

Agenda Item 650-2051 – Liquid Penetrant Test (PT) allowed to be substituted for Vacuum Box Test

Title: PT used instead of Vacuum Box

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Revision: 1

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Rev 0 of the item was handled by Rick Simmons

Purpose: Use of PT as a substitute for Vacuum Box

Source: Rick Simmons

Impact: Positive allowance overall cost and schedule and convenience.

Discussion:

1. This proposed addition to API is for allowing a no-indication PT leak test alternative to Vacuum Box or Solution Film Testing for weld seam locations which are difficult to access (or where it is inconvenient or uneconomical to perform currently specified Vacuum Box or Solution Film testing). There is no need to limit the areas where this substitution may be utilized, as it may be considered equivalent or better than vacuum box /solution film, and further it would be cost prohibitive to use PT excessively since it is far more expensive than vacuum box /solution film. It is proposed to simultaneously revise API 620 and API 653 via Agenda Items 620-2048 and 653-2041 respectively.
2. Storage Tank Manufacturers have for many years proposed and utilized PT instead of vacuum box for difficult to access areas, even though it has not actually been allowed by API, except for very limited special cases /situations.
3. PT with its usual acceptance criteria per ASME is considered more of a surface quality 'structural' check, as opposed to a leak test. Therefore, acceptance criteria for the alternative leak tightness use of PT is more stringent, in order to significantly increase the leak tightness probably of the tested weld, as ANY surface flaw could indicate a through thickness leak path.
4. Precedent. Refer to API 650 paragraph 7.3.4 item 4) for sumps, where PT with 'no indications' is allowed as an alternative to Vacuum Box, SFT, or penetrating oil.
5. [Rev 1: Applicability updated to cover tank components which are known to have impractical surface configurations for vacuum box testing.](#)

Proposed Changes:

Rev 1:

Section 7:

7.3.8 Testing of the Roof

7.3.8.1 Upon completion, the roof of a tank designed to be gas-tight (except for roofs designed under 7.3.8.2, F.4.4, and E.7.5) shall be tested by one of the following methods.

a) Applying internal air pressure not exceeding the weight of the roof plates and applying to the weld joints a bubble solution or other material suitable for the detection of leaks.

b) Vacuum testing the weld joints in accordance with 8.6 to detect any leaks. *When vacuum box testing is impractical due to the surface configuration, no-indication liquid penetrant examination may be substituted for vacuum box examination.*

Section 8:

8.4.4 Acceptance standards and the removal and repair of defects shall be in accordance with Section VIII, Annex 8, Paragraphs 8-3, 8-4, and 8-5, of the ASME Code. *Where no-indication liquid penetrant examination is specified, the acceptance criteria shall require examined surface to be completely free of indications, including linear, round, or crack-like.*

Annex C:

C.3.6 Compartments

Compartment plates are radial or circumferential dividers forming compartments that provide flotation for the roof (see C.3.4). All internal compartment plates (or sheets) shall be single-fillet welded along all of their edges, and other welding shall be performed at junctions as required to make each compartment leak tight. Each compartment weld shall be tested for leak tightness using internal pressure or a vacuum box and a soap solution or penetrating oil. *When vacuum box testing is impractical due to the surface configuration, no-indication liquid penetrant examination may be substituted for vacuum box examination.*

Annex H:

H.6.4 Any flotation compartment that is completely shop-fabricated or assembled in such a manner as to permit leak testing at the fabricating shop shall be leak tested at the shop as well as retested in the field by the floating roof erector for all accessible seams. In the field assembly yard or in the erected position, the erector shall spot leak test 10 % of the flotation compartments, whether shop- or field-fabricated. The Purchaser may select the specific compartments to test and the test location, based on his visual inspections for indications of damage or potential leaks (see the Data Sheet, Line 34). Any leaking compartments shall be repaired and re-tested by the roof Manufacturer. If the testing finds any leaks in compartments tested, except for those damaged by shipping, then 100 % of the roof compartments shall be leak tested. Unless prohibited by safety concerns, leak testing of cylindrical sections shall be at an internal pressure of 20 kPa to 55 kPa (3 lbf/in.² to 8 lbf/in.²) gauge using a soap solution or commercial leak detection solution. For other compartment shapes, each compartment weld shall be tested for leak tightness using internal pressure (pressure to be agreed between the Purchaser, roof manufacturer, and roof erector) or a vacuum box and a soap solution, or penetrating oil. *or when other testing methods are impractical due to the surface configuration, no-indication liquid penetrant examination.*

Annex T:

...
Air Test	Shop fabricated compartments (pontoons). Test in shop and field. Welds may be tested using vacuum box, penetrating oil or no-indication liquid penetrant examination when other testing methods are impractical due to surface configuration.	H.6.4
...
Pen. Oil	Compartment welds of external floating roofs not tested with internal pressure or VB or no-indication liquid penetrant examination when other testing methods are impractical due to surface configuration.	C.3.6
...
VB	Welds of roofs designed to be gas-tight if not air tested or no-indication liquid penetrant examination when other testing methods are impractical due to surface configuration.	7.3.8.1
...

Acceptance Standards:

....
PT: ASME Section VIII, Appendix 8 (paragraphs 8-3, 8-4, 8-5), where no-indication liquid penetrant examination is specified, the acceptance criteria shall require examined surface to be completely free of indications, including linear, round, or crack-like.
....

Rev 0 (for reference – balloted Spring 2020):

Add to paragraph 8.6.1 as follows, with commentary footnote XX:

8.6.1 Vacuum testing is performed using a testing box approximately 150 mm (6 in.) wide by 750 mm (30 in.) long with a clear window in the top, which provides proper visibility to view the area under examination. During testing, illumination shall be adequate for proper evaluation and interpretation of the test. The open bottom shall be sealed against the tank surface by a suitable gasket. Connections, valves, lighting and gauges, as required, shall be provided. A soap film solution or commercial leak detection solution, applicable to the conditions, shall be used.

Liquid Penetrant Test (PT) may be substituted for Vacuum Box Testing, per 8.4, but with the more stringent acceptance criteria that the surface be completely free of any indications^{XX}, including linear,

round, or crack-like indications. This PT with the more stringent criteria may hereinafter be referred to as 'no-indication PT', and abbreviated NI-PT.

xx Completely free of indications is sometimes referred to in industry as 'snow white PT' or 'white PT'.

7.2.4 Shell-to-Bottom Welds

7.2.4.1 The initial weld pass inside the shell shall have all slag and non-metals removed from the surface of the weld and then examined for its entire circumference both visually and by one of the following methods to be agreed to by Purchaser and the Manufacturer. If method "a" is applied, either inside or outside weld may be deposited first. If method b, c, d, or e is applied, the inside weld shall be deposited first:

- a) magnetic particle;
- b) applying a solvent liquid penetrant to the weld and then applying a developer to the gap between the shell and the bottom and examining for leaks after a minimum dwell time of one hour;
- c) applying a water-soluble liquid penetrant to either side of the joint and then applying a developer to the other side of the joint and examining for leaks after a minimum dwell time of one hour;
- d) applying a high flash-point penetrating oil such as light diesel to the gap between the shell and the bottom, letting stand for at least four hours, and examining the weld for evidence of wicking.

NOTE: Residual oil may remain on the surfaces yet to be welded even after the cleaning required below and contamination of the subsequent weld is possible.

- e) Applying a bubble-forming solution to the weld, using a right angle vacuum box, and examining for bubbles, **or alternatively utilize no-indication PT per 8.6.1.**

Thoroughly clean all residual examination materials from the as yet to be welded surfaces and from the unwelded gap between the shell and bottom. Remove defective weld segments and reweld as required. Reexamine the repaired welds and a minimum of 150 mm (6 in.) to either side in the manner described above. Repeat this clean-remove-repair-examine-and-clean process until there is no evidence of leaking. Complete all welding passes of the joint both inside and outside the shell. Visually examine the finished weld surfaces of the joint both inside and outside the shell for their entire circumference.

7.2.4.3 By agreement between the Purchaser and the Manufacturer, the examinations of 7.2.4.1 may be waived if the following examinations are performed on the entire circumference of the weld(s).

- a) Visually examine the initial weld pass (inside or outside).
- b) Visually examine the finished joint welded surfaces, both inside and outside the shell.
- c) Examine either side of the finished joint weld surfaces by magnetic particle, **or no-indication liquid penetrant per 8.6.1,** or right angle vacuum box.

7.3.3 Examination and Testing of the Tank Bottom

Upon completion of welding of the tank bottom, the bottom welds and plates shall be examined visually for any

potential defects and leaks. Particular attention shall apply to areas such as sump-to-bottom welds, 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 8.5. In addition, all welds shall be tested by one of the following methods.

- a) A vacuum-box or no-indication PT test in accordance with 8.6.
- b) A tracer gas test in accordance with 8.6.11.
- c) After at least the lowest shell course has been attached to the bottom, water (to be supplied by the Purchaser) shall be pumped underneath the bottom. A head of 150 mm (6 in.) of liquid shall be maintained using a temporary dam to hold that depth around the edge of the bottom. The line containing water for testing may be installed temporarily by running it through a manhole to one or more temporary flange connections in the bottom of the tank, or the line may be installed permanently in the subgrade beneath the tank. The method of installation should be governed by the nature of the subgrade. Reasonable care shall be taken to preserve the prepared subgrade under the tank.

7.3.4 Examination and Testing of Sump Welds

Welds of sumps shall be examined visually for any potential defects and leaks. This examination shall be performed before installation and may be conducted in either shop or field. Visual examination acceptance and repair criteria are specified in 8.5. In addition, all welds shall be leak tested by one or any combination of the following methods.

- 1) Vacuum box in accordance with 8.6 utilizing an appropriate size and shape vacuum box.
- 2) Pressurized solution film test treating the sump as a small tank in accordance with J.4.2.2.
- 3) Penetrating oil testing per 7.2.4.1 d).
- 4) Liquid penetrant testing with no indications per 7.2.4.1 c).

7.3.6 Testing of the Shell

After the entire tank and roof structure is completed, the shell (except for the shell of tanks designed in accordance with Annex F) shall be strength-tested and the foundation initially loaded by one of the following methods, as specified on the Data Sheet, Line 14.

- 1) If water is available for testing the shell,
 - a) the tank shall be filled with water as follows:
 - i) fill to the maximum design liquid level, H; or
 - ii) for a tank with a gas-tight roof, fill to 50 mm (2 in.) above the weld connecting the roof plate or compression bar to the top angle or shell; or
 - iii) fill to a level lower than that specified in Item i) or Item ii) above when restricted by overflows, an internal floating roof, or other freeboard by agreement between the Purchaser and the Manufacturer; or

- iv) fill to a level of seawater producing hoop stress in the first shell course equal to that produced by a fullheight fresh water test.
 - b) the tank shall be inspected frequently during the filling operation. Any welded joints above the test-water level shall be examined in accordance with Item 2) a) below.
- 2) If sufficient water to fill the tank is not available and hydrostatic test exemption is specified by the Purchaser,
- a) the tank shall be examined by one of the following:
 - i) applying highly penetrating oil, such as automobile spring oil, to all of the joints on the inside and examining the outside of the joints for leakage; or
 - ii) applying vacuum or alternatively using no-indication PT on to either side of the joints or, if above the liquid level, applying internal air pressure as specified for the roof test in 7.3.8 and visually examining the joints for leakage; or
 - iii) using any combination of the methods stipulated in Item i) or Item ii) above.
 - ...

7.3.7 Hydrostatic Testing Requirements

7.3.7.1 The tank hydrostatic test shall be conducted before permanent external piping is connected to the tank except for piping that is necessary to fill and empty the tank, which should have a flexible component to allow for settlement. Attachments to the shell defined in 5.8.1.1, located at least 1 m (3 ft) above the water level, and roof appurtenances may be welded during the filling of the tank with water. After completion of the hydro-test, only nonstructural small attachments may be welded to the tank in accordance with 7.2.1.12. Any welded joints above the testwater level shall be examined for leakage by one of the following methods:

- 1) applying a highly penetrating oil on all interior weld joints, e.g. automobile spring oil, and examining the outside of the joints for leakage;
- 2) applying vacuum to either side of the joints (or utilizing no-indication PT per 8.6.1 on either side) or applying internal air pressure as specified for the roof test in 7.3.8 and visually examining the joints for leakage; or
- 3) using any combination of the methods stipulated in Subitems 1 and 2.
- ...

7.3.8 Testing of the Roof

7.3.8.1 Upon completion, the roof of a tank designed to be gas-tight (except for roofs designed under 7.3.8.2, F.4.4, and E.7.5) shall be tested by one of the following methods.

- a) Applying internal air pressure not exceeding the weight of the roof plates and applying to the weld joints a bubble solution or other material suitable for the detection of leaks.
- b) Vacuum testing the weld joints in accordance with 8.6 or testing the weld joints using no-indication PT per 8.6.1 to detect any leaks.

C.3.6 Compartments

Compartment plates are radial or circumferential dividers forming compartments that provide flotation for the roof (see C.3.4). All internal compartment plates (or sheets) shall be single-fillet welded along all of their edges, and other welding shall be performed at junctions as required to make each compartment leak tight. Each compartment weld shall be tested for leak tightness using internal pressure or a vacuum box and a soap solution or penetrating oil or by utilizing no-indication PT per 8.6.1.

H.6.4 Any flotation compartment that is completely shop-fabricated or assembled in such a manner as to permit leak testing at the fabricating shop shall be leak tested at the shop as well as retested in the field by the floating roof erector for all accessible seams. In the field assembly yard or in the erected position, the erector shall spot leak test 10 % of the flotation compartments, whether shop- or field-fabricated. The Purchaser may select the specific compartments to test and the test location, based on his visual inspections for indications of damage or potential leaks (see the Data Sheet, Line 34). Any leaking compartments shall be repaired and re-tested by the roof Manufacturer. If the testing finds any leaks in compartments tested, except for those damaged by shipping, then 100 % of the roof compartments shall be leak tested. Unless prohibited by safety concerns, leak testing of cylindrical sections shall be at an internal pressure of 20 kPa to 55 kPa (3 lbf/in.2 to 8 lbf/in.2) gauge using a soap solution or commercial leak detection solution or by no-indication PT per 8.6.1. For other compartment shapes, each compartment weld shall be tested for leak tightness using internal pressure (pressure to be agreed between the Purchaser, roof manufacturer, and roof erector) or a vacuum box and a soap solution, or penetrating oil, or by no-indication PT per 8.6.1.

NOTE Special contract terms may be required to cover the costs of the field testing.

I.6 Testing and Inspection

I.6.1 The leak barrier, all leak-barrier penetrations, attachments of the leak barrier to the foundation ringwall, and other appurtenances shall be visually inspected for proper construction in accordance with applicable specifications.

The shop and field seams of flexible-membrane liners shall pass a vacuum-box test. All leaks shall be repaired and retested. Alternative testing methods may be used with the tank owner's approval.

Annex T (informative)

NDE Requirements Summary

	Continuation, Table 8.6.10.1	Change each "VB" to "VB (or NI-PT)"	8.6.1
VB	First pass of the internal shell-to-bottom weld if approved instead of MT, PT, or Pen. Oil.		7.2.4.1e
VB	Final shell-to-bottom weld, as alternative to requirements of 7.2.4.1 or 7.2.4.2 either side of the finished joint if not MT or PT tested.		7.2.4.3c 7.3.8.1 b)
VB	Bottom welds if not tested to 7.3.3b or 7.3.3c		7.3.3a
VB	Welds of roofs designed to be gas-tight if not air tested.		7.3.8.1
VB	Compartment welds of external floating roofs if not tested with internal pressure or penetrating oil.		C.3.6
VB	Seams of flexible membrane liners for leak protection.		I.6.2

Add a new item: H.6.4
Leak Testing of
Compartment, an option

Correct to I.6.1

Process	Welds Requiring Inspection	Reference Section
VB	Welded shell joints if no water is available, if not air tested or tested to 7.3.6, Item 2) a) i) or 7.3.6, Item 2) a) iii).	7.3.6, Item 2) a) ii)
VB	Welded shell joints above the hydrostatic test water level unless air-tested or tested to the requirements of 7.3.7.1, Item 1) or 7.3.7.1, Item 3).	7.3.7.1, Item 2)

Acceptance Standards:

MT: ASME Section VIII, Appendix 6 (Paragraphs 6-3, 6-4, 6-5)

PT: ASME Section VIII, Appendix 8, (Paragraphs 8-3, 8-4, 8-5)

No-indication PT (NI-PT): per ASME Section VIII, Appendix 8, (Paragraphs 8-3, 8-4, 8-5) and 8.6.1

RT: ASME Section VIII, Paragraph UW-51(b)

Tracer Gas: API Std 650, Section 8.6.11.b

UT: For welds examined by UT in lieu of RT, acceptance standards are in Annex U.6.6. For UT when RT is used for the requirements of 7.3.2.1, the acceptance standard is as agreed upon by the Manufacturer and Purchaser.

VB: API Std 650, Section 8.6.9

VE: API Std 650, Section 8