AMERICAN PETROLEUM INSTITUTE

Date: August 2010

To: Purchasers of API Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*, Fourth Edition

Re: Addendum 1

This package contains Addendum 1 of API Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*, Fourth Edition. This package consists of the pages that have changed since the April 2009 printing the Fourth Edition.

To update your copy of API Standard 653, replace, delete, or add the following pages as indicated:

Part of Book Changed	Old Pages to be Replaced	New Pages
Cover	front and back covers	front and back covers
Front Matter	title page – ii	title page – ii
TOC	vii – viii	vii – viii
Section 1	1-1 – 1-2	1-1 – 1-2
Section 2	2-1 – 2-2	2-1 – 2 – 2
Section 3	3-3 – 3-4	3-3 – 3-4
Section 4	4-9 – 4-10	4-9 – 4-10
Section 9	9-7 – 9-10	9-7 – 9-10
	9-13 – 9-16	9-13 – 9-16
Section 11	11-3 +blank	11-3 + blank
Section 12	12-3 – 12-4	12-3 – 12-4
Section 13	13-1 – 13-4	13-1 – 13-4
Annex S	S-1 – S-2	S-1 – S-2
Annex SC	none	SC-1 – SC-2
Annex X	none	X-1 – X-2

The parts of the text, tables, and figures that contain changes are indicated by a vertical bar and a small "10" in the margin.

Tank Inspection, Repair, Alteration, and Reconstruction

API STANDARD 653
FOURTH EDITION, APRIL 2009

ADDENDUM 1, AUGUST 2010

Tank Inspection, Repair, Alteration, and Reconstruction

Downstream Segment

API STANDARD 653
FOURTH EDITION, APRIL 2009

ADDENDUM 1, AUGUST 2010

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[text deleted]

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Portions of this publication have been changed from the previous edition. The locations of changes have been marked with a bar in the margin, as shown to the left of this paragraph. In some cases the changes are significant, while in other cases the changes reflect minor editorial adjustments such as renumbering of a section/subsection or figure/table (the references *within the text* that have been subsequently updated are not marked). The bar notations in the margins are provided as an aid to users, but API makes no warranty as to the accuracy of such bar notations.

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, D.C. 20005, standards@api.org.

Contents

Page

Figures

Tables

Page

Tank Inspection, Repair, Alteration, and Reconstruction

1 Scope

1.1 Introduction

1.1.1 This standard covers steel storage tanks built to API 650 and its predecessor API 12C. It provides minimum requirements for maintaining the integrity of such tanks after they have been placed in service and addresses inspection, repair, alteration, relocation, and reconstruction.

1.1.2 The scope is limited to the tank foundation, bottom, shell, structure, roof, attached appurtenances, and nozzles to the face of the first flange, first threaded joint, or first welding-end connection. Many of the design, welding, examination, and material requirements of API 650 can be applied in the maintenance inspection, rating, repair, and alteration of in-service tanks. In the case of apparent conflicts between the requirements of this standard and API 650 or its predecessor API 12C, this standard shall govern for tanks that have been placed in service.

1.1.3 This standard employs the principles of API 650; however, storage tank owner/operators, based on consideration of specific construction and operating details, may apply this standard to any steel tank constructed in accordance with a tank specification.

1.1.4 This standard is intended for use by organizations that maintain or have access to engineering and inspection personnel technically trained and experienced in tank design, fabrication, repair, construction, and inspection.

1.1.5 This standard does not contain rules or guidelines to cover all the varied conditions which may occur in an existing tank. When design and construction details are not given, and are not available in the as-built standard, details that will provide a level of integrity equal to the level provided by the current edition of API 650 must be used.

1.1.6 This standard recognizes fitness-for-service assessment concepts for evaluating in-service degradation of pressure containing components. API 579-1/ASME FFS-1, *Fitness-For-Service*, provides detailed assessment procedures or acceptance criteria for specific types of degradation referenced in this standard. When this standard does not provide specific evaluation procedures or acceptance criteria for a specific type of degradation or when this standard explicitly allows the use of fitness-for-service criteria, API 579-1/ASME FFS-1 may be used to evaluate the various types of degradation or test requirements addressed in this standard. 10

1.2 Compliance with This Standard

The owner/operator has ultimate responsibility for complying with the provisions of this standard. The application of this standard is restricted to organizations that employ or have access to an authorized inspection agency as defined in 3.3. Should a party other than the owner/operator be assigned certain tasks, such as relocating and reconstructing a tank, the limits of responsibility for each party shall be defined by the owner/operator prior to commencing work.

1.3 Jurisdiction

If any provision of this standard presents a direct or implied conflict with any statutory regulation, the regulation shall govern. However, if the requirements of this standard are more stringent than the requirements of the regulation, then the requirements of this standard shall govern.

1.4 Safe Working Practices

An assessment shall be made of the potential hazards to which personnel may be exposed when conducting internal tank inspections, making repairs, or dismantling tanks. Procedures shall be developed according to the

guidelines given in API 2015, API 2016, and API 2217A that will include safeguard for personnel health and safety, prevention of accidental fires and explosions, and the prevention of property damage. Conformance to permit procedures is an essential safe work practice for protection of personnel and property.Where welding and hot work are involved, API 2009 states “Except in areas specifically designated as safe for hot work, a hot work permit shall be obtained before starting any work that can involve a source of ignition.”

Special procedures may need to be developed for certain activities described in this standard that are not fully covered by the referenced API publications; e.g. safety precautions for personnel accessing floating roof tanks that are in service, or gas freeing the bottom side of a tank. Appendix B of API 2009 provides brief information on inerting tanks. Use of inerting as a safety precaution should address personnel hazards introduced when using inert gas in the workplace and implementation should be done in consultation with specialists that are familiar with such processes. Finally, procedures must comply with any federal or state safety regulations pertaining to “confined spaces” or any other relevant provisions.

Section 2—References

2.1 Referenced Publications

The following standards, codes, publications, and specifications are cited in this standard. The latest edition or revision shall be used unless otherwise noted.

API Recommended Practice 579-1/ASME FFS-1, *Fitness-For-Service* 10

API Standard 620, *Design and Construction of Large, Welded, Low-pressure Storage Tanks*

API Standard 650, *Welded Tanks for Oil Storage*

API Recommended Practice 651, *Cathodic Protection of Aboveground Storage Tanks*

API Recommended Practice 652, *Lining of Aboveground Petroleum Storage Tank Bottoms*

API Standard 2000, *Venting Atmospheric and Low-pressure Storage Tanks: Nonrefrigerated and Refrigerated*

API Recommended Practice 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

API Recommended Practice 2009, *Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries* 10

API Standard 2015, *Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks*

API Recommended Practice 2016, *Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks*

API Publication 2201, *Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries*

API Publication 2207, *Preparing Tank Bottoms for Hot Work*

API Publication 2217A, *Guidelines for Safe Work in Inert Confined Spaces in the Petroleum and Petrochemical Industries*

ASME *Boiler and Pressure Vessel Code (BPVC)* [1], *Section V: Nondestructive Examination*

ASME *BPVC*, *Section VIII: Pressure Vessels; Division 2: Alternative Rules*

ASME *BPVC*, *Section IX: Welding and Brazing Qualifications*

ASNT SNT-TC-1A [2], *Personnel Qualification and Certification in Nondestructive Testing*

ASTM A6 [3], *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling*

ASTM A20, *Standard Specification for General Requirements for Steel Plates for Pressure Vessels*

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1 ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.
2 American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, Ohio, 43228-0518, www.asnt.org.
3 ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, www.astm.org.

ASTM A36, *Standard Specification for Carbon Structural Steel*

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A992, *Standard Specification for Structural Steel Shapes*

AWS D1.1 [4], *Structural Welding Code—Steel*

AWS D1.6, *Structural Welding Code—Stainless Steel*

10 NACE Standard RP 0205-2005 [5], *Recommended Practice for teh Design, Fabrication, and Inspection of Tanks for the Storage of Petroleum Refining Alkylation Unit Spent Sulfuric Acid at Ambient Temperatures*

2.2 Other References

Although not cited in this standard, the following publication may be of interest.

API Standard 2610, *Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities*

10 ANSI/AWS Z49.1, *Safety in Welding and Cutting and Allied Processes*

[4] American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33135, www.aws.org.
[5] NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, www.nace.org.

d) removing or replacing annular plate ring material where the longest dimension of the replacement plate exceeds 12 in.;

e) complete or partial (more than one-half of the weld thickness) removal and replacement of more than 12 in. of vertical weld joining shell plates or radial weld joining the annular plate ring;

f) installing a new bottom;

NOTE Installation of a portion of a new bottom as described in 12.3.3.3 is not defined as a major repair. 10

g) removing and replacing part of the weld attaching the shell to the bottom, or to the annular plate ring, in excess of the amounts listed in 12.3.2.5.1 a);

h) jacking a tank shell.

3.19
owner/operator
The legal entity having both control of and/or responsibility for the operation and maintenance of an existing storage tank.

3.20
product-side
The side of the tank that is in contact with the stored liquid product.

3.21
recognized toughness
A condition that exists when the material of a component is deemed acceptable for use by the provisions of any of the following sections of this standard:

a) Section 5.3.2 (based on edition of standard of tank's original construction, or by coupon testing);

b) Section 5.3.5 (based on thickness);

c) Section 5.3.6 (based on lowest design metal temperature);

d) Section 5.3.8 (based on exemption curves).

3.22
reconstruction
Any work necessary to reassemble a tank that has been dismantled and relocated to a new site.

3.23
reconstruction organization
The organization having assigned responsibility by the owner/operator to design and/or reconstruct a tank.

3.24
repair
Work necessary to maintain or restore a tank to a condition suitable for safe operation. Repairs include both major repairs (see 3.18) and repairs that are not major repairs. Examples of repairs include:

a) removal and replacement of material (such as roof, shell, or bottom material, including weld metal) to maintain tank integrity;

b) re-leveling and/or jacking of a tank shell, bottom, or roof;

c) adding or replacing reinforcing plates (or portions thereof) to existing shell penetrations;

d) repair of flaws, such as tears or gouges, by grinding and/or gouging followed by welding.

3.25
repair organization
An organization that meets any of the following:

a) an owner/operator of aboveground storage tanks who repairs or alters his/her own equipment in accordance with this standard;

b) a contractor whose qualifications are acceptable to the owner/operator of aboveground storage tanks and who makes repairs or alterations in accordance with this standard;

c) one who is authorized by, acceptable to, or otherwise not prohibited by the jurisdiction, and who makes repairs in accordance with this standard.

3.26
similar service assessment
The process by which corrosion rates and inspection intervals are established for a candidate tank using corrosion rates and service history from a control tank for the purpose of establishing the next inspection date.

3.27
soil-side
The side of the tank bottom that is in contact with the ground.

3.28
storage tank engineer
One or more persons or organizations acceptable to the owner/operator who are knowledgeable and experienced in the engineering disciplines associated with evaluating mechanical and material characteristics that affect the integrity and reliability of aboveground storage tanks. The storage tank engineer, by consulting with appropriate specialists, should be regarded as a composite of all entities needed to properly assess the technical requirements.

3.29
unknown toughness
A condition that exists when it cannot be demonstrated that the material of a component satisfies the definition of recognized toughness.

4.3.3.6 As an alternative to the procedures described above, any thinning of the tank shell below minimum required wall thickness due to corrosion or other wastage may be evaluated to determine the adequacy for continued service by employing the design by analysis methods defined in Section VIII, Division 2, Appendix 4 of the ASME Code; or API 579-1/ASME FFS-1, Section 4, Section 5 or Section 6, as applicable. When using the ASME criteria, the stress value used in the original tank design shall be substituted for the S_m value of Division 2, if the design stress is less than or equal to the lesser of $^2/_3Y$ (specified minimum yield strength) or $^1/_3T$ (specified minimum tensile strength). If the original design stress is greater than $^2/_3Y$ or $^1/_3T$, then the lesser of $^2/_3Y$ or $^1/_3T$ shall be substituted for S_m. 10 10

4.3.4 Minimum Thickness Calculation for Riveted Tank Shell

4.3.4.1 The minimum acceptable thickness for riveted tank shells shall be calculated using the equation in 4.3.3.1 except that the following allowable stress criteria and joint efficiencies shall be used:

S is 21,000 lbf/in.^{2};

E is 1.0 for shell plate 6 in. or more away from rivets. See Table 4.3 for joint efficiencies for locations within 6 in. of rivets.

4.3.4.2 The rivet joint efficiencies given in Table 4.3 are conservative minimums for riveted tank construction details and are included to simplify riveted tank evaluations. However, in some cases it may be advantageous to calculate the actual rivet joint efficiencies using computational methods applicable to lap and butt type riveted joints. When this alternative of calculated joint efficiencies is used, the following maximum allowable stresses shall apply:

a) for the maximum tensile stress in net section of plate, use the lesser of $0.80Y$ or $0.429T$; use 21,000 lbf/in.^{2} if T or Y is unknown;

b) for the maximum shear in net section of rivet, use 16,000 lbf/in.^{2};

c) for the maximum bearing stress on plates or rivets, use 32,000 lbf/in.^{2} for rivets in single shear, and 35,000 lbf/in.^{2} for rivets in double shear.

4.3.4.3 For tanks with riveted joints, consideration shall be given to whether, and to what extent, corrosion affects such joints. If calculations show that excess thickness exists, this excess may be taken as corrosion allowance.

4.3.4.4 Non-liquid loads (see 4.3.3.5) shall also be considered in the analysis of riveted tanks.

4.3.5 Distortions

4.3.5.1 Shell distortions include out-of-roundness, buckled areas, flat spots, and peaking and banding at welded joints.

4.3.5.2 Shell distortions can be caused by many conditions such as foundation settlement, over- or under-pressuring, high wind, poor shell fabrication, or repair techniques, and so forth.

4.3.5.3 Shell distortions shall be evaluated on an individual basis to determine if specific conditions are considered acceptable for continuing tank service and/or the extent of corrective action.

4.3.6 Flaws

Flaws such as cracks or laminations shall be thoroughly examined and evaluated to determine their nature and extent and need for repair. If a repair is needed, a repair procedure shall be developed and implemented. The requirement for repairing scars such as arc strikes, gouges, or tears from temporary attachment welds must be evaluated on a case-by-case basis. Cracks in the shell-to-bottom weld shall be removed.

Table 4.3—Joint Efficiencies for Riveted Joints

Type of Joint	Number of Rivet Rows	Joint Efficiency *E*
Lap	1	0.45
Lap	2	0.60
Lap	3	0.70
Lap	4	0.75
Butt [a]	2 [b]	0.75
Butt	3 [b]	0.85
Butt	4 [b]	0.90
Butt	5 [b]	0.91
Butt	6 [b]	0.92

[a] All butt joints listed have butt straps both inside and outside.
[b] Number of row on each side of joint center line.

4.3.7 Wind Girders and Shell Stiffeners

The evaluation of an existing tank shell for suitability for service must also consider the details and condition of any wind girders or shell stiffeners. Degradation by corrosion of these structural elements or their attachment welds to the shell may render these elements inadequate for the design conditions.

4.3.8 Shell Welds

10 The condition of the tank shell welds shall be evaluated for suitability for service using criteria from this standard, the as-built standard, or fitness-for-service assessment. Any flaws or deterioration such as corrosion or pitting of the existing welds shall be evaluated. If necessary, appropriate repair procedures shall be established or the tank safe fill height reassessed. Some typical shell butt-welded flaws and recommended procedures for repairs are given in 9.6.

4.3.9 Shell Penetrations

4.3.9.1 The condition and details of existing shell penetrations (nozzles, manways, cleanout openings, etc.) shall be reviewed when assessing the integrity of an existing tank shell. Details such as type and extent of reinforcement, weld spacing, and thickness of components (reinforcing plate, nozzle neck, bolting flange, and cover plate), are important considerations and shall be reviewed for structural adequacy and compliance with the as-built standard. Existing welds on the tank shell that are not to be modified or affected by repairs and are closer than required by API 650 (Seventh Edition or later) are acceptable for continued service if the welds are examined by the magnetic particle method and have no rejectable defects or indications. Grinding to eliminate weld defects is permissible if the resulting profile satisfies base thickness and weld size requirements. Weld repairs may not be used to accept weld spacings closer than permitted by API 650 (Seventh Edition or later) except as permitted by 9.10.2.7. Any other noncompliance, or deterioration due to corrosion, must be assessed and repair procedures established where appropriate or the tank re-rated, as necessary.

4.3.9.2 Nozzle wall thickness shall be evaluated for pressure and all other loads.

4.3.10 Operation at Elevated Temperatures

Tanks of welded construction that operate at elevated temperatures (exceeding 200 °F, but less than 500 °F) shall be evaluated for suitability of service. The requirements of this section are based in part on the requirements of API 650, Appendix M.

9.7.3 As an alternative, the reinforcing plates may be added to the inside of the tank provided that sufficient nozzle projection exists.

9.8 Addition or Replacement of Shell Penetrations

9.8.1 New shell penetrations (addition or replacement) shall be in accordance with material, design, and stress relief requirements of API 650 and in accordance with 9.8.2 through 9.8.6 of this standard.

9.8.2 The required penetration reinforcement area of API 650, Section 5.7.2, shall be determined using the required shell thickness calculated by the equation in 4.3.3.1 b) of this standard except the variable S shall be the allowable design stress from Table 5-2 of API 650 for the existing shell plate; use 20,000 lbf/in.^{2} if of unknown material. A joint efficiency of 1.0 may be used (see 9.8.5). The variable H shall be the height from the centerline of the penetration to the maximum liquid level, in ft.

9.8.3 Penetrations shall be prefabricated in thermally stress relieved insert assemblies when required by API 650, Section 5.7.4. API 650, Section 4.1.5, may be used when reinforcing material is from API 650 Group-IV through Group-VI and the existing shell is a Group-I through Group-IIIA material.

9.8.4 The following erection requirements shall be met:

a) if an integral reinforcement design is used, the insert plate at its periphery shall have a 1:4 reduction taper to match the shell plate thickness when the insert plate exceeds the shell plate thickness by more than $^1/_8$ in.;

b) spacing of welds shall be in accordance with Figure 9.1;

c) the new insert plate shall be joined to existing shell plate with full penetration and full fusion butt welds.

9.8.5 Examinations shall be per Section 12, except penetrations located on a shell joint shall receive additional shell radiography in accordance with API 650, Section 5.7.3.

9.8.6 Penetrations larger than 2 in. NPS shall be installed with the use of an insert plate if the shell plate thickness is greater than $^1/_2$ in. and the shell plate material does not meet the current design metal temperature criteria. In addition, the following requirement shall be met:

a) the minimum diameter of the insert plate shall be at least twice the diameter of the penetration or the diameter plus 12 in., whichever is greater;

b) when reinforcing plates are used, the minimum diameter of the insert plate shall equal the diameter of the reinforcing plate plus 12 in.

9.9 Alteration of Existing Shell Penetrations

9.9.1 Existing shell penetrations may be altered if the altered details comply with the requirements of API 650, including the requirements for minimum reinforcing area and the requirements for spacing of welds around connections.

9.9.2 When installing a new tank bottom above the existing bottom, it may be necessary to alter existing shell penetrations in the bottom course of a tank shell. If the new bottom is slotted through the tank shell several inches above the existing bottom, the spacing between existing welds around penetrations and the new bottom-to-shell weld may not comply with API 650 requirements. Options for altering the penetrations and/or reinforcing plates are given in 9.9.2.1 through 9.9.2.3.

9.9.2.1 The existing reinforcing plate may be trimmed to increase the spacing between the welds provided that the altered detail complies with the requirements of API 650. Care must be exercised during the trimming operation to

avoid damaging the shell material beneath the reinforcing plate. The existing weld attaching the portion of the reinforcing plate to be removed shall be completely removed by gouging and grinding.

10 **9.9.2.2** The existing reinforcing plate may be removed and a new reinforcing plate added except that reinforcing plate replacement is not permitted in existing stress relieved assemblies unless the requirements of 11.3 are met. If it is not known whether the assembly was thermally stressed relieved, then the alteration shall meet the requirements of API 650, Section 5.7.4. Care must be exercised when removing the existing reinforcing plate to avoid damaging the shell plate beneath the reinforcing plate. When the upper half of the existing reinforcing plate meets all requirements of API 650, it can be left in place with approval of the purchaser. In this case, only the lower half of the existing reinforcing plate need be removed and replaced with the new one. The existing upper half of the reinforcing plate and the new lower section shall be provided with new a telltale hole, if needed, or drilled hole, and a welded pipe coupling for the pneumatic test. The shell plate thickness under the telltale hole or drilled hole shall be checked after drilling and the thickness shall not be less than $^1/_2\ t_{min}$, as calculated in 4.3.3.1, plus any required corrosion allowance. The welds to be replaced around the perimeter of the reinforcing plate and between the reinforcing plate and neck of the penetration shall be completely removed by gouging and grinding. The new reinforcing plate shall be in accordance with Figure 9.3. If required to maintain weld spacing, a tombstone shaped reinforcing plate may be used (see Figure 9.4).

9.9.2.3 The existing penetration may be moved by cutting the section of the shell containing the fitting and reinforcing plate, and raising the entire assembly to the correct elevation (see Figure 9.5).

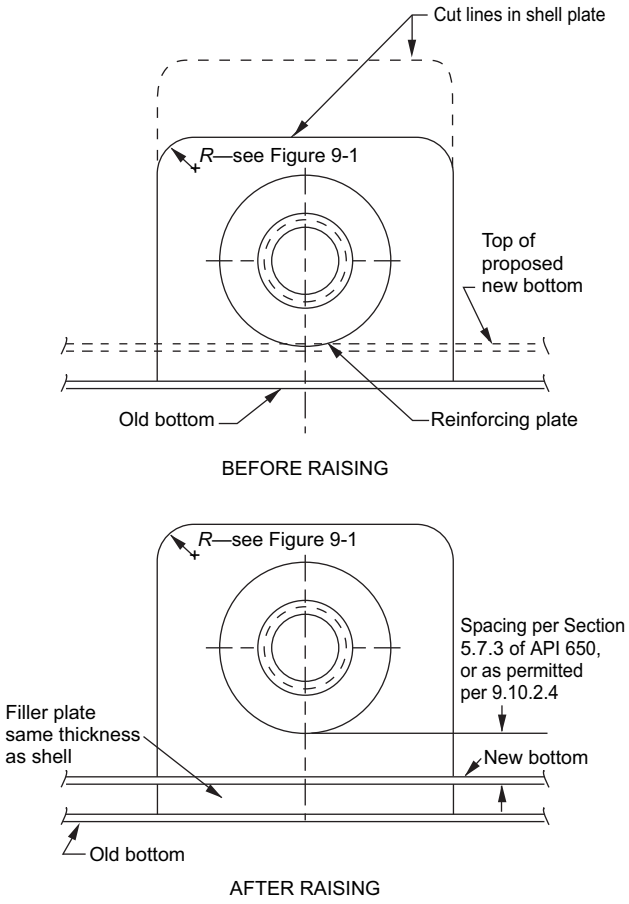
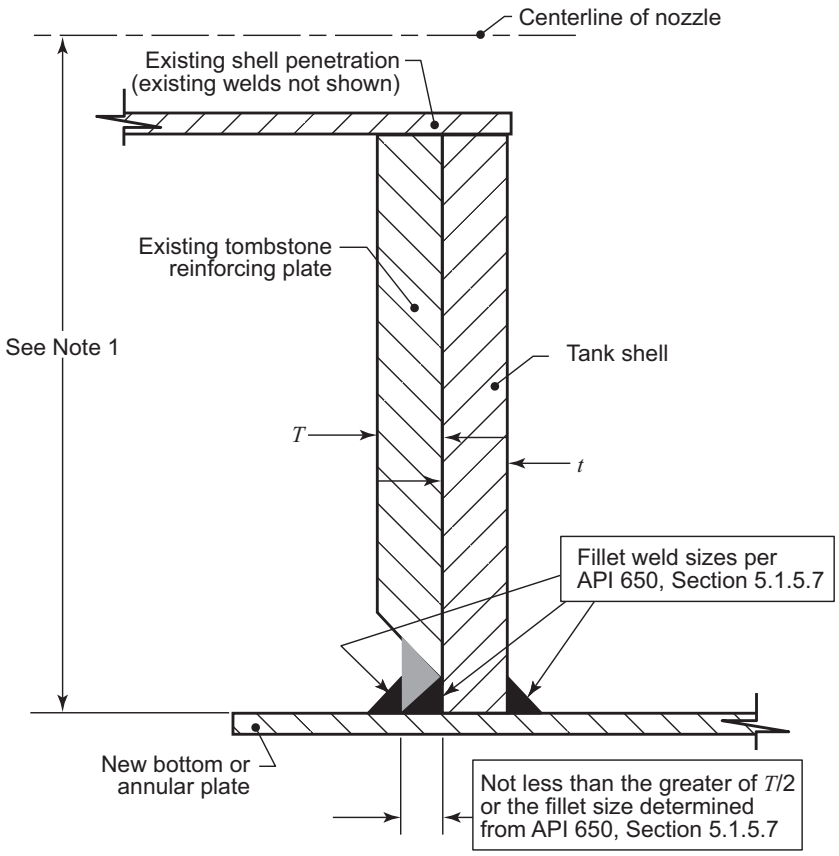


Figure 9.5—Method for Raising Shell Nozzles

9.9.3 Any components of the penetration (neck, flange, and reinforcing plate) that are in serviceable condition after removal may be reused.

9.9.4 A new bottom may be installed through an existing tombstone reinforcing plate, provided all weld spacing and reinforcement requirements, as specified in API 650, are met. One of the following methods shall be used.

a) Remove only that portion of the existing reinforcing plate necessary to weld and test the new bottom-to-shell weld. The lower edge of the reinforcing plate shall be cut reasonably straight and horizontal and beveled to facilitate welding. See Figure 9.6 for weld joint details.

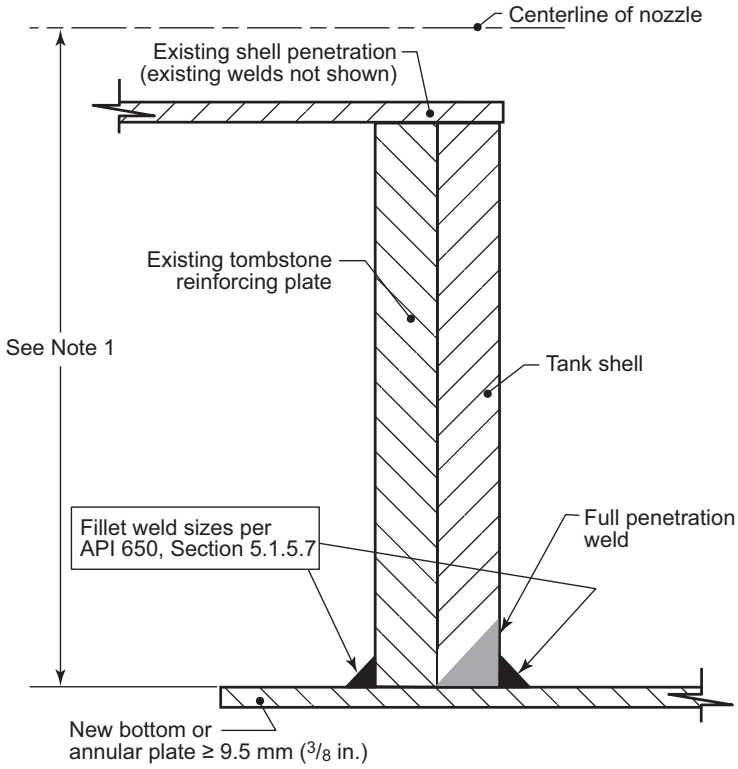


NOTE 1 In using this detail, it must be confirmed that the distance from top of new bottom to center of nozzle meets API 650, Table 5-6.

NOTE 2 All welds shown shall be individually examined to API 650, Section 7.2.4.

Figure 9.6—Details for Installing a New Bottom Through an Existing Tombstone Reinforcing Plate

b) Bevel the shell from the inside to allow for a full penetration weld between the bottom and shell. This method shall only be used on tanks where the annular plate or bottom sketch plate thickness is equal to or greater than 10 mm ($^3/_8$ in.). This weld detail shall be used along the full width of the reinforcing plate and shall extend a minimum of 25 mm (1 in.) beyond the edges of the reinforcing plate. Once beyond the reinforcing plate, the full penetration weld shall tie in to the outside shell-to-bottom fillet weld to create a “water stop” and then transition to the typical shell-to-bottom weld detail. See Figure 9.7 for weld joint details.



NOTE 1 In using this detail, it must be confirmed that the distance from top of new bottom to center of nozzle meets API 650, Table 5-6.

NOTE 2 All welds shown shall be individually examined to API 650, Section 7.2.4.

Figure 9.7—Details for Installing a New Bottom Through an Existing Tombstone Reinforcing Plate

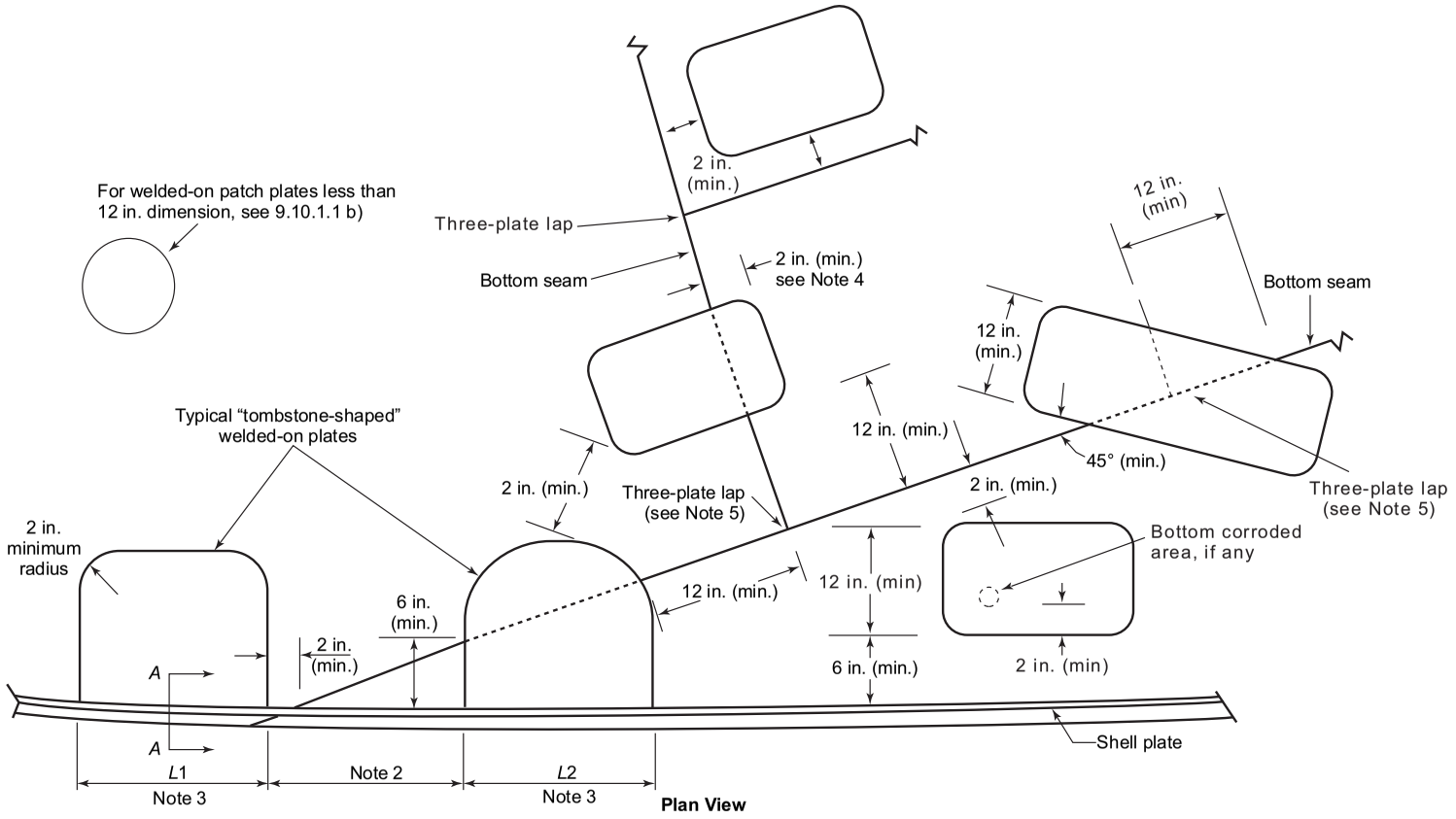
c) The bottom portion of the reinforcing plate may be removed using a horizontal cut between the bottom invert of the nozzle neck and the new bottom per requirements of Figure 9.8. The removed (or new) reinforcing plate shall be prepared for a full fusion splice weld with telltale hole added (see Figure 9.8). The removed (or new) reinforcing plate shall be re-installed after the shell-to-bottom weld has been completed, inspected, and tested. The splice weld shall be made prior to the reinforcing plate weld to bottom plate weld. The completed splice weld shall be magnetic particle examined.

d) The lower portion of the existing reinforcing plate may be removed and re-installed after the new shell-to-bottom weld is complete. The existing reinforcing plate shall be cut at the horizontal centerline of the nozzle. Telltale holes are required in both parts of the reinforcing plate (see Figure 9.4).

e) The existing reinforcing plate may be removed, modified and re-installed after the new shell-to-bottom weld is complete (see Figure 9.4).

10 NOTE 1 Options c) and d) are not permitted on existing post-weld heat treated nozzles unless the requirements of 11.3 are met.

NOTE 2 To minimize damage to the shell plate such that repairs can be made, care must be exercised when removing the existing reinforcing plate.



NOTE 1 Dimensions given are from toe of fillet welds or to centerline of butt-weld and also apply to new-to-existing welds.

NOTE 2 Minimum distance between two welded-on patch plates in the critical zone shall be one half of the lesser of *L*1 or *L*2.

NOTE 3 The maximum dimension along the shell for welded-on patch plates in the critical zone is 24 in.

NOTE 4 When the edge of a welded-on patch plate is approximately parallel to a bottom seam, the edge shall be held at least 2 in. from weld seam.

NOTE 5 Patches over three-plate laps shall extend a minimum of 12 in. in all directions along all laps beyond the three-plate lap.

NOTE 6 These rules apply to butt-welded bottoms, where applicable.

Figure 9.9—Typical Welded-on Patch Plates on Tank Bottom Plates

9.10.1.2.1 No welding or weld overlays are permitted within the critical zone except for the welding of: widely scattered pits (see 4.3.2.2), pinholes, cracks in the bottom plates, the shell-to-bottom weld, welded-on patch plates, or where the bottom plate welded to the shell is being replaced.

9.10.1.2.2 A welded-on patch plate shall not be used if the covered bottom plate minimum remaining thickness at the toe of the internal shell-to-bottom weld will be less than the minimum thickness required by 4.4.7 or 4.4.8 at the next internal inspection.

9.10.1.2.3 Welded-on patch plates are not permitted in the critical zone on a tank bottom with an operating temperature exceeding 200 °F for carbon steel or 100 °F for stainless steel.

9.10.1.2.4 If more extensive repairs are required within the critical zone than those listed in 9.10.1.2, the bottom plate welded to the shell shall be cut out and a new plate shall be installed. Weld spacing requirements shall be in accordance with 9.10.2.4, and API 650, Section 5.1.5.4 and Section 5.1.5.5. The shell-to-bottom weld shall be removed and replaced for a minimum distance of 12 in. on each side of the new bottom plate. 10

9.10.1.3 The use of welded-on patch plates that do not meet the requirements of 9.10.1.1 or 9.10.1.2 is permitted if the repair method has been reviewed and approved by an engineer experienced in storage tank design in accordance with API 650. The review shall consider brittle fracture, stress due to settlement, stress due to shell-bottom discontinuity, metal temperature, fracture mechanics, and the extent and quality of NDE.

9.10.1.4 Unacceptable indications such as cracks, gouges, tears, and corroded areas discovered in bottom plates, located outside the critical zone, may be repaired by deposition of weld metal followed by examination and testing in accordance with 12.1.7.3. Surface irregularities and contamination within the area to be repaired shall be removed before welding.

9.10.1.5 The repair of sumps located within the critical zone shall be in accordance with 9.10.1.2.

9.10.1.6 The repair of corroded plates in the critical zone is limited to pit welding or overlay welding as noted in this section. The weld repair of bottom plate corrosion is permitted if all of the following conditions are satisfied.

a) The sum of the pit dimensions along an arc parallel to the shell-to-bottom joint does not exceed 2 in. in an 8-in. length.

b) There must be sufficient remaining bottom plate thickness for completion of a sound weld and to avoid burn-through. The minimum acceptable bottom plate thickness for weld repairs is 0.10 in. A lesser thickness is permitted for weld repairs only if reviewed and approved by an engineer experienced in storage tank design and repair.

c) All weld repairs shall be ground flush with the surrounding plate material and be examined in accordance with 12.3.2.4.

9.10.2 Replacement of Tank Bottom Plates

9.10.2.1 Requirements governing the installation of a replacement bottom over an existing bottom are given in 9.10.2.1.1 through 9.10.2.1.5.

9.10.2.1.1 Suitable noncorrosive material cushion such as sand, gravel, or concrete shall be used between the old bottom and the new bottom.

9.10.2.1.2 The shell shall be slotted with a uniform cut made parallel to the tank bottom. The cut edges in the slot shall be ground to remove all slag and burrs from cutting operations. The new bottom plate shall extend outside the shell as required by API 650. All rules for weld spacing shall be followed.

9.10.2.1.3 Voids in the foundation below the old bottom shall be filled with sand, crushed limestone, grout, or concrete.

9.10.2.1.4 Except as permitted in 9.10.2.7, existing shell penetrations shall be raised or their reinforcing plates modified if the elevation of the new bottom results in inadequate nozzle reinforcement details (see Figure 9.4 and API 650, Section 5.7.2) or if the weld space requirements given in API 650, Section 5.7.3 are not met.

9.10.2.1.5 For floating roof tanks, the new bottom profile must keep the roof level when it is resting on its support legs. The levelness of the floating roof can be adjusted by changing the length of the support legs. The support legs can either remain the same length to maintain the original height above the bottom or be shortened by the same amount as the thickness of the cushion and new bottom plate.

9.10.2.2 New bearing plates for fixed roof support columns shall be installed. For steel floating roof legs, steel pads or other means shall be used to distribute the loads on the bottom of the tank and provide a wear surface. If pads are used, they shall be continuously welded to the tank bottom. For aluminum floating roofs, the pads may be omitted if the owner/operator approves and new austenitic stainless steel or acceptable non-metallic (e.g., Teflon) spacers are installed to isolate legs from the carbon steel bottom. For aluminum floating roofs, austenitic stainless steel or acceptable non-metallic (e.g., Teflon) spacers may installed to isolate legs from the carbon steel bottom instead of welded pads if the spacers will not damage bottom coatings, there is no evidence of corrosion damage from such spacers on the previous bottom, and if the owner/operator approves. 10

9.10.2.3 When removing an existing tank bottom, the tank shell shall be separated from tank bottom either by:

a) cutting the shell parallel to the tank bottom a minimum of $^1/_2$ in. above the bottom-to-shell weld (cut line B-B as shown in Figure 10.1), or

b) removing the entire shell-to-bottom attachment weld, including any penetration and heat affected zone by suitable methods such as arc gouging and/or grinding.

All arc-gouged areas of the tank shell-to-bottom weld shall be magnetic particle examined, and defective areas repaired and re-examined.

9.10.2.4 Installation of a new tank bottom, after removal of the existing tank bottom, shall meet all requirements of API 650. Except as permitted in 9.10.2.7, existing shell penetrations shall be raised or their penetration reinforcing plates modified if the elevation of the new bottom results in inadequate nozzle reinforcement (see Figure 9.4 and API 650, Section 5.7.2) or if the weld spacing requirements given in API 650, Section 5.7.3 are not met. For tanks with shell plate of unknown toughness as defined in Section 3, new weld joints in the bottom or annular ring shall be spaced at least the greater of 3 in. or 5t from existing vertical weld joints in the bottom shell course, where t is the thickness of the bottom shell course, in inches.

9.10.2.5 Replacement of portions of an existing tank bottom (entire rectangular plates or large segments of plates) not within the critical zone (see 3.10 for definition) are permitted under the same rules that govern installation of bottoms in new tank construction per API 650.

9.10.2.6 The following shall be considered for tanks with cathodic protection and under-bottom leak detection.

a) For tanks having cathodic protection (CP) installed under the existing bottom, consideration shall be given to removal of the entire bottom and unused dead shell to prevent shielding of CP current to the new bottom. Removal of the old bottom is also important in preventing galvanic corrosion (refer to API 651). Where this is possible, removal of the entire old bottom, except the unused dead shell and not more than 18 in. of bottom annulus attached to the shell, shall be considered.

b) Consideration shall be given to installing under-bottom leak detection at this time (such as a RPB) to contain and channel any bottom leak to a location where it can readily be observed from outside of the tank. See 4.4.3.5 and Footnote 5.

9.10.2.7 For tanks constructed from materials having 50,000 lbf/in.^{2} yield strength or less, existing shell penetrations need not be raised if the following conditions are met.

a) For reinforced penetrations, including low-types, a minimum of 4 in. shall be maintained between the shell-to-bottom weld toe and the nearest penetration attachment weld toe (reinforcing plate periphery weld, or nozzle neck weld to low type reinforcing plate and shell welds).

b) For self-reinforced penetrations, the greater of 3 in. or $2^1/_2t$ shall be maintained between the shell-to-bottom weld toe and the nearest penetration attachment weld toe.

c) The shell-to-bottom weld is to be welded with low hydrogen electrodes and with welding procedures that are designed to limit distortion and residual stress.

d) The toes of the welds shall be blend-ground to minimize stress concentrations as follows.

   i) For circular reinforcing plates, blend-grind the periphery attachment weld from the “four o'clock” position to the “eight o'clock” position. Blend-grind the inside and outside of the shell-to-bottom weld a minimum of one penetration diameter length on either side of the penetration centerline.

   ii) For diamond-shaped reinforcing plates, blend-grind the lower horizontal length of the diamond shaped attachment weld. Blend-grind the inside and outside of the shell-to-bottom weld a minimum of one penetration diameter length on either side of the penetration centerline.

   iii) For low-type penetrations, blend-grind the nozzle attachment weld (shell and reinforcing plate) from the “four o'clock” position to the “eight o'clock” position. Blend-grind the inside and outside of the shell-to-bottom weld a minimum of one penetration diameter length on either side of the penetration centerline.

e) The blend-ground lengths of welds listed in 9.10.2.1.7 d) shall be magnetic particle examined before and after hydrostatic test.

9.10.3 Additional Welded-on Plates

9.10.3.1 If other welded-on plates such as wear, isolation, striker, and bearing plates, are to be added to tank bottoms, they shall be installed in accordance with 9.10.1, and examined in accordance with 12.1.7. For these additional welded-on plates, if the lap weld spacing requirements as set forth in Figure 9.9 are not met, magnetic particle (MT) or liquid penetrant (PT) examination is required for the exposed welds or portions of welds failing to meet minimum spacing criteria. See Section 12 for acceptance requirements.

9.10.3.2 Welded-on plates that fall within the critical zone (see 3.10 for definition) shall be installed in accordance with 9.10.1.2 and comply with all of its requirements.

9.11 Repair of Fixed Roofs

9.11.1 Repairs

9.11.1.1 Roof repairs involving tank venting shall be made such that normal and emergency venting meet the requirements of API 650, Section 5.8.5.

9.11.1.2 Roof repairs involving modification of the roof structure and the frangible joint (if applicable) shall be in compliance with the requirements of API 650, Section 5.10.

3) The minimum preheat temperature for welding shall not be less than that used in the procedure qualification test.

4) The maximum inter-pass temperature for welding shall not be greater than that used in the procedure qualification test.

5) The preheat temperature shall be checked to assure that 100 mm (4 in.) of the material or four times the material thickness (whichever is greater) on each side of the weld joint will be maintained at the minimum temperature during welding. When the weld does not penetrate through the full thickness of the material, the minimum preheat temperature need only be maintained at a distance of 100 mm (4 in.) or four times the depth of the repair weld, whichever is greater, from the edge of each weld.

6) For the welding processes in 11.3.2 b), use only electrodes and filler metals that are classified by the filler metal specification with an optional supplemental diffusible-hydrogen designator of H8 or lower. When shielding gases are used with this process, the gas shall exhibit a dew point that is no higher than –50 °C (–60 °F). Surfaces on which welding is to performed shall be maintained in a dry condition during the welding and free of rust, mill scale and hydrogen-producing contaminants such as oil, grease and other organic materials.

7) The welding technique shall be a controlled-deposition, temper-bead or half-bead technique. The specific technique shall be used in the procedure qualification test.

8) For welds made by SMAW, after completion of welding and without allowing the weldment to cool below the minimum preheat temperature, the temperature of the weldment shall be raised to a temperature of 260 °C ± 30 °C (500 °F ± 50 °F) for a minimum period of two to four hours to assist out-gassing diffusion of any weld-metal hydrogen picked up during welding. This hydrogen bake-out treatment may be omitted provided the electrode used is classified by the filler metal specification with an optional supplemental diffusible-hydrogen designator of H4 (such as E7018-H4).

9) After the finished repair weld has cooled to ambient temperature, the final temper bead reinforcement layer shall be removed substantially flush with the surface of the base material.

11.4 Welding Safety

Welding shall conform to the permit and safety precautions of Section 1.4 of API 2009. Permits shall consider tank conditions in the hot-work areas which might release flammable vapors (such as perforation resulting from corrosion). 10

12.1.7.3 In addition to the requirements in 12.1.7.1, areas of bottom plate repaired by welding shall be examined by the magnetic particle method or the liquid penetrant method. In addition, the repaired area shall also be tested using a vacuum box and solution or a tracer gas and detector.

12.1.8 Shell Plate

12.1.8.1 Shell Plate Repairs by Weld Metal Deposit

Areas of shell plate to be repaired by welding shall be examined visually. In addition, shell plate areas repaired by welding shall be examined by the magnetic particle method (or the liquid penetrant method).

12.1.8.2 Shell Plate Repairs by Lap-welded Patches

The attachment welds of new lap-welded shell patches shall be visually examined, and shall be examined by either the magnetic particle or liquid penetrant methods.

12.1.9 Fixed Roofs

Newly welded roof joints and repairs shall be examined in accordance with API 650, Section 7.3.2.2 and Section 7.3.7.

12.1.10 Floating Roofs

12.1.10.1 Repair Work to Steel Floating Roofs

After repair work is complete:

a) perform a visual examination from the top and bottom side of the floating roof;
b) perform an air leak, vacuum box, penetrating oil, tracer gas, or other applicable non destructive test of the repaired welds (see Annex F).

As an alternative to Item b), conduct a flotation test of the repaired roof.

Examination and acceptance criteria for NDT shall be in accordance with 12.1.

12.2 Radiographs

12.2.1 Number and Location of Radiographs

The number and location of radiographs shall be in accordance with API 650 and the following additional requirements:

12.2.1.1 For vertical joints:

a) new replacement shell plates to new shell plates, no additional radiographs required, other than those required by API 650 for new construction;

b) new replacement shell plates to existing shell plates, one additional radiograph shall be taken in each joint;

c) repaired joints in existing shell plates shall have one additional radiograph taken in each joint.

12.2.1.2 For horizontal joints:

a) new replacement shell plates to new shell plates, no additional radiographs required, other than those required by API 650 for new construction;

b) new replacement shell plates to existing shell plates, one additional radiograph for each 50 ft of repaired horizontal weld;

c) repaired joints in existing shell plates shall have one additional radiograph taken for each 50 ft of repaired horizontal weld.

12.2.1.3 For intersections of vertical and horizontal joints:

a) new replacement shell plates to new shell plates, no additional radiographs required, other than those required by API 650 for new construction;

b) new replacement shell plates to existing shell plates, each intersection shall be radiographed;

c) all repaired intersections in existing shell plates shall be radiographed.

12.2.1.4 For reconstructed tanks, each butt-welded annular plate joint shall be radiographed in accordance with API 650.

12.2.1.5 For reconstructed tanks, radiographic inspection is required for 25 % of all junctions of new welds over existing seams.

The owner/operator shall, with the consent of the contractor, determine the extent of further inspection and repair that may be required.

Any further inspection or repair of existing welds will be handled by contractual agreement between the owner/operator and tank reconstruction contractor.

12.2.1.6 New and replaced shell plate and door sheet welds shall be radiographed. All junctions between repair and existing welds shall be radiographed. If defects are found, 100 % radiography shall be performed on the repaired weld.

12.2.1.6.1 For circular replacement plates, a minimum of one radiograph shall be taken regardless of thickness. When the circular replacement plate is located in a shell plate with thickness exceeding 1 in., the weld shall be fully radiographed.

12.2.1.6.2 For square and rectangular replacement plates, at least one radiograph shall be taken in a vertical joint, and at least one in a horizontal joint, and one in each corner. When the square or rectangular replacement plate is located in a shell plate with thickness exceeding 1 in., the vertical joints shall be fully radiographed.

12.2.1.7 The minimum diagnostic length of each radiograph shall be 6 in.

12.2.1.8 For penetrations installed using insert plates as described in 9.8.6, the completed butt welds between the insert plate and the shell plate shall be fully radiographed.

12.2.2 Acceptance Criteria for Existing Shell Plate to Shell Plate Welds

If the radiograph of an intersection between a new and old weld detects unacceptable welds by the current applicable standard, the existing welds shall be:

10 a) evaluated according to the as-built standard, or

b) evaluated using fitness-for-service assessment, or

c) repaired in accordance with 9.6.

12.2.3 Marking and Identification of Radiographs

12.2.3.1 Each film shall show an identification of the welder(s) making the weld. A weld map showing location of welds, weld number, radiograph number, welder identification, and grading of each weld is an acceptable alternative to this requirement.

Section 13—Marking and Recordkeeping

13.1 Nameplates

13.1.1 Reconstructed Tanks

13.1.1.1 Tanks reconstructed in accordance with this standard shall be identified by a corrosion-resistant metal nameplate similar to that shown in Figure 13.1. Letters and numerals not less than $^{5}/_{32}$ in. high shall be embossed, engraved, or stamped in the plate to indicate information as follows: 10

a) reconstructed to API 653;

b) edition and revision number;

c) year reconstruction was completed;

d) if known, the as-built standard and the year of original construction;

e) nominal diameter;

f) nominal shell height;

g) design specific gravity;

h) maximum permissible operating liquid level;

i) the name of the reconstruction contractor and the assigned serial number or contract number;

j) the owner/operator's tank number;

k) shell material for each shell course;

l) maximum operating temperature;

m) allowable stress used in calculations of each shell course.

13.1.1.2 The new nameplate shall be attached to the tank shell adjacent to the existing nameplate, if any. An existing nameplate shall be left attached to the tank. Nameplates shall be attached as specified in API 650.

13.1.2 Tanks Without Nameplates

13.1.2.1 At the owner's request a nameplate may be attached to a tank meeting the requirements in 13.1.2.2 through 13.1.2.4.

13.1.2.2 If information required to complete the nameplate as required by the as-built standard is available and traceable to the tank, a new Replacement Nameplate, similar to that shown in Figure 10-1 in API 650, may be attached under the direction of the Authorized Inspector. The new nameplate shall contain all of the information required by the as-built standard and be marked 'Replacement Nameplate.' 10

13.1.2.3 If information required to complete the nameplate as required by the as-built standard is not available, an 'Assessment Nameplate' may be attached under the direction of the Authorized Inspector, provided a suitability for service assessment is performed per API 653, Sections 4 and 5. The new nameplate shall contain the following information:

a) API Standard 653, *Assessment Nameplate*;

b) Owner's tank number;

c) the company performing the assessment;

d) the date the assessment was performed;

e) the date of the edition and the addendum number of API 653 used to perform the assessment;

f) the nominal diameter and nominal height, in meters (ft and in.);

g) the maximum capacity in m^3 (42-gallon barrels);

h) the liquid level in meters (ft. and in.) used to perform the assessment;

10 i) the specific gravity of the liquid used to perform the assessment;

j) the design metal temperature in °C (°F) used to perform the assessment;

k) the pressure and vacuum used to perform the assessment;

l) the maximum design temperature in °C (°F) used to perform the assessment;

m) the material specification, if known, for each shell course;

n) the allowable stress values in MPa (psi) used to perform the assessment;

o) the joint efficiency used to perform the assessment (see 4.3.3. or 4.3.4).

13.1.2.4 The nameplate shall be made of a corrosion resistant metal embossed, engraved, or stamped with letters and numerals not less than 4 mm ($^5/_{32}$ in.) high. Nameplates shall be attached as specified in API Std. 650. In addition, the nameplate shall be clearly marked as an API 653, *Assessment Nameplate*. Refer to Figure 13-2.

13.2 Recordkeeping

When a tank is evaluated, repaired, altered, or reconstructed in accordance with this standard, the following information, as applicable, shall be made a part of the owner/operator's records for the tank (see 6.8).

13.2.1 Calculations for:

a) component evaluation for integrity, including brittle fracture considerations (see Section 5);

b) re-rating (including liquid level);

c) repair and alteration considerations.

13.2.2 Construction and repair drawings.

13.2.3 Additional support data including, but not limited to, information pertaining to:

a) inspections (including thicknesses);

b) material test reports/certifications;

c) tests;

d) radiographs (radiographs shall be retained for at least one year);

e) brittle fracture considerations;

f) original tank construction data (date, as-built standard, etc.);

g) location and identification (owner/operator's number, serial number);

h) description of the tank (diameter, height, service);

i) design conditions (liquid level, specific gravity, allowable stress, unusual design loadings, etc.);

j) shell material and thickness by course;

k) tank perimeter elevations;

l) construction completion record;

m) basis for hydrostatic test exemption.

13.3 Certification

Tanks reconstructed in accordance with this standard shall require documentation of such reconstruction, and certification that the design, reconstruction, inspection, and testing was performed in compliance with this standard. The certification shall contain information as shown in Figure 13.2 for design and/or reconstruction as applicable.

RECONSTRUCTED TO API 653 EDITION _____

Reconstructed by:

_____ Original Standard _____

_____ Tank No. _____

Date Completed _____ Tank Diam. _____ Height _____

Serial No. _____ Specific Gravity _____

Design Pressure _____

Shell Course	Allowable Stress	Material

Orig. Const. Date _____

Year Reconstructed _____

Liquid Level Max. _____

Capacity _____

Max. Operating Temp. _____

Figure 13.1—Nameplate

CERTIFICATION FOR TANK RECONSTRUCTED TO API 653

We hereby certify that the tank reconstructed at _____ and described as follows:
Location

_____ _____ _____ _____ _____
Serial No. Owner's No. Height Capacity Floating or Fixed Roof

was reconstructed, inspected, and tested in accordance with all applicable requirements of API Standard 653,

_____ Edition, _____ Revision, Dated _____ (including all material supplied by the reconstruction organization).

_____
Reconstruction Organization

_____
Authorized Representative

_____
Date

CERTIFICATION FOR TANK DESIGNED TO API 653

We hereby certify that the design evaluation of the tank reconstructed at _____ and described as follows:
Location

_____ _____ _____ _____ _____
Serial No. Owner's No. Height Capacity Floating or Fixed Roof

was performed by the undersigned organization in accordance with all design requirements of API Standard 653,

_____ Edition, _____ Revision, Dated _____.

_____
Reconstruction Organization

_____
Authorized Representative

_____
Date

Figure 13.2—Certification Forms

Annex S

Austenitic Stainless Steel Storage Tanks

S.1 Scope

S.1.1 This annex covers the inspection, repair, alteration, and reconstruction of stainless steel tanks that were constructed in accordance with API 650, Appendix S.

S.1.2 This annex states only the requirements that differ from the basic rules in this standard. For requirements not stated, the basic rules must be followed.

S.2 References

No changes to Section 2.

S.3 Definitions

No changes to Section 3.

S.4 Suitability for Service

S.4.1 In 4.2.4.1, the requirements of API 650, Section S.3.5 shall also be satisfied.

S.4.2 In 4.2.4.3, Annex M requirements shall be met for stainless steel tanks with design temperatures over 40 °C (100 °F) as modified by S.3.6.2 thru S.3.6.7.

S.4.3 In 4.3.3.1, the maximum allowable stress S shall be modified as follows, for the design condition (S_d) and the hydrostatic test condition (S_t) the maximum allowable stress for all shell courses shall be the lesser of $0.95Y$ or $0.4T$.

S.4.4 Table 4.2 shall be in accordance with API 650, Table S-4. When the radiography schedule applied to the existing weld is unknown, the joint efficiency of 0.7 shall be used.

S.4.5 Section 4.3.3.5 c), shall be changed to read “Operation at temperatures over 40 °C (100 °F).” 10

S.4.6 In 4.3.3.6, the factor $^{2}/_{3}Y$ shall be replaced with $^{3}/_{4}Y$.

S.4.7 In 4.3.4, these rules do not cover stainless steel tanks.

S.5 Brittle Fracture

S.5.1 The tank is suitable for continued use in ambient temperature service.

S.6 Inspection

No changes to Section 6.

S.7 Materials

S.7.1 In 7.3.1.2, add reference to ASTM A480.

S.7.2 Structural may be shapes fabricated from plate. Plate and structural material shall meet API 650, Section S.2. 10

S.8 Design Considerations for Reconstructed Tanks

S.8.1 In 8.4.3, the allowable stress shall be revised to meet the allowable stresses of API 650, Appendix S.

S.9 Tank Repair and Alteration

10 **S.9.1** Hot taps for stainless steels (reference Section 9.14) are not addressed by this annex.

S.10 Dismantling and Reconstruction

S.10.1 Welding shall also meet the requirements of API 650, Section S.4.11.

S.10.2 Thermal cutting of stainless steel shall be by the iron powder burning, carbon arc, plasma-arc, water jet, or laser cutting methods.

10

S.10.3 The storage requirements of API 650, Section S.4.2 shall be met.

S.10.4 If specified by the owner/operator, the requirements of API 650, Section S.4.5 shall be met.

S.11 Welding

10 **S.11.1** Welding shall also meet the requirements of API 650, Section S.4.11.

S.12 Examination and Testing

S.12.1 Any reference to magnetic particle method shall be replaced with the liquid penetrant method.

10 **S.12.2** In 12.3, the quality of test water shall meet API 650, Section S.4.10.

S.13 Annexes

S.13.1 Annex F (NDE Requirements Summary)—any references to magnetic particle examination shall be disregarded.

Annex SC

Stainless and Carbon Steel Mixed Storage Tanks

SC.1 Scope

SC.1.1 This annex covers the inspection, repair, alteration and reconstruction of mixed material tanks constructed in accordance with API 650, Appendix SC.

SC.1.2 This annex states only the requirements that differ from the basic rules in this standard, Annex S of this standard, Annex X of this standard and API 650, Appendix SC. For requirements not stated, the basic rules shall be followed.

SC.1.3 In this annex the term “stainless steel” includes austenitic or duplex stainless steel unless noted otherwise.

SC.2 References

No changes to Section 2.

SC.3 Definitions

No changes to Section 3.

SC.4 Suitability for Service 10

SC.4.1 Add to 4.2.4.1: The requirements of API 650, Sections S.3.5 and API 650, and X.3.6, shall also be satisfied for the stainless steel components of the tank.

SC.4.2 Add to 4.2.4.3: This annex applies only to tanks in non-refrigerated services with a maximum design temperature not exceeding 93 °C (200 °F). Mixed material tanks operating at temperatures greater than 93 °C (200 °F) are not addressed in this annex except for tanks covered in SC.4.3 below. For the purposes of this annex, the design temperature shall be the maximum design temperature as specified by the owner/operator.

NOTE Exothermic reactions occurring inside unheated storage tanks can produce temperatures exceeding 40 °C (100 °F).

SC.4.3 Tanks containing mixed materials which do not meet the temperature limitations specified in SC.4.2, but have a successful service history of operation, shall be evaluated for thermal differential expansion at mixed material interface in order to remain in continued service. This analysis shall be performed in accordance with API 650 Appendix SC, Section SC.3 and by an engineer experienced in storage tank design and evaluation methodologies. If no accounting for differential expansion effects in prior design work is documented, then such effects shall be evaluated at the time of existing tank assessment.

SC.4.4 Add to 4.3.3.1: The maximum allowable stress S shall be modified as follows, for the design condition (Sd) and the hydrotest condition (St) the maximum allowable stress for austenitic stainless steel shell courses shall be the smaller of $0.95Y$ or $0.4T$.

SC.4.5 Table 4-2—Joint efficiencies for welded joints shall be in accordance with API 650, Table S-4, or API 650, Table X-3. When the radiography schedule applied to the existing weld is unknown, then the joint efficiency of 0.7 shall be used.

SC.4.6 Revise 4.3.3.5.c to read ‘Operation at temperatures over 40 °C (100 °F).’

SC.4.7 Revise 4.3.3.6 by replacing the $^{2}/_{3}Y$ factor with $^{3}/_{4}Y$ for austenitic stainless steel components.

SC.4.8 The rules in 4.3.4 for riveted tanks do not cover mixed material tanks.

SC.5 Brittle Fracture Considerations

Evaluation of brittle fracture shall be done according to Section 5 of this standard for carbon steel, Section S.5 of this standard for austenitic stainless steel, and Section X.5 of this standard for duplex stainless steel components.

SC.6 Inspection

No Changes to Section 6.

SC.7 Materials

Materials requirements for mixed materials situations are unchanged from the base document except as modified by API 653 Appendices S and X (S.7 and X.7) for stainless steels.

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SC.8 Design Considerations for Reconstructed Tanks

The allowable stress in 8.4.2 and 8.4.3 for stainless steel components shall be revised to meet the allowable stresses of API 650 Appendix S or API 650 Appendix X.

SC.9 Tank Repair and Alteration

SC.9.1 Revise 9.2 to read: Shell insert plates shall be made in accordance with API 650, Appendix SC 3.2.2.

SC.9.2 Revise 9.3 to read: Lap patches shall be made carbon steel to carbon steel and stainless steel to stainless steel

SC.9.3 Revise 9.8 to read: Shell penetrations and reinforcing shall be made in accordance with API 650, Appendix SC 3.4.

SC.9.4 Revise 9.10 to read: Repair of tank bottoms shall be made in accordance with API 650, Appendix SC 3.1.

SC.9.5 Revise 9.14 to read: Hot taps in stainless steel are not addressed by this annex.

SC.10 Other

For Dismantling and Reconstruction, Welding, Examination and Testing, and Annexes see the following sections of the basic document: S.10 through S.13 for austenitic stainless steel, and X.10 through X.13 for duplex stainless steel components.

Annex X

Duplex Stainless Steel Storage Tanks

X.1 Scope

X.1.1 This annex covers the inspection, repair, alteration and reconstruction of duplex stainless steel tanks that were constructed in accordance with API 650, Appendix X.

X.1.2 This annex states only the requirements that differ from the basic rules in this Standard. For requirements not stated, the basic rules shall be followed.

X.2 References

No changes to Section 2.

X.3 Definitions

No changes to Section 3.

X.4 Suitability for Service

X.4.1 In 4.2.4.1, the requirements of API 650, X.3.6 shall also be satisfied.

X.4.2 In 4.2.4.3, the requirements of API 650, Appendix M requirements shall be satisfied for duplex stainless steel tanks with design temperatures over 40 °C (100 °F) as modified by API 650, X.3.7.2 thru X.3.7.5. 10

X.4.3 In 4.3.3.1, the maximum allowable stress S shall be calculated the same way as for carbon steel.

X.4.3.1 Y = specified minimum yield strength of the plate at design temperature; use material S32304 properties if duplex material/specification is not known.

X.4.3.2 T= specified minimum tensile strength of the plate at design temperature; use material S32304 properties if duplex material/specification is not known.

X.4.4 Table 4-2 shall be in accordance with API 650, Table X-3. When the radiography schedule applied to the existing weld is unknown; the joint efficiency of 0.7 shall be used.

X.4.5 4.3.3.5c, shall be changed to read “Operation at temperatures over 40 °C (100 °F).”

X.4.6 The rules of 4.3.4 for riveted tanks do not cover duplex stainless steel tanks.

X.5 Brittle Fracture Considerations

X.5.1 In 5.3.2 the applicable API 650 edition and addendum for duplex stainless steel tanks is 11th edition, Addendum 1 or later.

X.5.2 5.3.5 does not apply to duplex stainless steel tanks.

X.5.3 The rules of 5.3.8 shall be replaced with the following: Tanks constructed of duplex stainless steels whose toughness testing or testing exemption conformed to API 650, X.2.3.2 may be considered to be adequately tough for continued operation.

X.6 Inspection

No Changes to Section 6.

X.7 Materials

X.7.1 In 7.3.1.2, add reference to ASTM A480 and A240.

X.7.2 Structural sections may be shapes fabricated from plate. Plate and structural material shall meet API 650, X.2.

X.8 Design Considerations for Reconstructed Tanks

In 8.4.2 and 8.4.3 the allowable stress shall be revised to meet the allowable stresses of API 650, Appendix X.

X.9 Tank Repair and Alteration

X.9.1 Hot taps for duplex stainless steels (reference section 9.14) are not addressed by this annex.

X.10 Dismantling and Reconstruction

X.10.1 Welding shall also meet the requirements of API 650, X.4.11.

X.10.2 Cutting of duplex stainless steel shall be by the plasma-arc method, water jet, or laser cutting. Carbon arc cutting is not recommended but may be used with post-cut preparation prior to welding when agreed to by the owner/operator.

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X.10.3 The storage requirements of API 650, X.4.2 shall be met.

X.10.4 When specified by the purchaser the requirements of API 650, X.4.5 shall be met.

X.11 Welding

Welding shall also meet the requirements of API 650, X.4.12.

X.12 Examination and Testing

X.12.1 Any reference to magnetic particle method shall be replaced with the liquid penetrant method.

X.12.2 In 12.3, the quality of test water shall meet API 650, X.4.10.

X.13 Annexes

Annex F, NDE Requirements Summary; any reference to magnetic particle method shall be replaced with the liquid penetrant method.

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