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Standard Practice

Design, Fabrication, and Inspection of Storage Tank Systems for Concentrated Fresh and Process Sulfuric Acid and Oleum at Ambient Temperatures

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Foreword

Sulfuric acid (H_2SO_4) is the largest-volume corrosive in use today and is generally considered the most important industrial chemical. Large storage tanks containing sulfuric acid or oleum are located in many areas.

Carbon steel corrodes moderately when in contact with concentrated sulfuric acid or oleum. If properly designed and adequately maintained, use of this material is an economical option for storage of these acids at moderate ambient temperatures. However, accelerated corrosion can occur in various forms, and several catastrophic failures that have focused attention on the hazards associated with undetected corrosion have occurred.

Large vertical sulfuric acid storage tanks are usually built to API[(1)] Standard 650,[1] and horizontal cylindrical tanks are built to the ASME[(2)] Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1.[2] While these standards/codes provide for sufficient material strength and toughness, they do not address the peculiarities of corrosion by sulfuric acid and oleum. Corrosion allowances and the design for corrosion control in these standards/codes are left to the individual designer, owner, or operator of the tank.

This standard provides recommended design, fabrication, and inspection practices for maintaining the mechanical integrity and minimizing the potential occurrence of undetected corrosion in concentrated fresh sulfuric acid tanks, process sulfuric acid tanks, or oleum storage tanks at atmospheric and low pressure. Inspection guidelines that aid in detecting and monitoring corrosion are presented, with the overall aim being to avert catastrophic failures. This standard is intended for use by sulfuric acid manufacturers and end users that have stationary sulfuric acid storage tank systems. Rail tank cars, tank trailers, barges, and portable tote containers for sulfuric acid are not within the scope of this standard. The standard may be used by personnel in many types of roles, including inspectors, plant maintenance personnel, plant engineers, consulting engineers, contract services personnel, etc. A wide variety of industries use sulfuric acid including, but not limited to, the chemical processing, agricultural, pharmaceutical, and hydrocarbon processing industries.

This standard was originally prepared by NACE International Task Group T-5A-18, a component of Unit Committee T-5A on Corrosion in Chemical Processes, in 1994. It was technically revised in 2006 by Task Group (TG) 217. This Task Group was administered by Specific Technology Group (STG) 36 on Process Industry—Chemicals, and is also sponsored by STG 03 on Protective Coatings and Linings—Immersion/Buried. This standard is issued by NACE International under the auspices of STG 36.

In NACE standards, the terms *shall, must, should*, and *may* are used in accordance with the definitions of these terms in the *NACE Publications Style Manual*, 4th ed., Paragraph 7.4.1.9. *Shall* and must are used to state mandatory requirements. The term *should* is used to state something considered good and is recommended but is not mandatory. The term *may* is used to state something considered optional.

(1) American Petroleum Institute (API), 1220 L St. NW, Washington, DC 20005-4070.
(2) ASME International (ASME), Three Park Ave., New York, NY 10016-5990.

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Contents

Section 1: General

1.1 This standard provides recommended design, fabrication, and inspection practices for maintaining the mechanical integrity of and minimizing the potential for the occurrence of undetected corrosion in concentrated fresh sulfuric acid tanks, process sulfuric acid tanks, or oleum storage tanks at atmospheric and low pressure. Inspection guidelines that aid in detecting and monitoring corrosion are presented, with the overall aim being to avert catastrophic failures. This standard is intended for use by sulfuric acid manufacturers and end users that have stationary sulfuric acid storage tank systems.

1.2 This standard covers the storage of fresh and process sulfuric acids and oleum that may be handled in carbon steel equipment. Typical fresh acid concentrations are 93% and 98% sulfuric acid. Process acid is sulfuric acid between 65% and 99.5% concentration that is recycled, purified, and/or concentrated in process units as part of a manufacturing process. Fresh acid and process acid may be referred to collectively in this standard as concentrated acid. Typical oleum concentrations range up to 65%.

1.3 This standard is intended for bulk acid at ambient temperatures. Situations in which the inlet stream is hotter than 40°C (104°F), the tank has heaters, or the geographical location results in a metal temperature greater than 40°C (104°F) require special consideration. In these cases, a materials engineer should be consulted to determine the materials of construction and corrosion allowance (see Paragraphs 2.6 and 2.7 for materials of construction and corrosion allowance considerations, respectively).

1.4 This standard covers vertical tanks for atmospheric pressure and low pressure built in accordance with API Standard 650 and API Standard 620,[3] respectively. API 650 covers atmospheric pressure tanks and API 620 covers tanks up to a gauge pressure of 100 kPa (15 psig). This standard covers horizontal tanks built in accordance with ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1. Vessels pressurized to transfer acid to other vessels without a pump are not in the scope of this standard.

1.5 Spent sulfuric acids from alkylation units and chemical processes can have significantly different corrosion rates from fresh and process sulfuric acid. In addition, there is a potential for deflagration in the vapor space of alkylation and chemical spent sulfuric acid tanks. Therefore, alkylation and chemical spent sulfuric acids are not within the scope this standard. See NACE Standard RP0205[4] for information on storing alkylation unit spent sulfuric acid.

1.6 Fresh acid typically has very low contaminant levels that do not impact corrosion performance. Sometimes, low levels of hydrogen sulfide (H_2S), hydrogen cyanide (HCN), or arsenic (As) may be present in fresh acid, depending on the origin of the raw materials and the manufacturing method. For example, fresh sulfuric acid manufactured with smelter sulfur may contain As. Process sulfuric acid may contain H_2S, HCN, or As because of the way it is used in a manufacturing process. Therefore, the potential effects of H_2S, HCN, and As on the corrosion performance of fresh acid and process acid are addressed in this standard.

1.7 This standard is based on good engineering practice. The underlying philosophy is that major failures can be avoided and minor incidents reduced to a minimum by ensuring a high degree of storage tank system integrity through good design and construction, followed by adequate and periodic inspection and maintenance. The end user should refer to this standard for guidance, but in all cases, the end user should:

- Prepare a tank specification that includes design, materials of construction, fabrication, inspection, and testing. Major acid suppliers can assist by providing examples of their specifications.
- Select an experienced and qualified designer and tank fabrication and erection contractor.
- Arrange for inspection during all stages of fabrication and construction to ensure the specification is being followed.
- Operate the tank within design limits.
- Monitor and maintain the condition of the tank in service through periodic inspection and maintenance.

1.8 This standard applies to all stationary sulfuric acid storage tank systems that contain fresh or process sulfuric acid or oleum at conditions within the scope of this standard. The sulfuric acid storage tank system is defined as the tank and piping internal to the tank and immediately adjacent to the tank, including acid recirculation pump piping loops associated with the tank. Piping up to the first safety device, double block and bleed valves, and appurtenances (e.g., vent goosenecks) are part of the sulfuric acid storage tank system. The sulfuric acid storage tank system also includes the berms, diking, and some tank siting issues. Rail tank cars, tank trailers, barges, and portable tote containers for sulfuric acid are not within the scope of this standard.

1.9 The symbol % is used throughout this standard to indicate the mass ratio of sulfuric acid to the total mass for sulfuric acid-water mixtures only.

1.10 Appendixes

1.10.1 Appendix A: Physical Properties of Concentrated Sulfuric Acid and Oleum

1.10.2 Appendix B: Corrosion-Resistant Alloys

1.10.3 Appendix C: Illustrations of Recommended Design

1.10.4 Appendix D: Radiographic Acceptance Standard for Welded Equipment in Corrosive Service

Section 2: Tank Design Criteria

2.1 Scope

API 620 and API 650 contain new tank construction requirements. The design criteria in Sections 2 and 3 of this standard contain additional requirements and recommendations for fresh and process sulfuric acid storage tanks intended to supplement the general tank requirements in API 620 and API 650. Existing tanks should be checked for compliance with this standard. In the case of notable differences, upgrades should be considered. For existing tanks with designs that differ from this standard, risk-based inspection (RBI) using API 510,[5] API RP 579,[6] API RP 580,[7] API Publication 581,[8] and API Standard 653,[9] or equivalent methods, should be used for determining inspection intervals and suitability for continued service.

2.2 Design Pressure

The design pressure shall not be less than the maximum liquid height plus pressure drop through the vent system.

2.3 Heating System

When freezing is a concern, a suitable heating system and proper insulation shall be used (see Paragraph 3.9).

2.4 Horizontal Tanks

Horizontal tanks shall be designed and fabricated in accordance with the ASME BPVC, Section VIII, Division 1, taking into account the lowest operating temperature and the specific weight of sulfuric acid (see Appendix A, Figures A1 and A2). The corrosion allowance shall be in accordance with Paragraph 2.7. A design pressure of 345 kPa (50 psig) is common for horizontal tanks even though horizontal tanks typically operate below 100 kPa (15 psig).

2.5 Vertical Tanks

Vertical tanks shall be designed in accordance with API 620 and/or API 650 and as appropriate for the specific weight and the lowest operating temperature of sulfuric acid (see Appendix A, Figures A1 and A2). The corrosion allowance shall be in accordance with Paragraph 2.7.

2.6 Materials of Construction

2.6.1 Carbon steel is the most widely used construction material for the storage of sulfuric acid within the concentration and temperature ranges covered by this standard[10-14] (see Paragraph 2.6.4). Only carbon steel that meets the following toughness requirements shall be used. Mechanical properties of selected materials, welds, and heat-affected zones (HAZs) must comply with applicable codes (e.g., ASME BPVC, Section VIII, Division 1) or standards (e.g., API 650, Section 2 [Materials] or API 620 Section 4 [Materials]) to ensure adequate toughness in worst-case service conditions. Additionally, the materials of construction shall be suitable for use at the minimum design metal temperature (MDMT) in accordance with API 650, Section 2 (Materials); API 620, Section 4 (Materials); or ASME BPVC, Section VIII, Division 1, Paragraph UCS-66.

2.6.2 Carbon steel with a specified maximum tensile strength exceeding 620 MPa (90 ksi) should not be used because of the potential for hydrogen embrittlement. For those environments with conditions that could promote hydrogen embrittlement, the end user should take appropriate steps to ensure that the tank materials and fabrication details are adequate to resist hydrogen embrittlement. Refer to NACE Standard RP0472[15] for further information on the potential effects of cathodic poisons like H_2S, HCN, and As. The end user shall have appropriate quality control procedures for the plate and tank fabrication to minimize the potential for damage from hydrogen embrittlement. Hardness values of welds and HAZs shall be reviewed. Weld HAZs that exceed a hardness of 22 HRC (approximately 248 HV microhardness, or 237 HBW hardness) may be more susceptible to hydrogen embrittlement; see NACE Standard MR0175/ISO[(3)] 15156[16] and NACE Standard MR0103.[17] The maximum acceptable hardness criterion is a matter of agreement between the end user and the tank fabricator. The hardness criteria should be based on the expected H_2S concentration in the tank contents, the possibility of moisture being present on the inside metal surface, the tensile strength, and the hardness characteristics of the base metal and weld metal (see API 620 and API 650 for additional information).

2.6.3 Low-alloy steels shall not be used as tank materials for new construction. Components made of gray cast iron should not be used in oleum service because this material can suffer cracking if exposed to oleum.

[(3)] International Organization for Standardization (ISO), Case Postale 56, Geneva CH-1211, Switzerland.