backfill which is located within 6 inches of the pipe that meets ASTM D 448-08 size number 67 to meet the objectives of SP0169-2007. Backfill quality may be demonstrated by plant records or by examining the backfill while conducting the inspections ~~conducted in program element 4 of this AMP~~. For purposes of initial and subsequent inspections, backfill not meeting this standard is acceptable if ~~the~~ inspections ~~conducted in program element 4 of this AMP~~ of piping within the scope of license renewal do not reveal evidence of mechanical damage to pipe coatings due to the backfill.

6. Aggregate size for backfill within 6 inches of the pipe must meet ASTM D 448-08 size number 10 or inspections do not reveal evidence of mechanical damage to pipe.

7. Backfill limits apply only if piping is coated.

8. Super austenitic stainless steel, e.g., Al6XN or 254 SMO.

9. AWWA C-105 provides a standard for determining if the ductile iron should be coated and/or cathodically protected-protected (primarily based upon soil conditions)"

b. Preventive Actions, Underground Piping and Tanks

i. Preventive actions for underground piping and tanks are conducted in accordance with Table 2b and its accompanying footnotes

Table 2b, Preventive Actions for **Underground** Piping and Tanks

Material[1]	Coating Provided[2]
Titanium	
Super Austenitic Stainless[4]	
Stainless Steel	~~X~~[3]
Steel	X
Copper	X
Aluminum	~~X~~[3]

Cementitious or Concrete	
Polymer	

1. Materials classifications are meant to be broadly interpreted; e.g., all alloys of titanium which are commonly used for buried piping are to be included in the titanium category. Material categories are generally aligned with P numbers as found in the ASME Code, Section IX. Steel is defined in chapter IX of this report. Polymer includes polymeric materials as well as composite materials such as fiberglass.

2. When provided, coatings are in accordance with Table 1 of NACE SP0169-2007 or Section 3.4 of NACE RP0285-2002. A broader range of coatings may be used if justification is provided in the LRA.

3. ~~Coatings are provided based on environmental conditions (e.g., stainless steel in chloride containing environments). If coatings are not provided, a justification is provided in the LRA.~~

4. Super austenitic stainless steel, e.g., Al6XN or 254 SMO.

3. ***Parameters Monitored/Inspected:*** The aging effects addressed by this AMP are: changes in material properties of polymeric materials, loss of material due to all forms of corrosion and, potentially, cracking due to stress corrosion cracking. Changes in material properties are monitored by manual examinations. Loss of material is monitored by visual appearance of the exterior of the piping or tank; and wall thickness of the piping or tank. Wall thickness is determined by a non-destructive examination technique such as ultrasonic testing (UT). Two additional parameters, the pipe-to-soil potential and the cathodic protection current, are monitored for steel, copper, and aluminum piping and tanks in contact with soil to determine the effectiveness of cathodic protection systems and, thereby, the effectiveness of corrosion mitigation.

4. ***Detection of Aging Effects:*** Methods and frequencies used for the detection of aging effects vary with the material and environment of the buried and underground piping and tanks. These methods and frequencies are outlined below.

a. Opportunistic Inspections

i. All buried and underground piping and tanks, regardless of their material of construction are inspected by visual means whenever they become accessible for any reason. The information in paragraph f of this program element is applied in the event deterioration of piping or tanks is observed.

b. Directed Inspections – **Buried Pipe**

i. Directed inspections for buried piping are conducted in accordance with Table 4a and its accompanying footnotes.

ii. Unless otherwise indicated, directed inspections as indicated in Table 4a will be conducted during each 10 year period beginning 10 years prior to the entry into the period of extended operation.

iii. Inspection locations are selected based on risk ~~susceptibility to degradation~~. Risk is the combination of likelihood of failure and consequence of failure. Characteristics such as coating type, coating condition, cathodic protection efficacy, backfill characteristics and soil resistivity are considered.

iv. Visual inspections ~~are~~ may be supplemented with surface and/or volumetric non-destructive examination ~~testing~~ (~~NDT~~NDE) if ~~significant indications are~~ aging resulting in pitting or surface corrosion is observed.

v. Opportunistic examinations may be credited toward these direct examinations if the location selection criteria in item iii, above, are met.

~~vi. At multi-unit sites, individual inspections of shared piping may be credited for only one unit.~~

vii. Visual inspections for polymeric materials are augmented with manual examinations to detect hardening, softening or other changes in material properties.

viii. The use of guided wave ultrasonic or other advanced inspection techniques is encouraged for the purpose of determining those piping locations that should be inspected but may not be substituted for the inspections listed in ~~the~~ table 4a.

~~ix. For the purpose of this program element, fire mains will be considered to be code class/safety related piping and inspected as such unless they are subjected to a flow test as described in section 7.3 of NFPA 25 at an a frequency of at least one test in each six month period.~~

x. Inspection as indicated in (A), ~~and~~ or (B) below may be performed in lieu of the inspections contained in Table 4a for either code class/safety significant or hazmat piping ~~or both~~:

A. At least 25% of the code class/safety related or hazmat piping or both constructed from the material under consideration is ~~hydrostatically~~ pressure tested at normal operating pressure in accordance with ~~49 CFR 195 subpart E~~ ASME Code requirements on an interval not to exceed 5 years.

B. At least 25% of the code class/safety related or hazmat piping or both constructed from the material under consideration is internally inspected by a method capable of ~~precisely~~ determining pipe wall thickness. The inspection method must be capable of detecting both general and pitting corrosion and must be qualified by the applicant ~~and approved by the staff~~. As of the effective date of this document, guided wave ultrasonic examinations do not meet this paragraph. Internal inspections are to be conducted at an interval not to exceed 5 years. Consideration should be given to NACE SP0169-2007 sections 6.1.2 and 6.3.3

Table 4a, Inspections of **Buried Pipe**

Material[1]	Preventive Actions[2]	Inspections[3]	
		Code Class Safety Related[4]	Hazmat[5]

Titanium			
Super Austenitic Stainless[7]			
Stainless Steel		1[6]	1[6]
HDPE[8]	A B	1[6] 2	1[6] 1%
Other Polymer[9]	A B	1[6] 2	1[6] 1%
Cementitious or Concrete		1[6]	1[6]
Steel	C D E F	1[6] 1 4 8	1[6] 2% 5% 10%
Copper	C D E F	1[6] 1 1 2	1[6] 1% 2% 5%
Aluminum	C D E F	1[6] 1 1 2	1[6] 2% 5% 10%

1. Materials classifications are meant to be broadly interpreted; e.g., all alloys of titanium which are commonly used for buried piping are to be included in the titanium category. Material categories are generally aligned with P numbers as found in the ASME Code, Section IX. Steel is defined in chapter IX of this report. Polymer includes polymeric materials as well as composite materials such as fiberglass.

2. Preventive actions are categorized as follows:

   A Backfill is in accordance with ~~NACE SP0169-2007 and~~ Table 2a.

   B Backfill is not in accordance with ~~NACE SP0169-2007 and~~ Table 2a.

   C Cathodic protection, coatings, and backfill have been provided in accordance with ~~NACE SP0169-2007 and~~ Table 2a. Each cathodic protection system has been operated in accordance with NACE SP0169-2007 for at least 90% of the ~~time since the piping under consideration was installed~~ prior five years of operation or the time since it was inspected in accordance with this program element.

   D Cathodic protection, coatings, and backfill have been provided in accordance with ~~NACE SP0169-2007 and~~ Table 2a. Each cathodic protection system has been operated in accordance with NACE SP0169-2007 for ~~at~~ less than 90% of the ~~time since the piping under consideration was installed~~ prior five years of operation or the time since it was inspected in accordance with this program element.

   E Coatings and backfill are in accordance with ~~NACE SP0169-2007 and~~ Table 2a but cathodic protection is not provided.

F ~~Preventive actions provided do not meet criteria C, D, or E.~~ Coatings, backfill, and cathodic protection are not provided.

3. Inspections are listed as either a discrete number of visual examinations (excavations) or as a percentage of the linear length of piping under consideration. The following guidance related to the extent of inspections is provided:

   a. Each inspection will examine either the entire length of a run of pipe or a minimum of 10 feet.

   b. If the ~~length of pipe to be inspected based on the~~ number of inspections times the minimum inspection length (10 feet) exceeds 10% of the length of the piping under consideration, only 10% need be inspected.

   c. If the total length of pipe material in scope ~~to be inspected~~ ~~based on the total length of pipe under consideration~~ times the percentage to be inspected is less than 10 feet, either 10 feet or the total length of pipe present, whichever is less, will be inspected.

4. Code Class and safety related pipe which also meets the definition of hazmat pipe will be inspected as hazmat pipe.

5. Hazmat pipe ~~is pipe which, during normal operation,~~ normally contains material which, if released, could be detrimental to the environment. This includes chemical substances such as diesel fuel and radioisotopes. For piping containing radioactive material to be considered hazmat, the concentration of radioisotopes within the pipe during normal operation must exceed established standards such as EPA drinking water standard. In the absence of such standards, the concentration of the radioisotope must exceed the greater of background or reliable level of detection. For tritium, the EPA drinking water standard (20,000 pCi/L) is used. (This approach for defining hazmat is consistent with that used in classifying fluid services in ASME B31.3 appendix M.)

6. Only 1 inspection is required ~~conducted~~ even if both Code Class/safety related and hazmat pipe are present with the same material.

7. Super austenitic stainless steel, e.g., Al6XN or 254 SMO.

8. High Density Polyethylene (HDPE) pipe includes only HDPE pipe approved for use by the NRC for buried applications.

9. Other polymer piping includes some HDPE pipe, and all other polymeric materials including composite materials such as fiberglass.

c. Directed Inspections – **Underground Pipe**

   i. Directed inspections for underground piping are conducted in accordance with Table 4b and its accompanying footnotes.

ii. Unless otherwise indicated, directed inspections as indicated in Table 4b will be conducted during each 10 year period beginning 10 years prior to the entry into the period of extended operation.

iii. Inspection locations are selected based on susceptibility to degradation. Characteristics such as coating type, coating condition, exact external environment, and flow characteristics within the pipe, are considered.

iv. Underground pipes are inspected visually to detect external corrosion.~~and by a volumetric technique such as UT to detect internal corrosion.~~

v. Opportunistic examinations may be credited toward these direct examinations if the location selection criteria in item iii, above, are met.

~~vi. At multi-unit sites, individual inspections of shared piping may be credited for only one unit.~~

~~vii. Visual inspections for polymeric materials are augmented with manual examinations to detect hardening, softening or other changes in material properties.~~

viii. The use of guided wave ultrasonic or other advanced inspection techniques is encouraged for the purpose of determining those piping locations that should be inspected but may not be substituted for the inspections listed in the table.

~~ix. For the purpose of this program element, fire mains will be considered to be code class/safety related piping and inspected as such unless they are subjected to a flow test as described in section 7.3 of NFPA 25 at an frequency of at least one test in each six month period.~~

x. Inspection as indicated in (A), ~~and~~ or (B) below may be performed in lieu of the inspections contained in Table 4a for either code class/safety significant or hazmat piping or both:

A. At least 25% of the code class/safety related or hazmat piping or both constructed from the material under consideration is pressure ~~hydrostatically~~ tested at normal operating pressure in accordance with ASME Code requirements ~~49 CFR 195 subpart E~~ on an interval not to exceed 5 years.

B. At least 25% of the code class/safety related or hazmat piping or both constructed from the material under consideration is internally inspected by a method capable of ~~precisely~~ determining pipe wall thickness. The inspection method must be capable of detecting both general and pitting corrosion and must be qualified by the applicant ~~and approved by the staff~~. As of the effective date of this document, guided wave ultrasonic examinations do not meet this paragraph. Internal inspections are to be conducted at an interval not to exceed 5 years. Consideration should be given to SP0169-2007 sections 6.1.2 and 6.3.3

Table 4b, Inspections of **Underground Pipe**

Material[1]	Inspections[2]	
	Code Class Safety Related and Hazmat[3]~~[4]~~	~~Hazmat~~[4]
Titanium		
Super Austenitic Stainless[6]		
Stainless Steel	1[5]	~~1[5]~~
HDPE[7]	1[5]	~~1[5]~~
Other Polymer[8]	1[5]	~~1[5]~~
Cementitious or Concrete	1[5]	~~1[5]~~
Steel	2	~~5%~~
Copper	1	~~2%~~
Aluminum	1	~~2%~~

1. Materials classifications are meant to be broadly interpreted; e.g., all alloys of titanium which are commonly used for buried piping are to be included in the titanium category. Material categories are generally aligned with P numbers as found in the ASME Code, Section IX. Steel is as defined in chapter IX of this report. Polymer includes polymeric materials as well as composite materials such as fiberglass.

2. Inspections are listed as either a discrete number of visual examinations ~~(excavations)~~ ~~or as a percentage of the linear length of piping under consideration.~~ The following guidance related to the extent of inspections is provided:

   a. Each inspection will examine either the entire length of a run of pipe or a minimum of 10 feet.

   b. If the ~~length of pipe to be inspected based on the~~ number of inspections times the minimum inspection length (10 feet) exceeds 10% of the length of the piping under consideration, only 10% need be inspected.

   c. If the total length of pipe material in scope ~~to be inspected~~ ~~based on the total length of pipe under consideration~~ times the percentage to be inspected is less than 10 feet, either 10 feet or the total length of pipe present, whichever is less, will be inspected.

3. Code Class and safety related pipe which also meets the definition of hazmat pipe will be inspected as hazmat pipe.

4. Hazmat pipe ~~is pipe which, during normal operation,~~ normally contains material which, if released, could be detrimental to the environment. This includes chemical substances such as diesel fuel and radioisotopes. To be considered hazmat, concentration of radioisotope within the pipe during normal operation must exceed established standards such as EPA drinking water standard. In the absence of such standards, the concentration of the radioisotope must exceed the greater of background or reliable level of detection. For tritium, the EPA drinking water

standard (20,000 pCi/L) is used. (This approach for defining hazmat is consistent with that used in classifying fluid services in ASME B31.3 appendix M)

5. Only 1 inspection is conducted even if both Code Class/safety related and hazmat pipe are present.

6. Super austenitic stainless steel, e.g., Al6XN or 254 SMO.

7. HDPE pipe includes only HDPE pipe approved for use by the NRC for buried applications.

8. Other polymer piping includes some HDPE pipe, and all other polymeric materials including composite materials such as fiberglass.

d. Directed Inspections – Buried Tanks

i. Directed inspections for buried tanks are conducted in accordance with Table 4c and its accompanying footnotes.

ii. Directed inspections as indicated in Table 4c will be conducted during each 10 year period beginning 10 years prior to the entry into the period of extended operation.

iii. Each buried tank is examined if it is Code Class/safety related or contains hazardous materials as defined in footnote 5 to Table 4a and is constructed from a material for which an examination is indicated in Table 4c.

iv. Examinations may be conducted from the external surface of the tank using visual techniques or from the internal surface of the tank using volumetric techniques. If the tank is inspected from the external surface a minimum 25% coverage is required. This area must include at least some of both the top and bottom of the tank. If the tank is inspected internally, ~~by UT, at least 1 measurement is required per square foot of tank surface. If the tank is inspected internally by another volumetric technique, at least 90% of the surface of the tank must be inspected~~ examinations are performed using qualified volumetric methods, preferably ultrasonic, for the portion of the tank in contact with the soil environment. When internal volumetric tank examinations are conducted, the internal tank cylinder wall shall be initially divided in 3 foot square (9 ft²) sections. Tank ends (heads) shall be divided into four equal quadrants and each quadrant then divided into 3 foot square (9 ft²) sections. Any remaining areas less than 3 ft by 3 ft in size shall be considered to be additional sections. Any sections with thickness readings of 75% or less of the original metal thickness shall be subdivided into 9 subsections and require additional gauging at the center of each subsection.

v. Visual inspections for polymeric materials are augmented with manual examinations to detect hardening, softening or other changes in material properties.

vi. Opportunistic examinations may be credited toward these direct examinations.

Table 4c, Inspections of **Buried Tanks**

Material[1]	Preventive	Inspections

	Actions[2]	
Titanium		
Super Austenitic Stainless[3]		
Stainless Steel		
HDPE[4]	A B	 X
Other Polymer[5]	A B	 X
Cementitious or Concrete		X
Steel	C D E	 X
Copper	C D E	 X
Aluminum	C D E	 X

1. Materials classifications are meant to be broadly interpreted; e.g., all alloys of titanium which are commonly used for buried piping are to be included in the titanium category. Material categories are generally aligned with P numbers as found in the ASME Code, Section IX. Steel is defined in chapter IX of this report. Polymer includes polymeric materials as well as composite materials such as fiberglass.

2. Preventive actions are categorized as follows:

   A Backfill is in accordance with ~~NACE RP0285-2002 and~~ Table 2a .

   B Backfill is not in accordance with ~~NACE RP0285-2002 and~~ Table 2a.

   C Cathodic protection, coatings, and backfill have been provided in accordance with ~~NACE SP0169-2007 and~~ Table 2a. Each cathodic protection system has been operated in accordance with NACE SP0169-2007 for at least 90% of the ~~time since the piping under consideration was installed~~ prior five years of operation or the time since it was inspected in accordance with this program element.

   D Cathodic protection, coatings, and backfill have been provided in accordance with ~~NACE SP0169-2007 and~~ Table 2a. Each cathodic protection system has been operated in accordance with NACE SP0169-2007 for ~~at~~ less than 90% of the ~~time since the piping under consideration was installed~~ prior five years of operation or the time since it was inspected in accordance with this program element.

   E Cathodic protection is not provided.

3. Super austenitic stainless steel, e.g. Al6XN or 254 SMO.

4. HDPE ~~pipe~~ tanks includes only HDPE ~~pipe~~ tanks approved for use by the NRC for buried applications.

5. Other polymer ~~piping~~ includes ~~some HDPE pipe, and~~ all other polymeric materials including composite materials such as fiberglass.

e. Directed Inspections – Underground Tanks

i. Directed inspections for underground tanks are conducted in accordance with Table 4d and its accompanying footnotes.

ii. Directed inspections as indicated in Table 4d will be conducted during each 10 year period beginning 10 years prior to the entry into the period of extended operation.

iii. Each underground tank which is Code Class/safety related or contains hazardous materials as defined in footnote 5 to Table 4a and is constructed from a material for which an examination is indicated in Table 4d is examined.

iv. Examinations may be conducted from the external surface of the tank using visual techniques or from the internal surface of the tank using volumetric techniques. If the tank is inspected from the external surface a minimum 25% coverage is required. This area must include at least some of both the top and bottom of the tank. If the tank is inspected internally, ~~by UT, at least 1 measurement is required per square foot of tank surface. If the tank is inspected internally by another volumetric technique, at least 90% of the surface of the tank must be inspected~~ examinations are performed using qualified volumetric methods, preferably ultrasonic, for the portion of the tank in contact with the soil environment. When internal volumetric tank examinations are conducted, one thickness measurement per square foot of tank surface for tanks with up to 22 square feet of surface area is performed. For tanks with greater than 22 square feet of surface area, the tank should be subdivided into a minimum of 22 equal surface areas and one thickness measurement should be made of each subdivided area.

v. Tanks that cannot be examined using volumetric examination techniques are examined visually from the outside.

~~vi. Visual inspections for polymeric materials are augmented with manual examinations to detect hardening, softening or other changes in material properties.~~

vii. Opportunistic examinations may be credited toward these direct examinations.

Table 4d, Inspections of **Underground Tanks**

Material[1]	Inspections
Titanium	
Super Austenitic Stainless[2]	
Stainless Steel	
HDPE[3]	

Other Polymer[4]	
Cementitious or concrete	
Steel	X
Copper	
Aluminum	

1. Materials classifications are meant to be broadly interpreted; e.g., all alloys of titanium which are commonly used for buried piping are to be included in the titanium category. Material categories are generally aligned with P numbers as found in the ASME Code, Section IX. Steel is as defined in chapter IX of this report. Polymer includes polymeric materials as well as composite materials such as fiberglass.

2. Super austenitic stainless steel, e.g., Al6XN or 254 SMO.

3. HDPE ~~pipe~~ tanks includes only HDPE ~~pipe~~ tanks approved for use by the NRC for buried applications.

4. Other polymer ~~pipe~~ tanks includes ~~some HDPE pipe, and~~ all other polymeric materials including composite materials such as fiberglass.

f. Adverse indications

i. Adverse indications observed during monitoring of cathodic protection systems or during inspections are entered into the plant corrective action program. Adverse indications which are the result of inspections will result in an expansion of sample size as described in item iv, below. Adverse indications which are the result of monitoring of a cathodic protection system may warrant increased monitoring of the cathodic protection system and/or additional inspections. Examples of adverse indications resulting from inspections include leaks, material thickness less than minimum, the presence of coarse backfill with accompanying coating degradation within 6 inches of a coated pipe or tank (see Table 2a Footnotes 5 and 6), and general or local degradation of coatings so as to expose the base material.

ii Adverse indications which fail to meet the acceptance criteria described in program element 6 of this AMP, will result in the repair or replacement of the affected component.

iii. If adverse indications are detected, ~~an analysis~~ ~~may be~~ an evaluation is conducted to determine the potential extent of the degradation observed and size of the expansion sample. Expansion of sample size may be limited by the extent of piping or tanks subject to the observed degradation mechanism.

~~iv. If adverse indications are detected, inspection sample sizes within the affected piping categories are doubled. If adverse indications are found in the expanded sample, the inspection sample size is again doubled. This doubling of the inspection sample size continues as necessary.~~

5. ***Monitoring and Trending:*** For piping and tanks protected by cathodic protection systems, potential difference and current measurements are trended to identify changes in the effectiveness of the systems and/or coatings as ~~describe~~ described in NACE Standards RP0285-2002 and SP0169-2007.

6. ***Acceptance Criteria:*** The principal acceptance criteria associated with the inspections contained with this AMP follow:

    a. Criteria for soil-to-pipe potential are listed in NACE RP0285-2002 and SP0169-2007.

    b. For coated piping or tanks, there should be either no evidence of coating degradation or the type and extent of coating degradation should be insignificant as evaluated by a NACE certified inspector or an equivalent qualified coating inspector.

    c. If coated or uncoated metallic piping or tanks show evidence of corrosion, the remaining wall thickness in the affected area is determined to ensure that the minimum wall thickness is maintained. This may include different values for large area minimum wall thickness, and local area wall thickness.

    d. Cracking or blistering of nonmetallic piping is evaluated.

    e. Cementitious or concrete piping may exhibit minor cracking and spalling provided there is no evidence of leakage or exposed rebar or reinforcing “hoop” bands.

    f. Backfill is in accordance with specifications described in program element 2 of this AMP.

    ~~g. Flow test results for fire mains are in accordance with NFPA 25 section 7.3.~~

    h. For hydrostatic tests, the condition “Without leakage” as required by 49 CFR 195.302 may be met by demonstrating that the test pressure, as adjusted for temperature, does not vary during the test.

7. ***Corrective Actions:*** The site corrective actions program, quality assurance (QA) procedures, site review and approval process, and administrative controls are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. The staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the corrective actions, confirmation process, and administrative controls.

8. ***Confirmation Process:*** The confirmation process ensures that preventive actions are adequate to manage the aging effects and that appropriate corrective actions have been completed and are effective. The confirmation process for this program is implemented through the site's QA program in accordance with the requirements of 10 CFR Part 50, Appendix B.

9. ***Administrative Controls:*** The administrative controls for this program provide for a formal review and approval of corrective actions. The administrative controls for this program are implemented through the site's QA program in accordance with the requirements of 10 CFR Part 50, Appendix B.

10. ***Operating Experience:*** Operating experience shows that buried and underground piping and tanks are subject to corrosion. Corrosion of buried oil, gas, and hazardous materials pipelines have been adequately managed through a combination of inspections and

mitigative techniques, such as those prescribed in NACE SP0169-2007 and NACE RP0285-2002. Given the differences in piping and tank configurations between transmission pipelines and those in nuclear facilities, it is necessary for applicants to evaluate both plant-specific and nuclear industry operating experience and to modify its aging management program accordingly. The following industry experience may be of significance to an applicant's program:

a. On February 21, 2005, a leak was detected in a 4-inch condensate storage supply line. The cause of the leak was microbiologically influenced corrosion or under deposit corrosion. The leak was repaired in accordance with the American Society of Mechanical Engineers (ASME) Section XI, "Repair/Replacement Plan".

b. On September 6, 2005, a service water leak was discovered in a buried service water header. The header had been in service for 38 years. The cause of the leak was either failure of the external coating or damage caused by improper backfill. The service water header was relocated above ground.

c. In October 2007, degradation of essential service water piping was reported. The riser pipe leak was caused by a loss of pipe wall thickness due to external corrosion induced by the wet environment surrounding the unprotected carbon steel pipe. The corrosion processes that caused this leak affected all eight similar locations on the essential service water riser pipes within vault enclosures and had occurred over many years

d. In February 2009, a leak was discovered on the return line to the condensate storage tank. The cause of the leak was coating degradation probably due to the installation specification not containing restrictions on the type of backfill allowing rocks in the backfill. The leaking piping was also located close to water table.

e. In April 2009, a leak was discovered in an aluminum pipe where it went through a concrete wall. The piping was for the condensate transfer system. The failure was caused by vibration of the pipe within its steel support system. This vibration led to coating failure and eventual galvanic corrosion between the aluminum pipe and the steel supports.

f. In June 2009, an active leak was discovered in buried piping associated with the condensate storage tank. The leak was discovered because elevated levels of tritium were detected. The cause of the through-wall leaks was determined to be the degradation of the protective moisture barrier wrap which allowed moisture to come in contact with the piping resulting in external corrosion.

References

10 CFR Part 50, Appendix B, *Quality Assurance Criteria for Nuclear Power Plants*, Office of the Federal Register, National Archives and Records Administration, 2009.

NACE Standard SP0169-2007, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*, 2007.

NACE Standard RP0285-2002, *Standard Recommended Practice Corrosion Control of Underground Storage Tank Systems by Cathodic Protection,* revised April 2002.

NFPA Standard 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances, 2010 edition.

ASTM Standard D 448-08, Standard Classification for Sizes of Aggregate for Road and Bridge Construction, 2008.

NFPA Standard 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, 2008 edition.

49 CFR 195 subpart E, Transportation of Hazardous Liquids by Pipeline, Pressure Testing.

ASME Standard B31.3 – 2002, Process Piping, Appendix M.

ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing.