Designation: ~~E2256 – 13~~ E2256 – 19

Standard Guide for Hydraulic Integrity of New, Repaired, or Reconstructed Aboveground Storage Tank Bottoms for Petroleum Service[1]

This standard is issued under the fixed designation E2256; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is intended to provide the reader with a knowledge of construction examination procedures and current technologies that can be used to give an owner or operator of an aboveground storage tank (AST) in petroleum service, relevant information on the hydraulic integrity of a new, repaired, or reconstructed tank bottom prior to return to service. This guide does not pertain to horizontal ASTs, manufacture of tanks using UL 142, or to tanks constructed of concrete or other non-ferrous materials.

1.2 The adoption of the ~~mathods~~methods and technologies presented in this guide are not mandatory, rather they represent options that may be selected to identify the likelihood of product leaking through a new, repaired, or reconstructed tank bottom.

1.3 This guide is not intended to suggest or treat any technology in a preferential manner.

1.4 The person responsible for applying this guide should be a knowledgeable individual with experience in the design, inspection, construction, or combination thereof, of aboveground storage tanks for use in petroleum service, and should also be certified under the requirements of API 653 when use is related to tank bottom repair.

1.5 Refer to API RP 575 for useful information and recommended practices for maintenance and inspection of atmospheric and low pressure stirage tanks.

1.6 This guide is written in metric measure units (SI Units) in accordance with requirements of Practice E621. English measure equivalents are in parentheses.

1.7 The applicability of this guide to the proposed tank configuration and service conditions should be established prior to use.

1.8 This guide complies with ASTM policy for development and subsequent use of a standard.

1.9 This guide is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this guide or for additional standards and should be addressed to ASTM International, 100 Barr Harbor Drive, W. Conshohocken, PA 19428.

1.10 This guide is not intended for use as a model code, ordinance or regulation.

1.11 This guide does not cover every tank bottom inspection procedure that may be properly applied.

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

1.13 *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

All documents refer to the latest edition.

2.1 *ASTM Standards:*[2]

A6/A6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

[1] This guide is under the jurisdiction of ASTM Committee E50 on Environmental Assessment, Risk Management and Corrective Action and is the direct responsibility of Subcommittee E50.01 on Storage Tanks.

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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.

A20/A20M Specification for General Requirements for Steel Plates for Pressure Vessels
A36/A36M Specification for Carbon Structural Steel
A53/A53M Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A106/A106M Specification for Seamless Carbon Steel Pipe for High-Temperature Service
A333/A333M Specification for Seamless and Welded Steel Pipe for Low-Temperature Service and Other Applications with Required Notch Toughness
D3282 Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
E165 Practice for Liquid Penetrant Testing for General Industry
E621 Practice for Use of Metric (SI) Units in Building Design and Construction(Committee E06 Supplement to E380) (Withdrawn 2008)[3]
E709 Guide for Magnetic Particle Testing
E1209 Practice for Fluorescent Liquid Penetrant Testing Using the Water-Washable Process
E1219 Practice for Fluorescent Liquid Penetrant Testing Using the Solvent-Removable Process
E1220 Practice for Visible Penetrant Testing Using Solvent-Removable Process

2.2 *Other Documents:*

ASME Section V and IX Boiler and Pressure Vessel Code[4]
SNT TC-1A Society for Nondestructive Testing Recommended Practice[5]
AWS B1.10 Guide for the Nondestructive Inspection of Welds[6]
AWS QC1-96 Standard for AWS Certification of Welding Inspectors[6]
API Publication 322 An Engineering Evaluation of Acoustic Methods of Leak Detection in Aboveground Storage Tanks, Jan. 1994[7]
API Publication 334 A Guide to Leak Detection for Aboveground Storage Tanks, Mar. 1996[7]
API 571 Damage Mechanisms[7]
API 575 Inspection of Atmospheric and Low-Pressure Storage Tanks[7]
API 577 Welding, Inspection and Metallurgy[7]
API RP 479 Fitness for Service[7]
API RP 580 Risk Based Inspection[7]
API 581 Base Resource Document-Risk-Based Inspection[7]
API 650 Welded Steel Tanks for Oil Storage[7]
API 653 Tank Inspection, Alteration, and Reconstruction[7]
STI 1–SP001 Steel Tank Institute Standard[8]

3. Terminology

3.1 *The following terms as used in this guide may differ from the more commonly accepted definitions elsewhere.*

3.1.1 *aboveground storage tank (AST), n*— a vertically oriented tank (normally cylindrical), ~~whose bottom is~~ is uniformly supported and is in contact with ~~the~~ soil or other ~~solid material and whose shell to bottom joint is designed to be at the plane of grade. See~~material. Many tanks are supported on a gravel or concrete ring foundation. Some tanks re supported on grillage ~~Fig. 1. Many tanks are supported on a gravel or concrete ring. Some tanks have a~~such that there is a space between the tank bottom and the supporting foundation. See Fig. 1~~full~~ for an example of tanks supported on the soil. See Fig. 2~~concrete pad foundation.~~

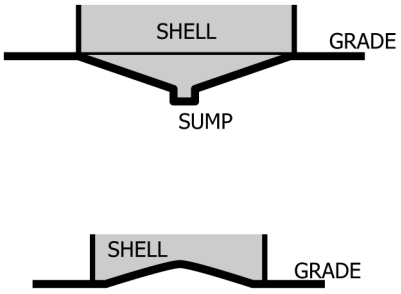

FIG. 1 Examples of ASTs per this Guide

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, ~~Three~~Two Park Ave., New York, NY 10016-5990, http://www.asme.org.
[5] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.
[6] Available from American Welding Society (AWS), ~~550 NW LeJeune Rd.,~~ 8669 NW 36 St., #130, Miami, FL ~~33126,~~33166-6672, http://www.aws.org.
[7] Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, http://www.api.org.
[8] Available from Steel Tank Institute / Steel Plate Fabricators Association 944 Donata Ct. Lake Zurich, IL 60047, http://www.steeltank.com

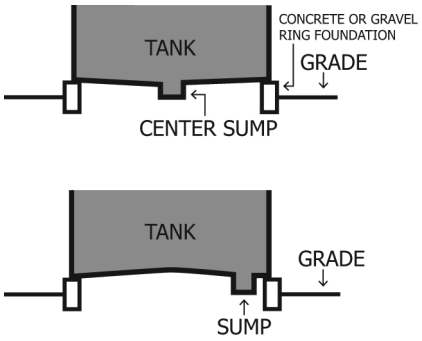

FIG. 2 ~~Flow Chart for API Established Methods and Enhancing Procedures for Tank Bottom Integrity~~Examples of ASTs per this Guide

for an example of tanks supported on gravel or concrete ring. See API 650 Annex I for an example of tanks supported on grillage.

3.1.2 *conditions and limitations, n*—the environmental and physical effects that restrict the collection of data.

3.1.3 *cut and cover or bunkered tank, n*— a field-constructed aboveground storage tank that has been cut into the soil and covered to protect it from damage either by accident or hostile intent of war.

3.1.4 *developing technology, n*—a procedure or testing method that may be used to provide additional information on a potential leak path.

3.1.5 *for petroleum service, n*—an AST that is designated for or expected to be used for petroleum product storage to include crude oil, residual, and refined petroleum products.

3.1.6 *hydraulic integrity, n*—the actual ability of a tank bottom to prevent passage of a stored product to the external environment.

3.1.7 *leak path, n*—the route or opening through which the tank contents are released through to the exterior environment.

3.1.8 *tank, n*—a field-erected steel structure constructed of welded or riveted steel and designed for petroleum service.

3.1.9 *tank bottom, n*—the floor of a vertically oriented tank, including the shell to bottom weld, connected piping supports, column base plates, sumps, floor plates, and floor welds, but not interior or exterior coatings or cathodic protection.

3.1.10 *tank owner or operator, n*—an individual or entity that owns or operates an aboveground storage tank in accordance with and definitions of The U.S. Environmental Protection Agency Regulation 40 CFR 112.

3.1.11 *technologies, n*—systems or services that provide information that can be used to evaluate the hydraulic integrity of a tank bottom.

3.2 *Abbreviations:*

3.2.1 *cm*—centimetre

3.2.2 *mm*—millimetre

3.3 *Acronyms:*

3.3.1 *ANSI*—American National Standards Institute

3.3.2 *API*—American Petroleum Institute

3.3.3 *ASM*—American Society for Metals

3.3.4 *ASME*—American Society of Mechanical Engineers

3.3.5 *ASNT*—Society for Nondestructive Testing

3.3.6 *AST*—aboveground storage tank

3.3.7 *AWS*—American Welding Society

3.3.8 *ERW*—electric resistance weld

3.3.9 *NDE*—non-destructive evaluation

3.3.10 *OSHA*—United States Occupational, Safety and Health Administration

3.3.11 *UL*—Underwriters Laboratory

3.3.12 *UST*—underground storage tank

3.4 *Measurement Units*—This guide is written in metric measure units (SI Units) in accordance with requirements of Practice E621. English measure equivalents are in parentheses.

4. Summary of Guide

4.1 This guide establishes a process and provides guidance about practices and procedures that are called for in API 650 and API 653, or available as optional selections and which will lead to a better understanding about the hydraulic integrity of an AST's bottom. The information contained in the guide is set out in three formats: a flowchart of the procedures and the appropriate point for employment in order to gather the most useful information; a table of the procedures briefly describing what and how they should be used in order to gather the most useful information; and an expanded listing of the procedures to provide the guide user with procedure background and expected results in order to determine the type and validity of the information gathered.

5. Significance and Use

5.1 Inspection, repair, and construction of ASTs in petroleum service should follow at a minimum the requirements of API 650 and API 653. These standards describe methods for testing the weld quality and structural and hydraulic integrity of new or repaired ASTs. With increasing emphasis on protecting the environment and with environmental issues related to the storing of petroleum materials in ASTs, owners and operators of such tanks may want or need a guide devoted to existing and enhanced methods for evaluating the hydraulic integrity of new or repaired tank bottoms.

5.2 The consequences of a tank bottom failure include the economic loss of product, cost of repair or replacing the tank bottom, and exposure to the cost of environmental remediation and potential damage or harm to adjacent lands that may give rise to adverse public relations or regulatory action. In addition, releases of petroleum products introduce potential fire or explosive conditions.

5.3 Owners and operators of ASTs or their agents can use this guide to help choose methods of evaluating the hydraulic integrity of their repaired or new tank bottoms. Selection of the methods should be based on regulatory and economic criteria that include operational and cost/benefit considerations.

5.4 This guide is intended for use by an individual experienced in repair and construction of ASTs in petroleum service.

5.5 This guide is intended for use when repairing or building ASTs. This guide does not address suitability for use or imply useful life of an AST bottom.

5.6 This guide is intended to be used in conjunction with and as a supplement to standards provided for hydraulic integrity in API 650 and API 653.

5.7 Procedures or methods included here may be supported by a previously completed and documented performance evaluation(s) that may lend itself as valuable results validation.

6. Procedures

6.1 This section provides information on established practices described in API 650 and API 653. This section provides information on other practices listed in this guide as optional during a hydrostatic test, and which may be used to assess the hydraulic integrity of the tank bottom. Also identified in this section ~~are developing technologies that may be used in conjunction with a hydro-test, and may produce supplemental information about the hydraulic integrity of the completed tank bottom construction.~~ is the developing robotic and drone inspection technology . Some of the procedures identified here are recognized to be voluntary when used for attaining an enhanced confidence in the hydraulic integrity for a repaired or newly constructed tank bottom. For those owners and operators that already have procedures for determining the suitability of the tank bottom, this guide may serve as a reference when policy warrants a change in their methods.

6.2 Table 1 identifies tests and procedures, and notes when application of those tests or procedures will provide the most useful information for assessing the hydraulic integrity of tank bottom.

6.3 Fig. 3 is a flow chart identifying typical applications of the inspection procedures listed in Table 1. Table 1 supplements the flow chart by listing the accepted tests and procedures ~~from API 650 and API 653,~~ as a readily available ~~reference, and also the developing technologies. These API~~ reference.. These procedures, although established chiefly to assess tank structural soundness, are also useful for determining the hydraulic soundness of tank bottom construction when it has been repaired or newly constructed. ~~Information relating to the developing technologies may be employed by an owner and operator in order to obtain hydraulic integrity and other supplementary information during a hydrostatic test.~~

6.4 Appendix X1 is additional information on the inspection methods described in Table 1.

TABLE 1 Tests and Procedures

Procedure	General Description of Procedure	General Application	Thresholds, Results, and Limitations
~~7.2Evaluation of Floor Plate, Weld Construction~~	~~Good practices, procedures, record keeping, and oversight of plate manufacturing process, shipment, and storage at site. Compliance with design requirements, welding procedures, certifications and plate preparation prior to completing welds. Experience requirements for construction personnel and inspectors. Performance of work in proposed hydrogen sulfide uses or other environments that may cause cracking. Review structural fill and concrete sub-floors for compliance with specification.~~	~~This procedure is performed on the steel floor plate, floor plate welds, floor plate to shell welds, internal piping supports connected to the floor plates, tank sumps, and gauging well wear plate. In addition, this procedure recognizes that improper preparation of the tank bottom substrate, by permitting hills and voids, contributes significantly to the potential for early tank bottom hydraulic integrity failure.~~	~~Impacts to tank bottom hydraulic integrity include: completion schedule, individual integrity, skill and experience in the plate manufacturing process, those individuals directing, performing, inspecting, and reviewing records. Reliance on subjective opinion. Plate Manufacture complies with Specification A6/A6M or Specification A20/A20M. Welding Complies with API 650, Section 7.2 and API 653, Section 11, ASME and AWS standards as applicable. Certification of Weld Inspectors complies with AWS QC1-96.~~
Evaluation of Floor Plate, Weld Construction	Good practices, procedures, record keeping, and oversight of plate manufacturing process, shipment, and storage at site. Compliance with design requirements, welding procedures, certifications and plate preparation prior to completing welds. Experience requirements for construction personnel and inspectors. Performance of work in proposed hydrogen sulfide uses or other environments that may cause cracking. Review structural fill and concrete sub-floors for compliance with specification.	This procedure is performed on the steel floor plate, floor plate welds, floor plate to shell welds, internal piping supports connected to the floor plates, tank sumps, and gauging well wear plate. In addition, this procedure recognizes that improper preparation of the tank bottom substrate, by permitting hills and voids, contributes significantly to the potential for early tank bottom hydraulic integrity failure.	Impacts to tank bottom hydraulic integrity include: completion schedule, individual integrity, skill and experience in the plate manufacturing process, those individuals directing, performing, inspecting, and reviewing records. Reliance on subjective opinion. Plate Manufacture complies with Specification A6/A6M or Specification A20/A20M. Welding Complies with API 650, Section 7.2 and API 653, Section 11, ASME and AWS standards as applicable. Certification of Weld Inspectors complies with AWS QC1-96. Certification of tank inspectors per API 653
~~7.3 Evaluation of Connected Under-floor Piping~~	~~Accepted practice, procedures, and inspection of completed water draw offs, drain dry piping, and sump systems including the bedding.~~	~~This procedure is performed on the tank piping that passes beneath the sub-floor and floor plates of a tank bottom including the welds.~~	~~Impacts to piping installation include: completion schedule, individual integrity, skill and experience in the pipe manufacturing process, those individuals directing, performing, inspecting, and reviewing records. Reliance on subjective opinion. Prior to back filling these systems inspect completely.~~
Evaluation of Connected Under-floor Piping	Accepted practice, procedures, and inspection of completed water draw offs, drain dry piping, and sump systems including the bedding.	This procedure is performed on the tank piping that passes beneath the sub-floor and floor plates of a tank bottom including the welds.	Impacts to piping installation include: completion schedule, individual integrity, skill and experience in the pipe manufacturing process, those individuals directing, performing, inspecting, and reviewing records. Reliance on subjective opinion. Prior to back filling these systems inspect completely.

TABLE 1 *Continued*

Procedure	General Description of Procedure	General Application	Thresholds, Results, and Limitations
~~7.4 Evaluation by Visual Examination of the Tank Floor~~	~~Visual inspection of the tank floor, including the plates, welds, shell to floor plate welds, and piping, sumps, and wastewater drains. The inspection may be performed using direct eye, mirrors, cameras, and other suitable instruments. The eye should be placed no more than 60.9 cm (24 in.) from the surface and at an angle of not less than 30°.~~	~~Plates, welds, shell to floor plate welds, and piping, sumps and wastewater drains.~~	~~Accessibility to visual inspection, cleanliness of area to be inspected, applies to surface defects only, lighting levels, visual acuity of individual performing inspection. Minimum illumination is 15 footcandles for general viewing and 50 footcandles for viewing small anomalies. Individual performing the test should have a visual acuity natural or corrected as measured by reading standard J-2 letters of the Jaeger Chart. Identify cracks, undercut, mechanical defects, gouges, arc strikes, temporary attachment removal area, and incomplete welds.~~
Evaluation by Visual Examination of the Tank Floor	Visual inspection of the tank floor, including the plates, welds, shell to floor plate welds, and piping, sumps, and wastewater drains. The inspection may be performed using direct eye, mirrors, cameras, and other suitable instruments. It is recommended that the eye should be placed no more than 60.9 cm (24 in.) from the surface and at an angle of not less than 30°.	Plates, welds, shell to floor plate welds, and piping, sumps and wastewater drains.	Accessibility to visual inspection, cleanliness of area to be inspected, applies to surface defects only, lighting levels, visual acuity of individual performing inspection. Minimum illumination is 15 footcandles for general viewing and 50 footcandles for viewing small anomalies. Individual performing the test should have a visual acuity natural or corrected as measured by reading standard J-2 letters of the Jaeger Chart at a distance of 300 mm (12 in.) and is capable of passing a color contrast test. Examiners should be checked annually to ensure they meet this requirement. Identify cracks, undercut, mechanical defects, gouges, arc strikes, temporary attachment removal area, and incomplete welds.
~~7.5Evaluation by Radiography Examination~~	~~A non-destructive method for inspection of welds that provides information about the internal condition using radiation. The radiation is directed at the weld and either penetrates, is absorbed, or scatters and is then recorded on film or by a device. There are two recognized methods of conducting radiography: Film/Paper Radiography, and Radioscopy.~~	~~Accessible annular plate welds and shell butt welds or at the owner's discretion.~~	~~The surface to be examined needs to be accessible from both sides. Discrepancies must be suitably aligned with the radiation beam in order to be reliably detected. Creating the image and the interpretation needs to be accomplished by experienced individuals. Radiation exposure to individuals is a hazard and they must be included in a monitoring program. It is a relatively expensive testing method. Perform prior to erecting shell. SNT-TC-1A Level II NDE personnel are required.~~

TABLE 1 *Continued*

Procedure	General Description of Procedure	General Application	Thresholds, Results, and Limitations
Evaluation by Radiography Examination	A non-destructive method for inspection of welds that provides information about the internal condition using radiation. The radiation is directed at the weld and either penetrates, is absorbed, or scatters and is then recorded on film or digitally. There are two recognized methods of conducting radiography: Film/Paper Radiography, and Digital Radiography.	Accessible annular plate welds and shell butt welds or at the owner's discretion.	The surface to be examined needs to be accessible from both sides. Discrepancies must be suitably aligned with the radiation beam in order to be reliably detected. Creating the image and the interpretation needs to be accomplished by experienced individuals. Radiation exposure to individuals is a hazard and they must be included in a monitoring program. It is a relatively expensive testing method. Perform prior to erecting shell. SNT-TC-1A Level II NDE personnel are required.
~~7.6Evaluation by Wicking Examination of Corner Weld~~	~~Apply highly penetrating oil or dye penetrant to opposite side of first weld pass, and let stand for a period of time. Observe the welded side of the joint.~~	~~Shell to bottom plate weld.~~	~~Accessibility to viewing, cleanliness of weld area, and visual acuity of individual performing the test.~~ ~~Perform in dry conditions. Test must be performed when ambient temperature is high enough to allow the oil or dye penetrant to flow.~~ ~~Apply dye penetrant or highly penetrating oil to opposite side of first weld pass. Let sit for a minimum of 4 h (12 h is the preferred length of time). Observe the weld side of the joint.~~ ~~Identifies through weld pinholes, porosity, and cracks not visible to the eye.~~ ~~Identifies a leak that passes oil instead of air.~~
Evaluation by Wicking Examination of Corner Weld	Apply highly penetrating oil or dye penetrant to opposite side of first weld pass, and let stand for a period of time. Observe the welded side of the joint.	Shell to bottom plate weld.	Accessibility to viewing, cleanliness of weld area, and visual acuity of individual performing the test. Perform in dry conditions. Test must be performed when ambient temperature is high enough to allow the oil or dye penetrant to flow. Apply dye penetrant or highly penetrating oil to opposite side of first weld pass. Let sit for a minimum of 4 h (12 h is the preferred length of time). Observe the weld side of the joint. Identifies through weld pinholes, porosity, and cracks not visible to the eye. Identifies a leak that passes oil instead of air.
~~7.7 Evaluation by Bubble Test Examination (Pressure)~~	~~Pressure method locates leaks in a pressurized component by the application of a solution or immersion in liquid that will form bubbles as leakage gas passes through it.~~	~~Tank floor fillet welded lapped seams, butt welded seams, and shell to bottom weld.~~	~~Limited to small tanks or parts of tanks.~~ ~~For visual plus training on the specific procedure used by the manufacturer or fabricator. Training to meet the requirements of SNT-TC-1A.~~
Evaluation by Bubble Test Examination (Pressure)	Pressure method locates leaks in a pressurized component by the application of a solution or immersion in liquid that will form bubbles as leakage gas passes through it.	Tank floor fillet welded lapped seams, butt welded seams, and shell to bottom weld.	Limited to small tanks or parts of tanks. For visual plus training on the specific procedure used by the manufacturer or fabricator. Training to meet the requirements of SNT-TC-1A.

TABLE 1 *Continued*

Procedure	General Description of Procedure	General Application	Thresholds, Results, and Limitations
~~7.8 Evaluation by Bubble Test Examination (Vacuum)~~	~~Apply solution and a vacuum to a localized area.~~	~~Tank floor fillet welded lapped seams, butt welded seams, and shell to bottom weld.~~	~~Accessibility requires minimum clearance of 15.3 cm (6 in.) between bottom plate and obstruction above test area for placement of device and viewing. Perform test in accordance with a written procedure and ASME BPVC, Section V, Art. 10 App II. Individuals performing the test require visual acuity and training to meet requirements of SNT-TC-1A.~~
Evaluation by Bubble Test Examination (Vacuum) Vacuum box technique.	Apply solution and a vacuum to a localized area.	Tank floor fillet welded lapped seams, butt welded seams, and shell to bottom weld.	Accessibility requires minimum clearance of 12.3 cm (6 in.) between bottom plate and obstruction above test area for placement of device and viewing. Perform test in accordance with a written procedure and ASME BPVC, Section V, Art. 10 App II. Individuals performing the test require visual acuity and training to meet requirements of SNT-TC-1A.
~~7.9~~Evaluation by Liquid Penetrant	~~Apply penetrant to welds in the tank floor. Discontinuities in the weld such as cracks or voids that are open to the surface will draw in the penetrant. Any discontinuities should show up against the developed background.~~	~~This applies to welds in the tank floor including the shell to bottom weld. May be most useful in areas where other physical weld checks cannot be done due to access limitations.~~	~~Acceptance Criteria: No recognizable indications that might indicate a through plate defect. Discontinuities must extend to the surface, and be accessible. The weld must be clean and free of dirt, grease, lint, scale, flux, and weld spatter, and so forth. The weld must be uncoated. Individual performing the procedure should have natural or corrected near distance acuity vision to read a Jaeger Type 2 standard chart and have the ability to distinguish color during the observation of the tested weld. Individual should be a Level II or Level III certification in accordance with SNT-TC-1A. Perform test in accordance with a written procedure and ASME BPVC, Section V, Art. 6 or Test Methods E165, E1209, E1219, and E1220.~~
Evaluation by Liquid Penetrant	Apply penetrant to welds in the tank floor. Discontinuities in the weld such as cracks or voids that are open to the surface will draw in the penetrant. Any discontinuities should show up against the developed background.	This applies to welds in the tank floor including the shell to bottom weld. May be most useful in areas where other physical weld checks cannot be done due to access limitations.	Acceptance Criteria: No recognizable indications that might indicate a through plate defect. Discontinuities must extend to the surface, and be accessible. The weld must be clean and free of dirt, grease, lint, scale, flux, and weld spatter, and so forth. The weld must be uncoated. Individual performing the procedure should have natural or corrected near distance acuity vision to read a Jaeger Type 2 standard chart and have the ability to distinguish color during the observation of the tested weld. Individual should be a Level II or Level III certification in accordance with SNT-TC-1A. Perform test in accordance with a written procedure and ASME BPVC, Section V, Art. 6 or Test Methods E165, E1209, E1219, and E1220.

TABLE 1 *Continued*

Procedure	General Description of Procedure	General Application	Thresholds, Results, and Limitations
~~7.10 Evaluation by Magnetic Particle Examination~~	~~The weld area to be inspected is magnetized and ferromagnetic particles placed on the weld. A pattern is formed and is deformed where discontinuities are present. The deformations are more distinguishable for discontinuities near the surface of the weld. A second test is conducted with the magnetic field perpendicular to the original test orientation as a way of picking up undetected discontinuities of the first test. The magnetic particles are color contrasted or made viewable in fluorescent or black light.~~	~~Welds in the tank floor and sump including the shell to bottom weld. May be most useful in areas where other physical weld checks cannot be done due to access limitations.~~	~~Acceptance Criteria: No recognizable indications that might indicate a through plate defect. Discontinuities below the surface are difficult to detect and not all discontinuities are defects. The weld must be accessible and be clean and free of dirt, grease, lint, scale, flux, and weld spatter, etc. Generally the weld must not be coated. Time consuming. The individual performing the test should have natural or corrected vision distance acuity vision to read a Jaeger Type 2, Standard Chart. They should be Level II or III certified in accordance with SNT-TC-1A. Perform test in accordance with a written standard and ASME BPVC, Section V, Art. 7, or Guide E709.~~
Evaluation by Magnetic Particle Examination	The weld area to be inspected is magnetized and ferromagnetic particles placed on the weld. A pattern is formed and is deformed where discontinuities are present. The deformations are more distinguishable for discontinuities near the surface of the weld. A second test is conducted with the magnetic field perpendicular to the original test orientation as a way of picking up undetected discontinuities of the first test. The magnetic particles are color contrasted or made viewable in fluorescent or black light.	Welds in the tank floor and sump including the shell to bottom weld. May be most useful in areas where other physical weld checks cannot be done due to access limitations.	Acceptance Criteria: No recognizable indications that might indicate a through plate defect. Discontinuities below the surface are difficult to detect and not all discontinuities are defects. The weld must be accessible and be clean and free of dirt, grease, lint, scale, flux, and weld spatter, etc. Generally the weld must not be coated. Time consuming. The individual performing the test should have natural or corrected vision distance acuity vision to read a Jaeger Type 2, Standard Chart. They should be Level II or III certified in accordance with SNT-TC-1A. Perform test in accordance with a written standard and ASME BPVC, Section V, Art. 7, or Guide E709.
~~7.11 Evaluation by Detectable Gas-Beneath Floor Injection~~	~~Testing of tank bottoms using detectable gas beneath the tank floor is accomplished by injecting a detectable gas, which is lighter than air, beneath the tank floor in adequate quantity to allow dispersal over the entire underside of the floor. A common gas used for this application is welding grade helium. The floor is then scanned with leak detection equipment.~~	~~One hundred percent of all floor plate welds, floor to shell weld, patch plate welds, clip attachment welds, sump welds, weld scars, tear-offs, or other defects away from weld seams should be tested. Special attention should be paid to three plate laps and areas of severe bulges or deformations.~~	~~If the subsurface of the floor or interstitial space is below the water table or saturated with water/product/ liquid, the dispersal of detectable gas along the bottom side of the floor plates may be restricted or impossible. Method of floor construction must be considered. If the floor is anchored to a concrete pad, such as in a cut and cover or bunkered tank, compartmentalization of floor plates or floor sections may exist. In this circumstance, it may be necessary to drill numerous holes in a floor to ensure complete dispersion on the underside. In addition, there is a risk of floor damage and failure of tank floor anchoring system from excessive pressure. This method of testing can detect leak paths smaller than can be detected by vacuum box testing because of its greater sensitivity. Also this method is useful for testing areas of a tank that normally would not be accessible by other methods and the general area of a tank bottom in addition to the welds. As a result of its sensitivity, the procedure should be conducted with individuals possessing a higher level of expertise.~~

TABLE 1 *Continued*

Procedure	General Description of Procedure	General Application	Thresholds, Results, and Limitations
Evaluation by Detectable Gas-Beneath Floor Injection	Testing of tank bottoms using detectable gas beneath the tank floor is accomplished by injecting a detectable gas, which is lighter than air, beneath the tank floor in adequate quantity to allow dispersal over the entire underside of the floor. A common gas used for this application is welding grade helium. The floor is then scanned with leak detection equipment.	One hundred percent of all floor plate welds, floor to shell weld, patch plate welds, clip attachment welds, sump welds, weld scars, tear-offs, or other defects away from weld seams should be tested. Special attention should be paid to three plate laps and areas of severe bulges or deformations.	If the subsurface of the floor or interstitial space is below the water table or saturated with water/ product/ liquid, the dispersal of detectable gas along the bottom side of the floor plates may be restricted or impossible. Method of floor construction must be considered. If the floor is anchored to a concrete pad, such as in a cut and cover or bunkered tank, compartmentalization of floor plates or floor sections may exist. In this circumstance, it may be necessary to drill numerous holes in a floor to ensure complete dispersion on the underside. In addition, there is a risk of floor damage and failure of tank floor anchoring system from excessive pressure. This method of testing can detect leak paths smaller than can be detected by vacuum box testing because of its greater sensitivity. Also this method is useful for testing areas of a tank that normally would not be accessible by other methods and the general area of a tank bottom in addition to the welds. As a result of its sensitivity, the procedure should be conducted with individuals possessing a higher level of expertise.
~~7.12 Evaluation by Detectable Gas Above Floor in Liquid as Inoculate~~	~~Testing of tank bottoms using detectable tracer chemical (inoculate) inside is accomplished by injecting a volatile chemical into the receipt line or water draw off line at a concentration of 1 to 10 parts per million (ppm). Inoculate may be injected in gaseous form into an empty tank. Hollow tubes are installed under the tank bottom to extract air samples for analysis. A tank with a secondary containment bottom may have suitable detection tubes.~~	~~The entire tank floor is tested so long as detection tubes provide adequate coverage of the tank bottom.~~	~~If the subsurface of the floor or interstitial space is below the water table or saturated with water/ product/ liquid, two options are available: (1) De-watering or purging prior to sample collection or, (2) Extension of waiting time for migration of tracer in the liquid up to 60 days depending upon conditions and tank size.~~
Evaluation by Detectable Gas Above Floor in Liquid as Inoculate	Testing of tank bottoms using detectable tracer chemical (inoculate) inside is accomplished by injecting a volatile chemical into the receipt line or water draw off line at a concentration of 1 to 10 parts per million (ppm). Inoculate may be injected in gaseous form into an empty tank. Hollow tubes are installed under the tank bottom to extract air samples for analysis. A tank with a secondary containment bottom may have suitable detection tubes.	The entire tank floor is tested so long as detection tubes provide adequate coverage of the tank bottom.	If the subsurface of the floor or interstitial space is below the water table or saturated with water/ product/ liquid, two options are available: (*1*) De-watering or purging prior to sample collection or, (*2*) Extension of waiting time for migration of tracer in the liquid up to 60 days depending upon conditions and tank size.
~~7.13.2.1 (1) Evaluation by Volumetric Level and Temperature Measurement (A Developing Technology)~~	~~Determines leaks in the tank floor by tracking how a level of liquid in a full tank changes over time while accounting for natural variations from product and tank temperature changes, product evaporation, and condensation, and so forth.~~	~~Entire tank floor, including plate, sumps and their welds.~~	~~This is a developing technology—See Section 7, Evaluation Methods.~~

TABLE 1 *Continued*

Procedure	General Description of Procedure	General Application	Thresholds, Results, and Limitations
Evaluation by Volumetric Level and Temperature Measurement	Determines leaks in the tank floor by tracking how a level of liquid in a full tank changes over time while accounting for natural variations from product and tank temperature changes, product evaporation, and condensation, and so forth.	Entire tank floor, including plate, sumps and their welds.	
~~7.13.2.1 (2) Evaluation by Mass Measurement (A Developing Technology)~~	~~Determines leaks in the tank floor by tracking the amount of pressure exerted by the product in the tank, while accounting for natural variations from tank temperature changes, product evaporation, and condensation, and so forth.~~	~~Entire tank floor, including plate, sumps and their welds.~~	~~This is a developing technology — See Section 7, Evaluation Methods.~~
Evaluation by Mass Measurement	Determines leaks in the tank floor by tracking the amount of pressure exerted by the product in the tank, while accounting for natural variations from tank temperature changes, product evaporation, and condensation, and so forth.	Entire tank floor, including plate, sumps and their welds.	
~~7.14 Evaluation by Acoustic Emission Examination (A developing technology)~~	~~The test detects and locates leaks in a tank bottom by measuring the impulsive (intermittent) and repetitive sound of liquid escaping through a small leak path, while the tank is under a hydraulic load. It uses sensors around the shell to detect the sound in conjunction with data collectors/converters to produce an electronic signal, which can be analyzed by algorithms to indicate the location of a possible leak path. The duration of field measurements is normally less than 4 h.~~	~~Floor plates (parent material), weld joints between the plates, sump(s), and their weld joints, all of which bear on a sand or similar type foundation.~~	~~Type of soil and its porosity effect the frequency of the impulse. The degree of saturation with water or liquid effects the frequency of the signal. Internal and external noise. Tank linings may mask results by obstructing the leak path. This is a developing technology.~~ ~~In general, clusters of dots on a tank map are an indicator of a possible leak, while random dots are allowances needed by the algorithm-sensor testing setup. The procedure should successfully detect 0.5 mm hole during development and field verification.~~
Evaluation by Acoustic Emission Examination	The test detects and locates leaks in a tank bottom by measuring the impulsive (intermittent) and repetitive sound of liquid escaping through a small leak path, while the tank is under a hydraulic load. It uses sensors around the shell to detect the sound in conjunction with data collectors/converters to produce an electronic signal, which can be analyzed by algorithms to indicate the location of a possible leak path. The duration of field measurements is normally less than 4 h.	Floor plates (parent material), weld joints between the plates, sump(s), and their weld joints, all of which bear on a sand or similar type foundation.	Type of soil and its porosity effect the frequency of the impulse. The degree of saturation with water or liquid effects the frequency of the signal. Internal and external noise. Tank linings may mask results by obstructing the leak path. In general, clusters of dots on a tank map are an indicator of a possible leak, while random dots are allowances needed by the algorithm-sensor testing setup. The procedure should successfully detect 0.5 mm hole during development and field verification.

6.5 When using information provided in this section, considerations for schedule, operational, economic, and environmental characterizations should be reviewed. An owner and operator or the owners' and operators' representative should be familiar with conditions under which the tests and procedures

can be used and in the case of the developing technologies, API 334 should be consulted.