

Inspecting Low-Pressure Storage Tanks

An outline of the inspection and NDE requirements for low-pressure storage tanks according to API 620

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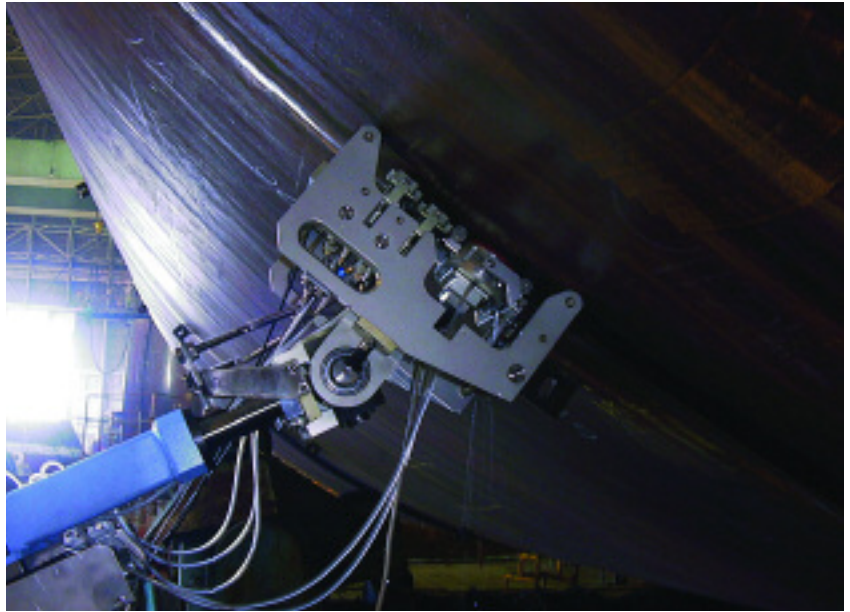
Low-pressure storage tanks are designed and constructed in accordance with American Petroleum Institute (API) Standard 620 (Ref. 1). This standard covers large, field-assembled storage tanks that contain petroleum gases or vapors as well as other liquid products. These large, low-pressure, above-ground tanks are welded from carbon steel. They are designed for metal temperatures not greater than 250°F and with pressures in the gas or vapor space not to exceed 15 lb/in.². Beside the basic requirements, API 620 includes appendixes that cover additional requirements; for example, Appendix Q for low-pressure storage tanks for liquid hydrocarbon gases, Appendix R for low-pressure storage tanks for refrigerated products, and Appendix S for austenitic stainless steel tanks.

API 620 covers the requirements for design, materials, fabrication, inspection, examination, and testing. It also covers requirements for examination methods, procedures, acceptance criteria, and qualification of examination personnel. This article covers basic API 620 examination requirements, but not those for the appendixes.

The nondestructive examination (NDE) methods include magnetic particle testing (MT), liquid penetrant testing (PT), radiographic testing (RT), ultrasonic testing (UT), and visual examination (VT). Other applicable test methods include the vacuum box leak test and air-solution film leak test.

Examination Procedures

API Standard 620 requires that the magnetic particle method be performed in accordance with Article 7 of Section V of the ASME *Boiler and Pressure Vessel Code* (Ref. 2). The examination must be done in accordance with a written procedure that complies with the requirements of Article 1 of ASME Section V, Nondestructive Examination. The liquid penetrant method is required to be performed in accordance with Article 6 of ASME Section V. Penetrant testing must comply with the applicable requirements of ASME Section V, and RT must meet the requirements of Section V, Article 2. The ultrasonic examination requirements are outlined in Article 4 of Section V; written procedures must comply with the applicable requirements of ASME Section V. Visual examination requirements are outlined in API 620.



An example of automated ultrasonic weld testing.

Personnel Qualifications

API Standard 620 requires that MT and PT personnel meet the vision and competency requirements outlined in the standard. Radiographic and ultrasonic testing personnel are required to be qualified and certified by the manufacturer as meeting the guidelines of ASNT Recommended Practice SNT-TC-1A.

Extent of Examination

Magnetic Particle/Liquid Penetrant

1. Nozzle to tank sidewall and reinforcing plate welds and the sidewall to bottom reinforcing plate welds shall be examined for their entire length using magnetic particle examination. The magnetic particle examination shall be performed on the root pass, on every ½ in. of deposited weld metal while the weld is being made, and on the completed weld.

2. The attachment welding around all openings and their reinforcements in the walls of the tank shall be examined by the magnetic particle method both inside and outside the tank.

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3. Welds connecting permanent attachments (such as wind girders, stairs, gauging systems, davits, riser pipe supports, tank anchors, walkways, supports for internal items such as heating coils or other piping, ladders, floating roof supports welded to the shell wall and electrical conduits and fixtures) to the tank surface shall be inspected visually and by the magnetic particle method (or at the option of the purchaser, by the liquid penetrant method).

4. After any stress relieving, but before hydrostatic testing of the tank, welds attaching nozzles, manholes, and cleanout openings shall be examined visually and by the magnetic particle method (or at the option of the purchaser, the liquid penetrant method).

Radiographic/Ultrasonic Examinations

1. Examination for the quality of butt joint welds shall be made using either the radiographic method, or by agreement between the purchaser and manufacturer, using ultrasonic examination in lieu of radiography.

2. Complete examination is required for all double welded butt joints whenever the thinner of the plates or the tank wall thickness at the joint exceeds 1½ in. and the joint is subjected to tension stress greater than 0.1 times the specified minimum tensile strength of the material.

3. If radiographic or ultrasonic examination is considered impractical for final or closing-up joints because of the location or construction of the joint, magnetic particle examination may be substituted for radiographic or ultrasonic examination of the joint if the substitute procedure is applied at stages of the welding acceptable to the inspector and it indicates that the joint is sound. In no case shall this exception be interpreted to apply because equipment suitable for making the radiographic or ultrasonic examination is not available or is not in usable condition.

4. All such welded joints on which backing strips are to remain shall be examined by the magnetic particle method after the first two layers or beads of weld metal have been deposited and again after the joint has been completed.

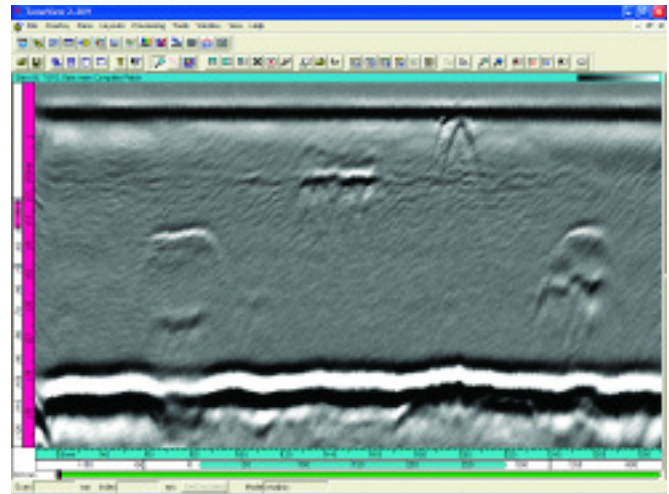
5. All longitudinal butt joint welds in the nozzle neck and transition piece if any, and the first circumferential butt joint weld in the neck closest to the sidewall, excluding neck to flange weld, shall receive 10% radiographic examination.

6. For all main butt joint welds that are not completely examined, spot examination is mandatory as follows:

- ◆ At least one spot shall be examined from the first 10 ft of completed joint of each type and thickness welded by each welder or welding operator.
- ◆ Thereafter, without regard to the number of welders and welding operators involved, one additional spot shall be examined for each additional 50 ft (or remaining fractional part of this length) of each type and thickness of welded joint. At least 25% of the selected spots shall be at junctions of vertical and horizontal joints with a minimum of two such intersections per tank.
- ◆ If more than one welding procedure is used or if more than one welder or welding operator does the welding, at least one spot shall be examined for each procedure and for each welder or welding operator.

7. Spot examination retests shall be performed as follows:

- ◆ When a spot has been examined and the welding does not comply with the standards prescribed for radiographic or ultrasonic examination, two additional spots shall be examined in the same joint at locations to be selected by the inspector, one on each side of the original spot. If any welding is found at either spot that fails to comply with the minimum quality requirements, additional spots nearby shall be examined until the limits of unacceptable welding are determined. In addition, the inspector may require that an additional spot be examined at one location selected by the inspector in each



A typical time of flight diffraction (TOFD) image.

joint not previously examined on which the same operator has welded. If any additional spot fails to comply with the minimum quality requirements, the limits of unacceptable welding shall be determined as in the original examination.

- ◆ All welding within the limit for spot examination found to be below the standards required for radiographic or ultrasonic examination shall be rejected. The rejected weld shall be removed and the weld shall be rewelded, or at the manufacturer's option, the entire unit of weld represented shall be completely examined and only the defective welding needs to be corrected.

Acceptance Criteria

Magnetic Particle/Liquid Penetrant

All examined surfaces shall be free of the following:

- ◆ Relevant linear indications.
- ◆ Relevant rounded indications over ⅜ in.
- ◆ Four or more rounded indications in a line separated by ⅜ in. or less edge to edge.

Radiographic Examination

The following indications are unacceptable:

- ◆ Any indication characterized as a crack or zone of incomplete fusion or penetration.
- ◆ Any other elongated indication on the radiograph that has length greater than ¼ in. for thicknesses (t) up to ⅜ in.; ⅓ t for ⅜ to 2¼ in.; ⅜ in. for t over 2¼ in. where t is the thickness of the weld excluding any allowable reinforcement.
- ◆ Any group of aligned indications that have an aggregate length greater than t in a length of 12t except when the distance between the successive imperfections exceed 6L where L is the length of the longest imperfection in the group.
- ◆ Rounded indications in excess of that specified in Appendix 4 (rounded indications charts) of Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code (Ref. 3).

Ultrasonic Examination

The acceptance criteria shall be in accordance with Appendix U of API 620.

Visual Examination

Visual examination requirements include material inspection, marking, and thickness verification; in-process inspection;

fabrication requirements, cleaning, end preparation, alignment; weld quality and reinforcement; and postweld heat treatment. Welding acceptance criteria is as follows:

A weld shall be acceptable by visual examination if the examination shows the following:

- ◆ The weld has no crater cracks or other surface cracks.
- ◆ Undercut does not exceed $\frac{1}{4}$ in. for longitudinal welds and $\frac{1}{2}$ in. for circumferential welds. For welds that attach nozzles, manholes, or clean-up openings, the maximum allowable undercut is $\frac{1}{4}$ in.
- ◆ The frequency of surface porosity in welds does not exceed one cluster (one or more pores) in each 4 in. of length and the maximum diameter of each cluster does not exceed $\frac{1}{2}$ in.
- ◆ Complete fusion and required penetration exists at the joint between the weld and the base metal.

Treatment of Unacceptable Welds.

Welds that fail to meet the visual examination criteria shall be reworked before hydrostatic testing in accordance with the following:

- ◆ Defects shall be repaired as required by API 620.
- ◆ Rewelding shall be required if the resulting thickness is below the minimum required for design and hydrostatic test conditions. All defects in areas above the minimum thickness shall be feathered to at least a 4:1 taper.
- ◆ The repaired weld shall be examined visually for defects.

Conclusion

The requirements mentioned in this article are considered the minimum inspection and NDE requirements for verification of weld quality and compliance with API Standard 620.

Additional requirements may be specified as agreed upon between the buyer and the manufacturer.❖

References

1. API Standard 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*. 2004. Washington, D.C.: American Petroleum Institute.
2. ASME *Boiler and Pressure Vessel Code*, Section V, Nondestructive Examination. 2004. New York, N.Y.: American Society of Mechanical Engineers.
3. ASME *Boiler and Pressure Vessel Code*, Section VIII, Rules for Construction of Pressure Vessels, Division 1. 2004. New York, N.Y.: American Society of Mechanical Engineers.

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