



NACE Standard RP0391-2001
Item No. 21050

Standard Recommended Practice

Materials for the Handling and Storage of Commercial Concentrated (90 to 100%) Sulfuric Acid at Ambient Temperatures

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Foreword

This standard recommended practice provides information for use in the design and selection of materials used in the handling and storage of commercial concentrated sulfuric acid (H₂SO₄) at ambient temperatures. Currently there is no uniform, industry-wide standard for handling sulfuric acid. The primary purpose of this standard is to provide information allowing the reader to make a more informed decision regarding the design and selection of materials. Only in sections containing information about which there is general agreement among users are specific recommendations made. This standard is intended to assist engineers and operations and maintenance personnel in the chemical process industries (CPI) who are involved in the design, modification, and maintenance of ambient-temperature, concentrated sulfuric acid systems and equipment.

This standard was originally prepared in 1991 by NACE Task Group T-5A-18, a component of Unit Committee T-5A on Corrosion in Chemical Processes. It was revised in 2001 by Task Group 216. This Task Group was composed of industry representatives from firms producing and using sulfuric acid. It is administered by Specific Technology Group (STG) 36 on Process Industry—Chemicals, and is sponsored by STG 03 on Protective Coatings and Linings—Immersion/Buried. This standard is issued by NACE 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. *Should* is used to state something considered good and is recommended but is not mandatory. *May* is used to state something considered optional.

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Section 1: General

1.1 This standard provides information about the design and selection of materials used in the handling and storage of commercial concentrated sulfuric acid at ambient temperatures. The term ambient is intended to include temperatures up to 50°C (120°F). This is the approximate maximum temperature that arises from solar heating of piping or vessels in a tropical climate.

1.2 This standard does not consider sulfuric acid strengths above 100% or below 90% by weight.

1.3 For completeness, this standard includes Appendix A, containing a listing of all alloys mentioned in this standard, and Appendix B, which gives guidance on applicable materials for a sulfuric acid dilution system.

1.4 Concentrated sulfuric acid is a colorless, odorless, syrupy liquid whose oily appearance suggested the name oleum (Latin for oil) to early chemists.⁽¹⁾ Today, the term oleum is used only for sulfuric acid containing free sulfur

trioxide. The term sulfuric acid is used to refer to acid that does not contain free sulfur trioxide.

1.5 The term concentrated sulfuric acid broadly refers to the concentration range of 90 to 100% by weight. Commercial acid is usually stored at 93% concentration because its minimum freezing point is -34°C (-30°F). Sulfuric acid is commonly transported in the 98 to 99.5% concentration range. The latter limit is imposed by the much greater corrosiveness of 100% sulfuric acid to carbon steel and by its higher freezing point of about 7°C (45°F).

1.6 Concentrated sulfuric acid is an oxidizing agent, and because of its affinity for water, it is also a desiccant. The major problems in its handling and storage relate to its hygroscopic nature (absorbing atmospheric humidity), the exothermic reactivity with water on dilution, and velocity effects that tend to accelerate corrosion of iron- and lead-based alloys.

Section 2: Specific Materials

2.1 Carbon Steel

2.1.1 Carbon steel is satisfactorily resistant to concentrated sulfuric acid at ambient temperatures under static or low-velocity conditions (less than 0.9 m/s [3 ft/s]); for some restrictions, see Paragraphs 2.1.4 and 3.3.6. The initially high corrosion rate is quickly reduced by the formation of an insoluble sulfate film that is highly protective unless physically disturbed. However, even at nominal flow velocities within the prescribed limits, rapid, localized attack may occur. For example, short-radius elbows or excessive internal protrusion of circumferential welds may cause downstream turbulence resulting in high corrosion rates.

2.1.2 An important form of accelerated localized attack is hydrogen grooving on vertical or inclined walls exposed to the liquid phase in piping or vessels. Hydrogen grooving is caused by evolution and movement of hydrogen bubbles, resulting in deterioration of the protective film.

2.1.3 Anodic protection is effective in minimizing corrosion and preventing hydrogen grooving.

2.1.4 In the 99.5 to 100% concentration range, increased corrosion rates may limit the fitness of carbon steel. The actual corrosion rate is strongly affected by temperature, acid concentration, ferrous and ferric ion concentration, flow conditions, and chloride contamination, because these parameters determine the dissolution rate and stability of the protective iron-sulfate film.

2.1.5 In all steel fabrication, weldments shall be thoroughly inspected to ensure that they do not contain slag, porosity, laps, or other welding defects that may initiate accelerated corrosion. Steel vessels and piping must also be free of mill scale, or serious local attack may occur (see also Paragraph 3.1.7).

2.1.6 Because of a lack of internal smoothness resulting in localized turbulence, threaded or socket-welded piping may cause accelerated corrosion. As an alternative, butt-welded and flanged carbon steel piping have been used successfully (see also Paragraph 3.1.6).

⁽¹⁾ Sulfuric acid was called oil of vitriol (from the Latin vitreum for glass) because of the glassy appearance of some metallic sulfates.