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Standard Guide for Three Methods of Assessing Buried Steel Tanks¹

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INTRODUCTION

The purpose of this guide is to provide three methods of inspecting and assessing buried steel tank(s) for corrosion damage and determining the suitability of these tanks prior to application of cathodic protection.

1. Scope

1.1 This guide covers procedures to be implemented prior to the application of cathodic protection for evaluating the suitability of a tank for upgrading by cathodic protection alone.

1.2 Three procedures are described and identified as Methods A, B, and C.

1.2.1 *Method A*—Noninvasive with primary emphasis on statistical and electrochemical analysis of external site environment corrosion data.

1.2.2 *Method B*—Invasive ultrasonic thickness testing with external corrosion evaluation.

1.2.3 *Method C*—Invasive permanently recorded visual inspection and evaluation including external corrosion assessment.

1.3 This guide presents the methodology and the procedures utilizing site and tank specific data for determining a tank's condition and the suitability for such tanks to be upgraded with cathodic protection.

1.4 While this guide provides minimum procedures for assessing a tank's condition, this guide does not provide minimum installation procedures or requirements for upgrades of the tank by cathodic protection.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate*

safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 The most recent version of the following documents should be consulted as references by those using this guide:

2.2 *ASTM Standards*:²

[E114 Practice for Ultrasonic Pulse-Echo Straight-Beam Contact Testing](#)

[E797/E797M Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method](#)

[E1323 Guide for Evaluating Laboratory Measurement Practices and the Statistical Analysis of the Resulting Data](#)

[E1526 Practice for Evaluating the Performance of Release Detection Systems for Underground Storage Tank Systems \(Withdrawn 2002\)](#)³

[G51 Test Method for Measuring pH of Soil for Use in Corrosion Evaluations](#)

[G57 Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method](#)

[G193 Terminology and Acronyms Relating to Corrosion](#)

2.3 *ASNT Standard*:⁴

[ASNT SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing](#)

¹ This guide is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.10 on Corrosion of Soils.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, <http://www.asnt.org>.

2.4 *AMPP (formerly NACE International) Standards:*⁵
NACE SP0169 (formerly RP0169) Standard Practice – Control on External Corrosion on Underground or Submerged Metallic Piping Systems

NACE SP0187 (formerly RP0187) Standard Practice – Design Considerations for Corrosion Control of Reinforcing Steel in Concrete

NACE SP0285 (formerly RP0285) Standard Practice – Corrosion Control of Underground Storage Tank Systems by Cathodic Protection

2.5 *Environmental Protection Agency Methods:*⁶
EPA SW 846 Test Methods for Evaluating Solid Waste
EPA 371.1 Measurement of Sulfate Reducing Bacteria

2.6 *National Fire Protection Association (NFPA) Practice:*⁷
NFPA 329 Recommended Practice for Handling Underground Releases of Flammable and Combustible Liquids

2.7 *Underwriters Laboratories Standard:*⁸
UL 58 Steel Underground Tanks for Flammable and Combustible Liquids

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *buried, adj*—to be placed in the ground and covered with earth.

3.1.2 *cathodic protection, n*—an applied technique to prevent further corrosion of a metal surface by making that surface the cathode of an electrochemical cell. For example, a tank system can be cathodically protected through the application of either galvanic anodes or impressed current.

3.1.3 *corrosion specialist/cathodic protection specialist, n*—a competent person who by reason of knowledge of the physical sciences and the principles of engineering and mathematics, acquired by education and related practical experience, is qualified to engage in the practice of corrosion control on buried or submerged metallic piping systems and metallic tanks. Such persons are recommended to be registered professional engineers or persons recognized as corrosion specialists or cathodic protection specialists by NACE (AMPP), if their professional activities include suitable experiences in external corrosion control on buried or submerged metallic piping and tanks.

3.1.4 *corrosion technician, n*—a person possessing basic knowledge of corrosion and corrosion control, who is capable of performing routine, well defined work under the supervision of the corrosion specialist/cathodic protection specialist.

3.1.5 *invasive procedure, n*—a method of determining the corrosion status of a tank by assessing the tank from the inside

as part of the upgrade procedure. Further, for the purposes of this guide, it does not require manned entry into the tank. (See *non-invasive*.)

3.1.6 *limitations, n*—The user of this guide is encouraged to review any available third party verification information provided as part of the vendor selection process.

3.1.7 *noninvasive procedure, n*—a method of determining the corrosion status of a tank from the characteristics of its surroundings with minimal entry into the tank. Further, for the purposes of this guide, it does not require manned entry into the tank. (See *invasive*.)

3.1.8 *tank tightness test, n*—a method capable of detecting a 0.1 gal/h leak rate, while accounting for any applicable effects of thermal expansion or contraction of the product, of vapor pockets, of tank deformation, of evaporation or condensation, and of the location of the water table. The method should be capable of detecting a 0.1 gal/h leak rate with a probability of detection of at least 0.95 and a probability of false alarm of at most 0.05 or in accordance with NFPA 329.

3.1.9 *unconditional probability of corrosion failure, n*—the probability of corrosion failure which includes a determination of whether localized, pitting, or general corrosion is occurring.

3.1.10 *underground storage tank (UST), n*—any one or combination of tanks (including connected underground piping), the volume of which is 10 % or more beneath the surface of the ground.

3.1.11 *upgrade, n*—the addition to or retrofit of UST systems using approaches including, but not limited to, cathodic protection to improve the ability of a UST system to prevent a release.

3.1.12 *UST, n*—see underground storage tank (see 3.1.10).

3.1.13 *vendor provided information, n*—The user is referred to **Annex A1** for a specific form and format of information which should be provided by a vendor. This information consists of historic performance data on a method and is recommended as part of the guide.

4. Significance and Use

4.1 This guide provides three methods for determining the suitability of a buried steel tank to be upgraded with cathodic protection.

4.2 This guide may be used to assess any UST, including non-regulated USTs.

4.3 This guide provides three alternative methods but does not recommend any specific method or application. The responsibility for selection of a method rests with the user.

4.4 This guide has specific suggestions for vendor provided information which should be requested and reviewed by the user.

5. Permits, Plans and Tank Leak Testing

5.1 Prior to engaging in any activities relating to the alteration, repair, or upgrade of any UST system, all necessary authorities should be consulted to obtain any required permits.

5.2 *Tank Leak Testing:*

⁵ Available from AMPP International, 15835 Park Ten Pl., Houston, TX 77084, <http://www.ampp.org>.

⁶ Available from United States Environmental Protection Agency (EPA), Office of Underground Storage Tanks, William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, <http://www.epa.gov>.

⁷ Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269-9101.

⁸ Available from Underwriters Laboratories (UL), UL Headquarters, 333 Pfingsten Road, Northbrook, IL, 60062, <http://www.ul.com>.

5.2.1 To establish that tanks are not leaking prior to assessment, they should be assessed by a leak detection system. This leak detection assessment alone is not sufficient to determine that a tank is suitable for upgrading with cathodic protection under this guide.

5.2.2 A tightness test or another release detection system in accordance with NFPA 329 should be used. Any release detection should be capable of detecting a leak from any portion of the tank that routinely contains product, and be independently evaluated and certified in accordance with Practice E1526 or the equivalent. Leak detection results should be provided to the corrosion specialist/cathodic protection specialist.

5.2.3 This testing is recommended to be accomplished within six months prior to performing any of the assessment procedures.

6. Required Approvals and Certifications

6.1 The corrosion assessment work carried out under this guide should be performed under the responsible direction of a corrosion specialist/cathodic protection specialist as defined in 3.1.3.

6.2 The corrosion specialist/cathodic protection specialist should certify to the tank owner or operator that the personnel performing the assessment work on the tank are knowledgeable of all the applicable procedures in this guide.

6.3 The corrosion specialist/cathodic protection specialist should certify to the tank owner or operator that all work was performed in strict accordance with this guide.

7. General Safety Requirements

7.1 All personnel should comply with applicable federal, state, and local health and safety codes and regulations.

8. Preliminary Site Survey

8.1 A corrosion technician, under the responsible direction of the corrosion specialist/cathodic protection specialist, should obtain tank site specific information as appropriate to the method of assessment to be used.

8.1.1 Facility Information:

8.1.1.1 Address or location, and

8.1.1.2 Name and telephone number of owner and operator contact personnel.

8.1.2 Tank and Piping Details:

8.1.2.1 Number and capacity,

8.1.2.2 Location and dimensions,

8.1.2.3 Age,

8.1.2.4 Material of construction,

8.1.2.5 Electrical isolation,

8.1.2.6 Type of product stored,

8.1.2.7 Names of site contact personnel,

8.1.2.8 Backfill material,

8.1.2.9 Coatings and linings,

8.1.2.10 Leak history,

8.1.2.11 Repair history,

8.1.2.12 Site plans,

8.1.2.13 Installation specifications,

8.1.2.14 Tank excavation liners, and

8.1.2.15 As-built drawings.

8.1.3 *Information Not in the Immediate Vicinity of the Tanks*—The presence of the following items, that are external to the tank area, should be investigated and included as appropriate to the method of assessment of the suitability of tanks for upgrading with cathodic protection:

8.1.3.1 Stray dc current sources,

8.1.3.2 Existing cathodic protection systems,

8.1.3.3 Steel product and vent piping and fittings, and

8.1.3.4 Adjacent subsurface metallic/steel-reinforced concrete structures.

8.2 *Preliminary Evaluation*—Prior to assessing the tank, a preliminary site survey should be performed pursuant to Section 8 and a tightness test performed pursuant to 5.2 to establish that the tank is not leaking.

9. Method A—Noninvasive with Primary Emphasis on Statistical and Electrochemical Analysis of External Site Environment Corrosion Data^{9,10}

9.1 *Field and Laboratory Testing—Noninvasive with Primary Emphasis on Statistical and Electrochemical Analysis of External Site Environment Corrosion Data.*

9.1.1 Tests are recommended to be conducted by, or as directed by a corrosion specialist/cathodic protection specialist.

9.1.2 *Field Testing Procedures*—Tests to be performed should include, but are not limited to, the following:

9.1.2.1 *Stray Currents*—Perform tests to detect the presence of stray currents at each tank site. This test is recommended to consist of measuring structure-to-soil potentials at right angles at a minimum of two locations within the tank facilities and observing the measurements for not less than 2 h at a time when such influences are most likely to occur. The monitor should consist of a field data acquisition unit, with a minimum of 10 M Ω input impedance, used in conjunction with a stable reference cell(s) placed in contact with the soil in the vicinity of the tank. The instrument is recommended to measure and store structure-to-electrolyte potential (voltage) data at least every 5 s throughout the entire duration of field investigation at the site or for 2 h, whichever is greater. If variations of ± 50 mV or greater are measured during the test period, 24 h recording measurements are recommended to confirm stray current effects.

9.1.2.2 Tank Information:

(a) Locate all tanks and confirm materials of construction, age, capacity, and dimensions. Produce detailed site sketches describing the layout of the UST system and above grade pertinent details for each site.

(b) Determine the presence and extent of internal corrosion immediately below the fill riser. If the depth of corrosion penetration in the tank shell exceeds 50 % of the tank wall thickness, the UST is recommended to be declared to have failed the test and the procedure.

⁹ Bushman, J., B. and Mehalick, T., E. "Statistical Analysis of Soil Characteristics to Predict Mean Time to Corrosion Failure of Underground Metallic Structures," ASTM STP 1013, ASTM, 1989.

¹⁰ Rogers, W., F. "Statistical Prediction of Corrosion Failures," NACE International, CORROSION 89, Paper No. 596.

(c) Determine if the tanks and piping are electrically continuous.

9.1.2.3 Bore Hole Tests:

(a) Determine locations for soil borings in the field. Make two test holes for each tank excavation zone with four or fewer tanks. For tank excavation zones with more than four tanks, make one additional bore hole for each two additional tanks, or part thereof. Make the tank bore holes at opposite diagonal ends of the tank excavation zone. The tank excavation zone is recommended to extend no farther than 4 ft from the nearest tank. Complete the holes to the bottom of the deepest tank.

(b) In each tank bore hole, record measurements as the boring progresses. At 2 ft (0.6 m) intervals, the following tests are recommended:

(1) Measure the soil resistivity using the Wenner four pin method in accordance with Test Method G57.

(2) Make structure-to-soil potential measurements in each bore hole using a minimum 10 M Ω input impedance digital voltmeter and a calibrated copper-copper sulfate reference electrode sensing tip in direct contact with the soil in the bore hole.

(c) Measure the depth of observed, perched, or static water table in each bore hole, if encountered.

(d) In accordance with industry practices, gather one soil sample each at the top, mid depth, and bottom of each hole using either a split spoon or core sampling tube and place, seal, and preserve the soil samples in containers for laboratory analysis.

(e) Backfill each hole and seal with a concrete or asphalt plug.

9.1.2.4 *Other Field Considerations*—The corrosion specialist/cathodic protection specialist may also consider performing and evaluating the following tests:

(a) Current requirement,

(b) Coating resistance, and

(c) Coating efficiency.

9.1.3 *Laboratory Testing Procedures*—It is recommended to send soil samples collected at each site to a qualified soil laboratory where they can be tested in accordance with EPA SW 846 Guide E1323, or other recognized industry test methods. The report should include the results of all test methods used in the evaluation. At a minimum, the following data are recommended to be obtained:

9.1.3.1 Soil resistivity/conductivity,

9.1.3.2 Moisture content,

9.1.3.3 Soil pH,

9.1.3.4 Soluble chloride ion concentration, and

9.1.3.5 Sulfide ion concentration.

9.1.4 The corrosion specialist/cathodic protection specialist should also consider, but not be limited to, performing and evaluating the following tests. The report should include all test methods used in the evaluation:

9.1.4.1 Redox potential,

9.1.4.2 Sulfate ion concentration, and

9.1.4.3 Any other tests required by the external corrosion rate analysis model.

9.1.5 *Quality Control*—One soil sample of every ten samples analyzed is recommended to be subjected to an

independent quality control analysis of all data gathered in 9.1.3. If the results of the quality control analysis fail to agree with the original analysis (within limits of experimental accuracy), reanalyze all samples collected since the last successful quality control analysis.

9.2 *Analysis and Determination of Suitability of a Tank for Upgrading with Cathodic Protection-Noninvasive with Primary Emphasis on Statistical Analysis of External Site Environment Corrosion Data:*

9.2.1 *Basis for Analysis*—By examining the environment in the specific vicinity of the tank, a relationship between the aggressiveness of the environment and the rate of corrosion can be statistically established. Base the statistical analysis model used on a sufficient size data base with various factors that are accounted for statistically to reach a confidence level of 0.99. This will achieve consistency and reliability of the results. One general form of the multivariate, non-linear regression analysis, which contains the minimum essential variables, is as follows:

$$E(\text{Age}) = f(R, M, Cl, \text{pH}, S, SC, TS, P) \quad (1)$$

where:

$E(\text{Age})$ = unconditional predicted age to corrosion failure,

R = resistivity,

M = moisture content,

Cl = chloride ion concentration,

pH = soil pH,

S = sulfide ion concentration,

SC = stray current magnitude,

TS = tank size, and

P = tank structure to soil potential.

9.2.2 *Criteria of Acceptance for Upgrading With Cathodic Protection* (using SP0169, SP0187, and SP0285)—To be acceptable as a means of determining the condition of tanks and their suitability for upgrading with cathodic protection, the procedure used should, at a minimum, meet the following criteria:

9.2.2.1 The procedure is based on an evaluation of all data gathered *in situ* in each bore hole together with all soil sample data and the stray dc earth current monitor measurements taken at each site.

9.2.2.2 The mathematical formulation of the procedure conforms to accepted physical and electrochemical characteristics of the tank corrosion process. Independent professional validation of these processes is recommended to be conducted by an individual or individuals with experience in the relevant scientific or engineering disciplines.

9.2.2.3 Parameter estimates are based on data derived from at least 100 sites where a minimum of 200 tanks were excavated, fully exposed, and evaluated by a qualified corrosion specialist/cathodic protection specialist. Maximum likelihood estimation or another procedure that meets the standards of statistical or electrochemical admissibility should be required. Data used in estimation should contain representative samples of leaking and non-leaking tanks.

9.2.2.4 Models proposed should be specific as to soil type and incorporate depth of ground water and rainfall experienced in the immediate geographical area where testing takes place.

9.2.2.5 The standard deviation of the predicted time to corrosion failure is recommended to not exceed 1.5 years. The model should generate an unconditional probability of corrosion failure based upon a comparison of actual tank age to its expected leak-free life.

9.2.3 *Report Including Results, Analysis, and Recommendations*—The corrosion specialist/cathodic protection specialist should prepare a report including results, analysis, and recommendations as follows:

9.2.3.1 Base the report conclusions on the expected leak-free life of a tank at a specific site as determined by the analysis of the data necessary to determine which tanks are suitable for upgrading with cathodic protection.

9.2.3.2 The report should provide the expected leak-free life and present and future probabilities of corrosion failure for all tanks investigated.

9.2.3.3 The report should include a listing of tanks whose age is less than the expected leak-free life and for those tanks where the probability of corrosion perforation is less than 0.05.

9.3 Cathodic protection can be applied to those tanks that have been tested in accordance with Sections 8 and 9 and meet the following criteria:

9.3.1 The tank is confirmed to be leak-free in accordance with 5.2.

9.3.2 The tank age is less than the expected leak-free life.

9.3.3 The probability of corrosion perforation of the tank is less than 0.05.

9.3.4 Either a tank tightness test is conducted between three and six months after the tank is cathodically protected, or monthly monitoring with another leak detection system should be implemented within one month after the addition of cathodic protection. Any leak detection system is recommended to meet 5.2.2.

9.4 A recommended form is included in Annex A1 which can be utilized to report the results of the authenticated vendor provided information. A research report containing examples of actual authenticated vendor provided information is filed and available from ASTM.¹¹

10. Method B—Invasive Ultrasonic Thickness Testing with External Corrosion Evaluation

10.1 *Field and Laboratory Testing—Invasive Ultrasonic Thickness Testing with External Corrosion Evaluation:*

10.1.1 The following procedures are recommended when assessing the suitability of a steel tank for upgrading with cathodic protection using an invasive method.

10.1.2 Conduct tests by, or as directed by, the corrosion specialist/cathodic protection specialist.

10.1.3 Before a tank is suitable for upgrading with cathodic protection using an invasive approach, the following site-specific tests should be conducted for each tank excavation zone in accordance with industry recognized standard practices:

10.1.3.1 Perform the tests described in 9.1.2.1.

10.1.3.2 Soil resistivity in accordance with Test Method G57. These values are recommended to be measured in the immediate vicinity of the tank excavation zone and should, as a minimum, be measured at depths of 5 ft, 7½ ft, 10 ft, 12½ ft, and 15 ft (1.5 m, 2.3 m, 3.5 m, and 5 m).

10.1.3.3 Structure to soil potential in accordance with NACE SP0285 with at least five such measurements spaced uniformly about each tank excavation zone.

10.1.3.4 Soil pH in accordance with Test Methods G51, soil chlorides and sulfides in accordance with EPA SW 846 uniformly gathered from three locations about each tank excavation zone.

10.1.3.5 Electrical continuity/isolation in accordance with NACE SP0285 of each UST being evaluated.

10.1.4 The corrosion specialist/cathodic protection specialist should also consider, but not be limited to, performing and evaluating the following tests:

10.1.4.1 Redox potential,

10.1.4.2 Current requirement,

10.1.4.3 Coating resistance,

10.1.4.4 Coating efficiency,

10.1.4.5 Wall thickness,

10.1.4.6 Soluble chloride ion concentration,

10.1.4.7 Sulfide ion concentration,

10.1.4.8 Sulfate ion concentration, and

10.1.4.9 Any other tests deemed necessary.

10.2 *Invasive Ultrasonic Thickness Testing with External Corrosion Evaluation:*

10.2.1 This subsection provides the general procedure for assessing tanks prior to upgrading with cathodic protection through the use of invasive ultrasonic thickness testing in combination with the leak detection testing in accordance with 5.2 and external corrosion evaluation procedures contained in 10.1. This procedure may be conducted using either manually manipulated or computer controlled remote controlled (robotic) ultrasonic sensor placement, control and measurement devices which do not require manned entry into the UST.

10.2.2 *Certification*—Corrosion technicians performing invasive ultrasonic thickness testing should also be certified in accordance with ASNT recommended practice SNT-TC-1A and qualified under similar written practice with the equipment and procedures to be employed.

10.2.3 *Surface Preparation*—In accordance with Practice E114, the interior surface of the tank to be examined should be uniform and free of loose scale, loose paint, dirt, or other deposits that affect examination. If any such loose scale, loose paint, dirt, or other deposits exist which would prevent accurate ultrasonic thickness measurement of the remaining steel wall, they should be removed prior to performing these measurements. Tightly adhering paint, scale, or bonded coatings do not need to be removed if they present uniform attenuation characteristics.

10.2.4 *Calibration*—Calibrate the thickness measurement sensor in accordance with Practice E797/E797M.

10.2.5 *Couplant*—Any couplant used should be the stored product or a material compatible with the stored product and should be appropriate for the surface finish of the material to be examined. The surface finish and couplant of the reference

¹¹ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:G01-1019.

standards are recommended to be acoustically similar to those of the tank and the couplant therein.

10.2.6 *Ultrasonic Gauging:*

10.2.6.1 The invasive ultrasonic inspection is recommended to make located wall thickness measurements of at least 15 % of the entire tank interior surface area excluding man way entries. The thickness measurements should be uniformly distributed over the surface of the tank. The invasive ultrasonic inspection equipment is recommended to be capable of accessing at least 95 % of the tank interior surface area excluding man way entries and other tank penetration fittings. In areas where corrosion damage is more severe, as determined by the corrosion technician, additional measurements are recommended to be made as directed by the corrosion specialist/cathodic protection specialist so as to provide a sufficient amount of inspection data to accurately define the extent of corrosion and to ensure an accurate leak-free life prediction.

10.2.6.2 Depending on surface conditions, the minimum ultrasonic thickness measurement capability may vary from 0.050 in. to 0.125 in. (1.2 mm to 3.2 mm). The instrumentation should be able to measure remaining wall thickness of the tank to an accuracy of ± 0.010 in. (0.25 mm) and to detect a flat bottom pit of 0.125 in. (3.2 mm) diameter.

10.2.6.3 The maximum allowable position error in each wall thickness measurement position location coordinate is 5 % of the maximum tank dimension.

10.2.7 *Ultrasonic Test Reports*—The following data are recommended as a minimum for future reference at the time of each investigation:

- 10.2.7.1 Operator's name and certification level,
 - 10.2.7.2 Instrument description including make, model, and serial number and setup couplant,
 - 10.2.7.3 Instrument calibration certification including date performed,
 - 10.2.7.4 Cable type and length,
 - 10.2.7.5 Mode of scanning (manual or automatic),
 - 10.2.7.6 Search unit description, such as type, size, frequency, special shoes,
 - 10.2.7.7 Reference standards (and calibration data required to duplicate the examination), and
 - 10.2.7.8 Location data (coordinates) for thickness measurement data points.
- 10.2.8 Invasive ultrasonic wall thickness measurement may pose certain safety hazards. It is the responsibility of the user of this guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

10.3 *Data Analysis and Determination of Suitability of a Tank for Upgrading With Cathodic Protection (SP0169 and SP0187) Using Invasive Ultrasonic Thickness Testing and Evaluation Including External Site Environment Corrosion Assessment:*

10.3.1 This alternative method includes a mathematical corrosion prediction model and an analytical report. The analytical report contains the tank, soil chemistry (using Guide E1323), and inspection data. The model is then used to

estimate the leak-free life of the tank using the tank information, ultrasonic thickness measurement test data, and soil chemistry data.

10.3.2 *Prediction Model:*

10.3.2.1 Use a prediction model to determine the probability of an individual tank leak as a result of corrosion. It should yield the years of leak-free life remaining and the probability of a potential leak of the tank in a specific soil condition. The model should be based on tank inspection data collected and should include all of the site specific parameters listed in 10.1.3.1 – 10.1.3.5 and any test(s) performed in 10.1.4. The mathematical formulation used in the prediction model is recommended to be based on accepted physical and electrochemical characteristics of the tank corrosion process.

10.3.2.2 Consider the tank suitable for upgrading with cathodic protection if there is:

- (a) No measured pitting which perforates the tank wall,
- (b) Ninety-eight percent of all ultrasonic thickness measurements made on the tank is greater than or equal to 50 % of the minimum recommended wall thickness as provided in Underwriters Laboratories Standard UL 58 or the documented original tank wall thickness,
- (c) The average metal wall thickness of each 1 m² is greater than 85 % of the original wall thickness, and
- (d) The results of the prediction model (for example CERL N 91/18), as determined by the corrosion specialist/cathodic protection specialist, support that cathodic protection is both reasonable and viable.

10.3.3 *Inspection Report*—This report is recommended to summarize all tank data collected from the inspection and provide results from the prediction model for each tank including recommendations with respect to each tank's suitability for upgrading using cathodic protection. The corrosion specialist/cathodic protection specialist is responsible for all data analysis and recommendations.

10.4 Cathodic protection can be applied to those tanks which have been evaluated using one of the procedures provided for in Sections 8 and 10 and meet the following criteria

- 10.4.1 Passes all requirements defined in 10.3.2.2.
- 10.4.2 Either a tank tightness test is conducted between three and six months after the tank is cathodically protected, or monthly monitoring with another leak detection system is implemented within one month after the addition of cathodic protection. Any leak detection system is recommended to meet 5.2.2.

10.5 A recommended form is included in Annex A1 which can be utilized to report the results of the authenticated vendor provided information. A research report containing examples of actual authenticated vendor provided information is filed and available from ASTM.¹¹

11. Method C—Invasive Permanently Recorded Visual Inspection and Evaluation Including External Corrosion Assessment

11.1 *External Corrosion Assessment Data Gathering:*