

## Agenda Item 620-2048 – Liquid Penetrant Test (PT) allowed to be substituted for Vacuum Box and Solution Film Test

### Title: PT used instead of Vacuum Box or Solution Film Test

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Revision: 1

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Rev 0 of the item was handled by Rick Simmons

**Purpose:** Use of no-indication PT as a leak test substitute for Vacuum Box and Solution Film Testing

**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 650 and API 653 via Agenda Items 650-2051 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 a surface quality 'structural' check, not 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:**

**7.15.4.4** The acceptance standards, defect removal, and repair shall be in accordance with Section VIII, Appendix 8, Paragraphs 8-3, 8-4, and 8-5 of the ASME Code. **When 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 P:**

|          |   |         |
|----------|---|---------|
| ...      | ....  | ....    |
| Air Test | Annex Q: Attachment welds around all openings and their reinforcements in the bottom, shell and roof. <b>When vacuum box testing is impractical due to the surface configuration, no-indication liquid penetrant examination may be substituted for vacuum box examination.</b> | Q.5.8.3 |
| ...      | ....  | ....    |
| Air Test | Annex R: Attachment welds around all openings and their reinforcements in the bottom, shell and roof. <b>When vacuum box testing is impractical due to the surface configuration, no-indication liquid penetrant examination may be substituted for vacuum box examination.</b> | R.5.9.4 |
| ...      | ....  | ....    |
| VB       | Annex Q: All welds of bottom, wall, and roof metallic liners of concrete containers. <b>When vacuum box testing is impractical due to the surface configuration, no-indication liquid penetrant examination may be substituted for vacuum box examination.</b>                  | Q.5.8.7 |
| ...      | ....  | ....    |
| VB       | Annex R: All welds of bottom, wall, and roof metallic liners of concrete containers. <b>When vacuum box testing is impractical due to the surface configuration, no-indication liquid penetrant examination may be substituted for vacuum box examination.</b>                  | R.5.9.6 |
| ...      | ....  | ....    |

Acceptance Standards:

....  
PT: ASME Section VIII, Appendix 8, (Paragraph 8-3, 8-4, 8-5), **when 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 Q:**

**Q.5.8.3** The attachment welding around all openings and their reinforcements in the bottom, shell, and roof shall be examined by solution film test in accordance with 7.18.2.3. **When solution film testing is impractical due to the opening configuration, no-indication liquid penetrant examination may be substituted for solution film examination.** Following the solution film test, the telltale hole in warm vapor and purge gas container reinforcing plates may be sealed with a threaded plug.

**Q.5.8.7** All welds of bottom, wall, and roof metallic liners of concrete containers shall be examined by applying a solution film to the welds and applying a partial vacuum of between 3 lbf/in.<sup>2</sup> and 5 lbf/in.<sup>2</sup> gauge above the welds by means of a vacuum box with transparent top. Where single pass lap welds less than 3/16 in. are used for wall liners, a second partial vacuum of at least 8 lbf/in.<sup>2</sup> shall be applied. *When vacuum box testing is impractical due to the surface configuration, no-indication liquid penetrant examination may be substituted for vacuum box examination.*

#### **Annex R:**

**R.5.9.4** The attachment welding around all openings and their reinforcements in the bottom, shell, and roof shall be examined by a solution film test in accordance with 7.18.2.3. *When solution film testing is impractical due to the opening configuration, no-indication liquid penetrant examination may be substituted for solution film examination.* Following the solution film test, the telltale hole in warm vapor and purge gas container reinforcing plates may be sealed with a threaded plug.

**R.5.9.6** All welds of bottom, wall, and roof metallic liners of concrete containers shall be examined by applying a solution film to the welds and applying a partial vacuum of between 3 lbf/in.<sup>2</sup> and 5 lbf/in.<sup>2</sup> gauge above the welds by means of a vacuum box with transparent top. Where single pass lap welds less than 3/16 in. are used for wall liners, a second partial vacuum of at least 8 lbf/in.<sup>2</sup> shall be applied. *When vacuum box testing is impractical due to the surface configuration, no-indication liquid penetrant examination may be substituted for vacuum box examination.*

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#### **Rev 0 (for reference – balloted Spring 2020):**

*Add to 7.15.7.1 and 7.18.1 as follows, including commentary footnote xx:*

**7.15.7.1** Vacuum testing is performed using a testing box approximately 6 in. wide by 30 in. long with a clear window in the top, which provides proper visibility to view the area under inspection. 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 Examination Method (PT) per 7.15.4 may be substituted for Vacuum Box Testing, but with the more stringent acceptance criteria that the surface be completely free of any indications<sup>xx</sup>, including linear, round, or crack-like indications. This alternative may be referred to as 'no-indication PT, abbreviated as NI-PT'.***

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

### **7.18 Standard Hydrostatic and Pneumatic Tests**

#### **7.18.1 General**

After erection is completed and stress relieving, radiographic examinations, or other similar operations, as may be required, are performed, each tank shall satisfactorily pass a series of hydrostatic and pneumatic tests as

prescribed in 7.18.2 through 7.18.6. Whenever a solution film is specified in this section to be applied to welding, linseed oil or **no-indication PT per 7.15.7.1** or another equivalent material for disclosing air leakage may be substituted. In freezing weather, linseed oil or **no-indication PT per 7.15.7.1** or a similarly suitable material shall be used. **Whenever a vacuum box test is specified in this section to be applied to welded joints, linseed oil or no-indication PT per 7.15.7.1 or another equivalent material for disclosing air leakage may be substituted.**

**7.18.2.4** In cases in which the bottom of the tank rests directly on the tank grade (preventing access to the underside of the bottom of the tank), all joints between the bottom plates shall be tested on the inside of the tank by applying a solution film to the joints and pulling a partial vacuum of at least 3 lbf/in.<sup>2</sup> gauge by means of a vacuum box with a transparent top. **As an Suitable** alternate **s** to vacuum box testing, **are 1)** a suitable tracer gas and compatible detector can be used to test the integrity of welded bottom joints for their entire length if an appropriate tracer gas testing procedure has been reviewed and approved by the Purchaser **or 2)** **no-indication PT per 7.15.7.1.**

**7.18.3.4** As the pressure is being increased, the tank shall be inspected for signs of distress. The maximum test pressure of 1.25 times the vapor space design pressure shall be held for at least one hour, after which the pressure shall be released slowly and the blinds shall be removed from the pressure-vacuum relief valves. The operation of the relief valves shall then be checked by injecting air into the top of the tank until the pressure in the vapor space equals the pressure,  $P_g$ , for which this space is designed, at which time the relief valves shall start to release air. :

**7.18.3.5** While this latter pressure is held, a solution film shall be applied to all of the welding involved above the high liquid (capacity) design level for which the tank is designed. A prior vacuum box check **(or alternatively no-indication PT)** may be substituted for the close visual with solution-film examination. The solution-film examination **(or alternatively no-indication PT)** shall still be made, above the liquid level, on all welds around openings, all piping joints, and the compression ring welds to the roof and shell, except the prior vacuum box is permitted for any listed below.

- Continuous double lap roof to compression ring welds.
- Shell to compression ring welds, continuous inside and outside, and applying a thickened upper shell ring detail similar to Figure 5-6 details f or f-1. The thickened upper shell ring shall be greater than 1/2 of the conical compression ring thickness and greater than two times the adjacent shell ring thickness.
- Full fusion butt-welded connections.

Annex P:

Change each to:  
VB (or NI-PT)

|    |  |         |
|----|--|---------|
| VB | Annex Q: Following the hydrostatic and pneumatic test, all shell-to-bottom welds not having complete penetration and complete fusion, unless a direct pressure solution film test is performed at the option of the Purchaser. | Q.6.6.8 |
| VB | Annex Q: For temporary shell openings installed after the hydrostatic test: The butt-weld around the periphery of the plate.   | Q.6.7.4 |
| VB | Annex R: All welded joints in the bottom of the tank, including components in primary liquid, secondary liquid, purge gas, and warm vapor containers.  | R.5.9.1 |
| VB | Annex R: Full penetration shell-to-bottom welds, including components in primary liquid, secondary liquid, purge gas, and warm vapor containers.   | R.5.9.2 |
| VB | Annex R: Fillet welds around bottom openings that do not receive repad pressure test.  | R.5.9.5 |
| VB | Annex R: All welds of bottom, wall, and roof metallic liners of concrete containers.   | R.5.9.6 |
| VB | Annex R: All welded joints above the water level when approved by purchaser as substitute for a solution-film examination.   | R.6.5.4 |
| VB | Annex R: For temporary shell openings installed after the hydrostatic test: The butt-weld around the periphery of the plate.   | R.6.6.4 |
| VE | Tack welds left in place.  | 6.9.1.4 |

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**Definitions:**

- MT= Magnetic Particle Examination
- PT = Liquid Penetrant Examination
- Pen Oil = Penetrating Oil Test
- RT = Radiographic Testing
- UT = Ultrasonic Testing
- VB = Vacuum Box Testing
- VE = Visual Examination

Add: NI-PT = No Indication Liquid Penetrant Examination

**Annex Q**

**Q.5.8 Examination for Tightness of Welds in Liquid, Product Vapor, and Purge Gas Containers**

**Q.5.8.1** All welded joints in all bottoms and all complete penetration and complete fusion sidewall-to-bottom welds shall be examined by applying a solution film to the welds and pulling a partial vacuum of at least 3 lbf/in.<sup>2</sup> gauge above the welds by means of a vacuum box with a transparent top, or by the alternative method of No Indication PT per 7.15.7.1. This includes those components in primary liquid containers, secondary liquid container, purge gas containers, and warm vapor containers.

**Q.5.8.3** The attachment welding around all openings and their reinforcements in the bottom, shell, and roof shall be examined by solution film test in accordance with 7.18.2.3, or by the alternative method of No Indication PT per 7.15.7.1. Following the solution film test, the telltale hole in warm vapor and purge gas container reinforcing plates may be sealed with a threaded plug.

**Q.5.8.5** Where the pneumatic pressure to be applied in Q.6.5 will be equalized on both sides of the inner tank, all welded joints above the test water level shall be checked with a solution film and by a vacuum box examination (the alternative method of No Indication PT per 7.15.7.1 may be substituted for either the solution film or vacuum box examination).

**Q.5.8.6** The attachment fillet welds around bottom openings, which do not permit the application of air pressure behind their reinforcing plates, shall be examined by applying a solution film and by a vacuum box examination (the alternative method of No Indication PT per 7.15.7.1 may be substituted for either the solution film or vacuum box examination).

**Q.5.8.7** All welds of bottom, wall, and roof metallic liners of concrete containers shall be examined by applying a solution film to the welds and applying a partial vacuum of between 3 lbf/in.2 and 5 lbf/in.2 gauge above the welds by means of a vacuum box with transparent top (or by the alternative method of No Indication PT per 7.15.7.1). Where single pass lap welds less than 3/16 in. are used for wall liners, a second partial vacuum of at least 8 lbf/in.2 shall be applied.

#### **Q.6.6 Pneumatic Pressure**

**Q.6.6.1** An air pressure equal to 1.25 times the pressure for which the vapor space is designed shall be applied to the enclosed space above the water level. In the case of a double-wall tank with an open-top inner tank, where the air pressure acts against the outer tank and the inner tank is thus not stressed by the air pressure, the inner tank may be emptied of water before the pneumatic pressure test begins.

**Q.6.6.4** Above the water level, all welded joints shall be checked with a solution film. A prior vacuum box check or no-indication PT may be substituted for the solution-film examination. The solution-film examination shall still be made, above the water level, on all welds around openings, all piping joints, and the compression ring welds to the roof and shell except any listed below.

— Continuous double lap roof to compression ring welds.

— Shell to compression ring welds, continuous inside and outside, and applying a thickened upper shell ring detail similar to Figure 5-6 details f or f-1. The thickened upper shell ring shall be greater than half of the conical compression ring thickness and greater than two times the adjacent shell ring thickness.

— Full fusion butt welded connections.

**Q.6.6.8** Following the hydrostatic and pneumatic test, all welded seams in the primary liquid container bottom, and complete penetration and complete fusion sidewall-to-bottom welds in the primary liquid container, shall be examined by means of a vacuum box test as described in Q.5.8.1 or by the no-indication PT method. Sidewall-to-bottom welds not having complete penetration and complete fusion shall be examined by means of either a vacuum box test of the inside weld as described in Q.5.8.1 or by the no-indication PT method, or where approved by the Purchaser, a direct pressure solution film test as described in Q.5.8.2. If any leaks are detected, they shall be repaired and the vacuum box test or the no-indication PT examination repeated. The primary liquid container hydrostatic test need not be repeated.

**Q.6.7.4** The butt weld around the periphery of the plate shall be examined over 100 % of its length by both liquid penetrant method and radiographic method. The liquid penetrant examination is required on the root pass, on the back-gouged surface, and on the inside and outside finished weld surfaces. Additionally, the weld shall be vacuum box leak tested or no-indication PT performed.

**Q.7.2.3** While the test pressure is being held, all lap welded seams and all welds in connections in the outer shell and roof shall be thoroughly examined with a solution film unless they were previously checked with a vacuum box or by the no-indication PT method.

## Annex R

### **R.5.9 Examination for Tightness of Welds in Primary Liquid, Product Vapor, and Purge Gas Containers**

Welds which are not examined for tightness during the hydrostatic or pneumatic test shall be examined as required by R.5.9.1 through R.5.9.6.

**R.5.9.1** All welded joints in all the bottoms of the tank shall be examined by applying a solution film to the welds and pulling a partial vacuum of at least 3 lbf/in.<sup>2</sup> gauge above the welds by means of a vacuum box with a transparent top, or by the alternative method of No Indication PT per 7.15.7.1. This includes those components in primary liquid containers, secondary liquid container, purge gas containers, and warm vapor containers.

**R.5.9.2** Complete penetration and complete fusion welds that join the cylindrical wall to the tank bottom shall be examined by applying a solution film to the welds and pulling a partial vacuum of at least 3 lbf/in.<sup>2</sup> gauge above the welds by means of a vacuum box with a transparent top, or by the alternative method of No Indication PT per 7.15.7.1. This includes these components in primary liquid containers, secondary liquid container, purge gas containers, and warm vapor containers.

**R.5.9.3** When the weld in R.5.9.2 does not have complete penetration and complete fusion, the initial weld passes, inside and outside of the shell, shall have all slag and non-metals removed from the surface of the welds and the welds examined visually. 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 lbf/in.<sup>2</sup> gauge and applying a solution film to both welds. To ensure 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.

**R.5.9.4** The attachment welding around all openings and their reinforcements in the bottom, shell, and roof shall be examined by a solution film test in accordance with 7.18.2, or by the alternative method of No Indication PT per 7.15.7.1. Following the solution film test or no-indication PT, the telltale hole in warm vapor and purge gas container reinforcing plates may be sealed with a threaded plug.

**R.5.9.5** The attachment fillet welds around bottom openings, which do not permit the application of air pressure behind the reinforcing plate, shall be examined by applying a solution film and by a vacuum box examination, or by the alternative method of No Indication PT per 7.15.7.1.

**R.5.9.6** All welds of bottom, wall, and roof metallic liners of concrete containers shall be examined by applying a solution film to the welds and applying a partial vacuum of between 3 lbf/in.<sup>2</sup> and 5 lbf/in.<sup>2</sup> gauge above the welds by means of a vacuum box with transparent top, or by the alternative method of No Indication PT per 7.15.7.1. Where single pass lap welds less than 3/16 in. are used for wall liners, a second partial vacuum of at least 8 lbf/in.<sup>2</sup> shall be applied.

**R.6.6.4** The butt weld around the periphery of the plate shall be examined over 100 % of its length by the magnetic particle method, by the radiographic method and by the ultrasonic method. Ultrasonic examination acceptance criteria shall be as given in Table U-1. The magnetic particle examination is required on the root pass, on the back-gouged surface, and on the inside and outside finished weld surfaces. Additionally, the weld shall be vacuum box leak tested, **or tested by the alternative method of No Indication PT per 7.15.7.1.**

**R.7.4** While the test pressure is being held, all lap welded seams and all welds in connections in the outer shell and roof shall be thoroughly examined with solution film unless they were previously checked with a vacuum box **or tested by the alternative method of No Indication PT per 7.15.7.1**

For Committee Review Only