12.1.3 Examination of Repaired Weld Defects

12.1.3.1 Cavities resulting from gouging or grinding operations to remove weld defects shall be examined by the magnetic particle or liquid penetrant methods.

18 **12.1.3.2** Completed weld repairs of butt welds shall be examined over their full length by radiographic or ultrasonic methods. However, for completed repairs to butt welds found in shell plate to shell plate joints, the additional radiographs, as required in 12.2.1.1.c), 12.2.1.2.c), and 12.2.1.3.c), do not apply.

12.1.3.3 Completed weld repairs of fillet welds shall be examined over their full length by the appropriate NDE method listed herein.

12.1.4 Temporary and Permanent Attachments to Shell Plates

12.1.4.1 The welds of permanent attachments (not including shell-to-bottom welds) and areas where temporary attachments are removed and the remaining weld projections have been removed shall be examined visually.

19 **12.1.4.2** The requirements of this section shall be followed when welding to API 650 Group IV, IVA, V, and VI materials, or when the API Group for the material cannot be reasonably ascertained in Section 11.1.2. Completed welds of new permanent attachments (not including shell-to-bottom welds) and areas where temporary attachments have been removed shall be examined by the magnetic particle method (or, at the option of the Purchaser, by the liquid penetrant method).

12.1.5 Shell Plate to Shell Plate Welds

12.1.5.1 New full penetration welds attaching existing shell plate to existing or new shell plate shall be examined by radiographic methods (see 12.2). In addition, for plate thicknesses greater than 1 in., the back-gouged surface of the root pass and final pass (each side) shall be examined for its complete length by magnetic particle or liquid penetrant methods.

12.1.5.2 New welds joining new shell plate material to new shell plate material (partial or full shell course replacement or addition) need only be examined radiographically in accordance with API 650, Section 8.1.

12.1.6 Shell-to-bottom Weld

12.1.6.1 New welding on the shell-to-bottom joint shall be examined for its entire length by using a right-angle vacuum box and a solution film, or by applying light diesel oil. Additionally, the first weld pass shall be examined by applying light diesel oil to the side opposite the first weld pass made. The oil shall be allowed to stand at least 4 hours (preferably overnight) and then the weld examined for wicking action. The oil shall be removed before the weld is completed.

19 **12.1.6.2** As an alternative to 12.1.6.1, the initial weld passes, inside and outside of the shell, shall have all slag and nonmetals removed from the surface of the welds and examined visually. Additionally, after completion of the inside and outside fillet or partial penetration welds, the welds shall be tested by pressurizing the volume between the inside and outside welds with air pressure to 15 psig and applying a solution film to both welds. To assure that the air pressure reaches all parts of the welds, a sealed blockage in the annular passage between the inside and outside welds must be provided by welding at one or more points. Additionally, a small pipe coupling communicating with the volume between the welds must be welded on each side of and adjacent to the blockages. The air supply must be connected at one end and a pressure gauge connected to a coupling on the other end of the segment under test.

12.1.6.3 The existing weld at the shell-to-bottom joint shall be examined by visual, as well as by magnetic particle or liquid penetrant methods, for the full length under a welded-on patch plate. An additional 6 in. of the shell-to-bottom joint on each side of the welded-on patch plate shall be examined similarly before placement of the repair plate to assure weld integrity and to confirm the absence of weld cracks.

12.1.7 Bottoms

12.1.7.1 Upon completion of welding on a tank bottom, the plates and the entire length of new welds for tank bottom plates shall be examined visually for any potential defects and leaks. Particular attention shall apply to areas such as sumps, dents, gouges, three-plate laps, bottom plate breakdowns, arc strikes, temporary attachment removal areas, and welding lead arc burns. Visual examination acceptance and repair criteria are specified in API 650, Section 8.5. In addition, all new welds, including the weld attaching a patch plate to the bottom, the areas of bottom plate restored by welding, and the restoration of welds found with defects during an internal inspection shall be examined by one of the methods specified in API 650, Section 7.3.3. Leaking areas shall be repaired by grinding and rewelding as required, and the repaired area shall be retested.

12.1.7.2 In addition to the requirements in 12.1.7.1, the root and final pass of a welded-on patch plate weld in the critical zone (see 3.10 for definition) shall be visually examined and examined by either magnetic particle or liquid penetrant method over its full length.

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 7.3.8. 18

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 NDE shall be in accordance with 12.1. 18

12.2 Radiographs

12.2.1 Number and Location of Radiographs

The number and location of radiographs of the full penetration shell plate to shell plate welds shall be in accordance with API 650, Section 8.1.2 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, Section 8.1.2.2 and Figure 8.1 for new construction; 18

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, Section 8.1.2.3 and Figure 8.11 for new construction; 18

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, Section 8.1.2 and Figure 8.1 for new construction; 18

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, Section 8.1.2.9.

12.2.1.5 For reconstructed tanks, radiographic examination 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 examination and repair that may be required.

Any further examination 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 or thickened insert plates as described in 9.9.6, the completed butt welds between the insert plate or thickened insert plate and the adjoining shell material shall be fully radiographed. 19 18

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:

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

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

c) repaired in accordance with 9.7. 19

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.

12.2.3.2 Radiographs and radiograph records of all repaired welds shall be marked with the letter “R.”

12.3 Hydrostatic Testing

12.3.1 When Hydrostatic Testing is Required

A hydrostatic test shall be performed on the following. 18

a) A reconstructed tank.

b) Any tank that has undergone major repairs or major alterations (see Section 3) unless exempted by 12.3.3 for the applicable combination of materials, design, and construction features. 19

c) A tank where an engineering evaluation indicates the need for the hydrostatic test due to an increase in the severity of service. Examples of increased service severity are an increase in operating pressure (such as storing a product with a higher specific gravity), lowering the service temperature (see Figure 5.2), and using tanks that have been damaged.

12.3.2 Hydrostatic Test Procedure

The hydrostatic test procedure encompasses the following steps:

1) A tank with a hydrostatic test required by this standard shall be filled to the level stated in API 650, Section 7.3.6(1)(a), unless the level is limited by the tank condition as given in section 4.3.3.2 of this standard. 18

2) That liquid level shall be held for a minimum of 24 hours. 18

3) The tank shall be inspected frequently during the filling operation for indications of leaks and/or settlement. Any repaired weld joints above the liquid level shall be examined in accordance with API 650, Section 7.3.6(1)(b). 18

18 **12.3.3 Hydrostatic Testing Exemptions (Major Repairs/Alterations)**

12.3.3.1 General

19 A full hydrostatic test of the tank is not required for major repairs and major alterations if 12.3.3.2 is satisfied plus either of the following:

18 a) appropriate parts of 12.3.3.3 through 12.3.3.6, or

18 b) fitness-for-service evaluation per 12.3.3.7.

18 **12.3.3.2 Review/Approval/Authorization Requirements**

Items a) and b) below must be satisfied.

a) The repair has been reviewed and approved by an engineer experienced in storage tank design in accordance with API 650. The engineer must concur in writing with taking the hydrostatic testing exemption.

b) The tank owner/operator has authorized the exemption in writing.

18 **12.3.3.3 Shell Repair**

18 **12.3.3.3.1** For welds to existing metal, develop welding procedure qualifications based on existing material chemistry, including strength requirements. Welding procedures shall be qualified with existing or similar materials, and shall include impact testing. Impact testing requirements shall follow appropriate portions of API 650, Section 9.2.2 and shall be specified in the repair procedure.

18 **12.3.3.3.2** New materials used for the repair shall meet the current edition of API 650, Section 4, requirements.

18 **12.3.3.3.3** Existing tank materials in the repair area shall meet at least one of the following requirements.

a) API 650 requirements (Seventh Edition or later).

b) Fall within the “safe for use” area on Figure 5.2.

c) Stress in the repair area shall not exceed 7000 lbf/in.^{2}. This limiting stress shall be calculated as follows:

$$S = \frac{2.6\,H\,D\,G}{t}$$

where

S is the shell stress in pound force per square inch (lbf/in.^{2});

H is the tank fill height above the bottom of repair or alteration in feet (ft);

t is the shell thickness at area of interest in inches (in.);

D is the tank mean diameter in feet (ft);

G is the specific gravity of product.

18 **12.3.3.3.4** New vertical and horizontal shell butt welds shall have complete penetration and fusion.

12.3.3.3.5 The root pass and final pass examination shall be in accordance with 12.1.5. In addition, the finished weld shall be fully radiographed. 18

12.3.3.3.6 Shell welds for the reinforcing plate-to-nozzle neck and nozzle neck-to-shell joints shall have complete penetration and fusion. The root pass of the nozzle attachment weld shall be back-gouged and examined by magnetic particle or liquid penetrant methods. Completed welds shall be examined by magnetic particle or liquid penetrant methods. Additionally, completed welds shall be examined by the ultrasonic method. Examination and acceptance criteria for NDE shall be in accordance with 12.1. 18 19

12.3.3.3.7 See 12.3.3.5 for shell-to-bottom weld restrictions. 18

12.3.3.3.8 Door sheets shall comply with the requirements of this standard for shell plate installation, except they shall not extend to or intersect the bottom-to-shell joint. 18

12.3.3.4 Bottom Repair within the Critical Zone

Repairs to the annular ring or bottom plates, within the critical zone (defined in Section 3) shall comply with the following. 18

a) Meet the requirements of 12.3.3.3.1 through 12.3.3.3.3. 18

b) Be examined visually prior to welding, and examined after the root pass and the final pass by the magnetic particle or liquid penetrant methods. Annular plate butt welds shall also be examined by ultrasonic methods after the final pass. Examination and acceptance criteria for NDE shall be in accordance with 12.1. 18

12.3.3.5 Shell-to-bottom Weld Repair 18

12.3.3.5.1 Repair of the weld attaching the shell to the annular ring or the shell to the bottom plate shall meet one of the following requirements. 18

a) A portion of the weld (of any length) may be removed and replaced as long as the replaced weld meets the size requirements of API 650, Section 5.1.5.7, and the portion replaced does not represent more than 50 % of the required weld cross-sectional area.

b) The weld on one side of the shell may be completely removed and replaced for a length not exceeding 12 in. Shell-to-bottom weld repairs replacing more than 50 % of the required weld cross-sectional area shall not be closer than 12 in. to each other, including repairs on the opposite side of the shell.

12.3.3.5.2 Repairs shall be examined prior to welding, after the root pass, and after the final pass by visual, as well as magnetic particle or liquid penetrant methods. Examination and acceptance criteria for NDE shall be in accordance with 12.1. 18

12.3.3.6 Minor Shell Jacking 18

12.3.3.6.1 Tank shell and critical zone materials shall meet one of the requirements of 12.3.3.3.3. 18

12.3.3.6.2 The engineer shall consider all pertinent variables when exempting a minor shell jacking repair from hydrostatic testing, including but not limited to: the magnitude of jacking required; material; toughness; quality control; inspection before and after repair; material temperature; future foundation stability; and jacking techniques (including controls and measurement). Careful consideration shall be given to potential stresses and damage that may result from jacking. 18

18 #### 12.3.3.7 Fitness-for-Service Evaluation

The owner/operator may utilize a fitness-for-service or other appropriate evaluation methodology based on established principles and practices to exempt a repair from hydrostatic testing. The procedures and acceptance criteria for conducting an alternative analysis are not included in this standard. This evaluation shall be performed by an engineer experienced in storage tank design and the evaluation methodologies used.

18 ### 12.3.4 Hydrostatic Testing Exemptions (Other)

18 #### 12.3.4.1 General

18 For clarity, the situations of 12.3.4.2 and 12.3.4.3 do not in themselves require a hydrostatic test because they are not major repairs or major alterations.

18 #### 12.3.4.2 Repair or Alteration Made to a Floating Roof

No hydrotest is required.

18 #### 12.3.4.3 Bottom Repair or Replacement Outside the Critical Zone

Portions of new bottoms (any or all rectangular plates or large segments of plates) in tanks may be replaced without a hydrotest when the subgrade under the new plates is found to be in a condition acceptable to the authorized inspector or is restored to such condition and either of the following conditions is met.

1) For tanks with annular rings, the annular ring and the area of support under the annular ring (concrete foundation or grade material) remains intact.

2) For tanks without annular rings, the bottom repair or replacement does not result in welding on the remaining bottom within the critical zone and the shell and bottom support in the critical zone (defined in Section 3) 18 remains intact.

12.4 Leak Tests

New or altered reinforcing plates of shell penetrations shall be given an air leak test in accordance with API 650, 18 Section 7.3.5.

12.5 Settlement Survey During Hydrostatic Testing

12.5.1 When Settlement Survey is Required

A settlement survey shall be conducted for all existing tanks that undergo a hydrostatic test, except for tanks that have a documented service history of acceptable settlement values, **and** no settlement is anticipated to occur during the hydrotest.

12.5.2 Initial Settlement Survey

When a settlement survey is required in accordance with 12.5.1, the tank settlement shall initially be surveyed with the tank empty, using an even number of elevation measurement points, N, uniformly distributed around the circumference. An initial settlement survey, prior to the first hydrostatic test, provides baseline readings for future settlement evaluation. In the absence of this initial survey, the tank shall be assumed to be initially level.

The minimum number of elevation points shall be as indicated by the following equation:

$$N = D/10$$

where

D is the tank diameter, in feet (ft).

And

N is the minimum required number of settlement measurement points, but no less than eight. All values of N shall be rounded to the next higher even whole number. The maximum spacing between settlement measurement points shall be 32 ft.

12.5.3 Settlement Survey During Hydrostatic Testing

When a settlement survey is required in accordance with 12.5.1, tank settlement shall be measured during filling and when the test water reaches 100 % of the test level.

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:

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;

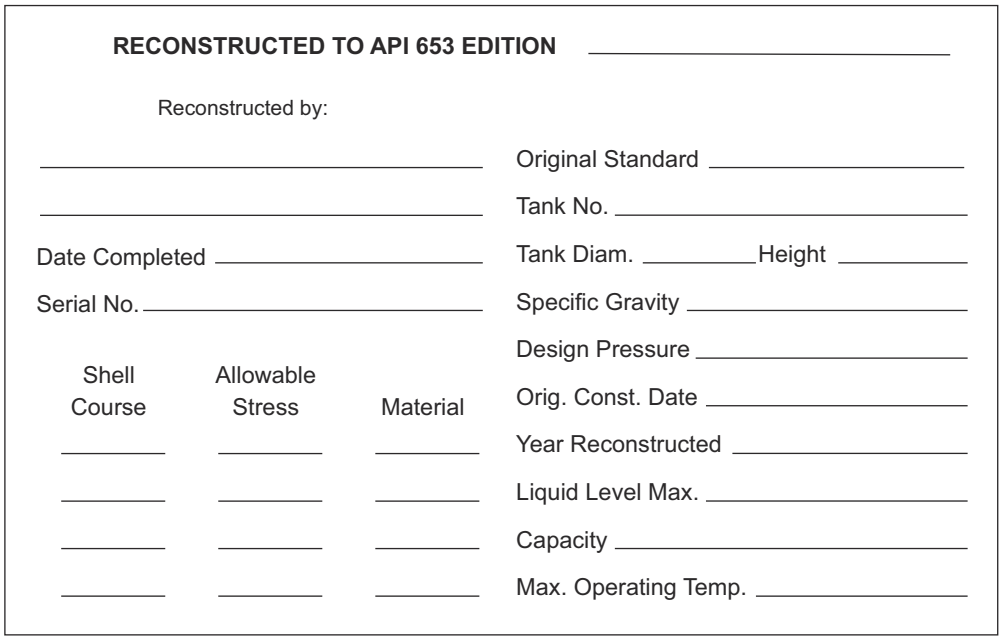

Figure 13.1—Nameplate

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, Section 10.1 and Figure 10.1.

18

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."

18

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 Sections 4 and 5. The new nameplate shall contain the following information:

18

a) API Standard 653, *Assessment Nameplate*;

18 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;

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).