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# Guidelines and Best Practices for Titanium Storage Tanks for Sodium Hypochlorite

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# Storing Sodium Hypochlorite in Titanium Storage Tanks

Sodium hypochlorite is a hazardous chemical. Refer to published guidance from the Chlorine Institute for safe manufacturing, storage, handling and use of this chemical. The Chlorine Institute has many references available in their online bookstore on this topic at www.chlorineinstitute.org/products.

Titanium, grade 2, is an excellent material choice for storage of Sodium Hypochlorite. It is the longest lasting and lowest maintenance solution for storage tanks in this service. There are some key design, fabrication, operation and maintenance considerations to keep in mind to ensure maximum performance and reliability.

## Design Considerations

### API vs. ASME Code

The typical approach for design of non-pressure vessel bleach storage tanks from Titanium is to use a combination of American Petroleum Institute (API) and the American Society of Mechanical Engineers (ASME) standards.

- API Tanks:
  Titanium is not a listed material in API standards for storage tanks, such as API 650. API tanks are typically flat-bottom storage tanks designed for low pressure. They require uniform support, such as concrete foundations, and must be anchored for wind loads. For tanks with a diameter of less than 30 feet, a minimum wall thickness of 5/16 inches is recommended.

- ASME Tanks:
  Titanium is recognized as a material suitable for pressure vessel design under ASME Section VIII. ASME standard design methods focus on internal pressure and temperature when determining minimum required wall thickness. ASME design codes are for pressure vessels with a design pressure rating of 15 PSIG or more. ASME tanks require a code stamp (“U” stamp for new construction, “R” stamp for repairs). Welding procedures and welder qualifications are also governed by ASME Section IX, which is critical for maintaining the integrity of titanium welds in both shop and field applications.

It is impractical to design a low pressure storage tank as a pressure vessel, so aspects of API tank design like flat-bottom designs that require uniform support, concrete foundations, anchorage for wind loads, and minimum 5/16” wall thickness for diameters of less than 30 feet are used.

However, material properties and requirements from the ASME code should be used to make up for the lack of guidance in the API standards in this area. It is a conservative approach to use the stringent material properties and requirements from the ASME code in design of a titanium API tank, but it provides the ultimate assurance that RAGAGEP (Recognized And Generally Accepted Good Engineering Practices) has been employed in design and construction.

Excellent procedures, skilled workers and careful planning are required in titanium fabrication to ensure well-constructed, reliable equipment. For this reason, ASME Section IX requirements for welding procedures and welder qualifications are critical for maintaining the integrity of titanium welds in both shop and field applications.

The combination of API 650 and ASME Section VIII standards as described can be used to optimize the design of titanium bleach storage tanks, ensuring safety, performance, and compliance with regulatory requirements.

## Chemical Resistance

The corrosion resistance of titanium to moist chlorine gas and chloride-containing solutions is the basis for the largest number of titanium applications. Titanium is fully resistant to solutions of chlorites, hypochlorites, chlorates, perchlorates and chlorine dioxide. Titanium has been used to handle these chemicals in the pulp and paper industry for many years with no evidence of corrosion. Titanium is used today in nearly every piece of equipment handling wet chlorine or chlorine chemicals in a modern beach plant.[1]

The general corrosion rate for Titanium, grade 2 in Sodium Hypochlorite is quite good:

| Chemical | Concentration | Temperature | Corrosion Rate | Source of Data |
|---|---|---|---|---|
| Sodium Hypochlorite | 6% | Ambient | Non detectable | Corrosion Resistance of Titanium, TIMET, 1997 |
| Sodium Hypochlorite | 20% | 180 | <2 mpy | Compass Chemical Resistance Guide, 1995 |
| Sodium Hypochlorite | 0.5% | 212 | <2 mpy | Compass Chemical Resistance Guide, 1995 |

Titanium is immune to Microbiologically Induced Corrosion (MIC), has excellent resistance to stress corrosion cracking in hot chloride solutions, and exhibits excellent resistance to flow-induced and erosion corrosion at velocities above 40 m/sec.

Titanium can be susceptible to hydrogen embrittlement, although this is less of a problem for low-strength grades like grade 2. Hydrogen embrittlement generally occurs at temperature above 80˚C (175˚F), and when one of the following conditions also exist:

- the titanium is galvanically coupled to a dissimilar, active metal
- there is an impressed current
- the pH is less than 3
- the pH is greater than 12

Like all metals, galvanic corrosion can occur is dissimilar metals are electrically coupled in the presence of an electrolyte. Titanium is most noble than most other metals, so it will tend to act as the cathode and can accelerate the corrosion of the other metal it is coupled to.[2]

The limiting factor for application of titanium to aqueous chloride environments tends to be crevice corrosion. When crevices are present, titanium will sometimes corrode under conditions not predicted by general corrosion rates. Crevice corrosion can be prevented through temperature and pH control. Crevices can also be avoided or minimized with good engineering design and operational practices.

The following engineering design techniques that can help prevent or reduce crevice corrosion:

- Avoid Overlapping Joints: Overlapping joints can create crevices where corrosion may initiate. Whenever possible, use butt joints to minimize gaps.
- Use Continuous Welds: Specify continuous welds instead of spot or stitch welding to reduce the chances of crevice formation.
- Design to Eliminate Crevices: Design components to avoid features that could trap fluids or debris, such as sharp corners or tightly fitting parts.

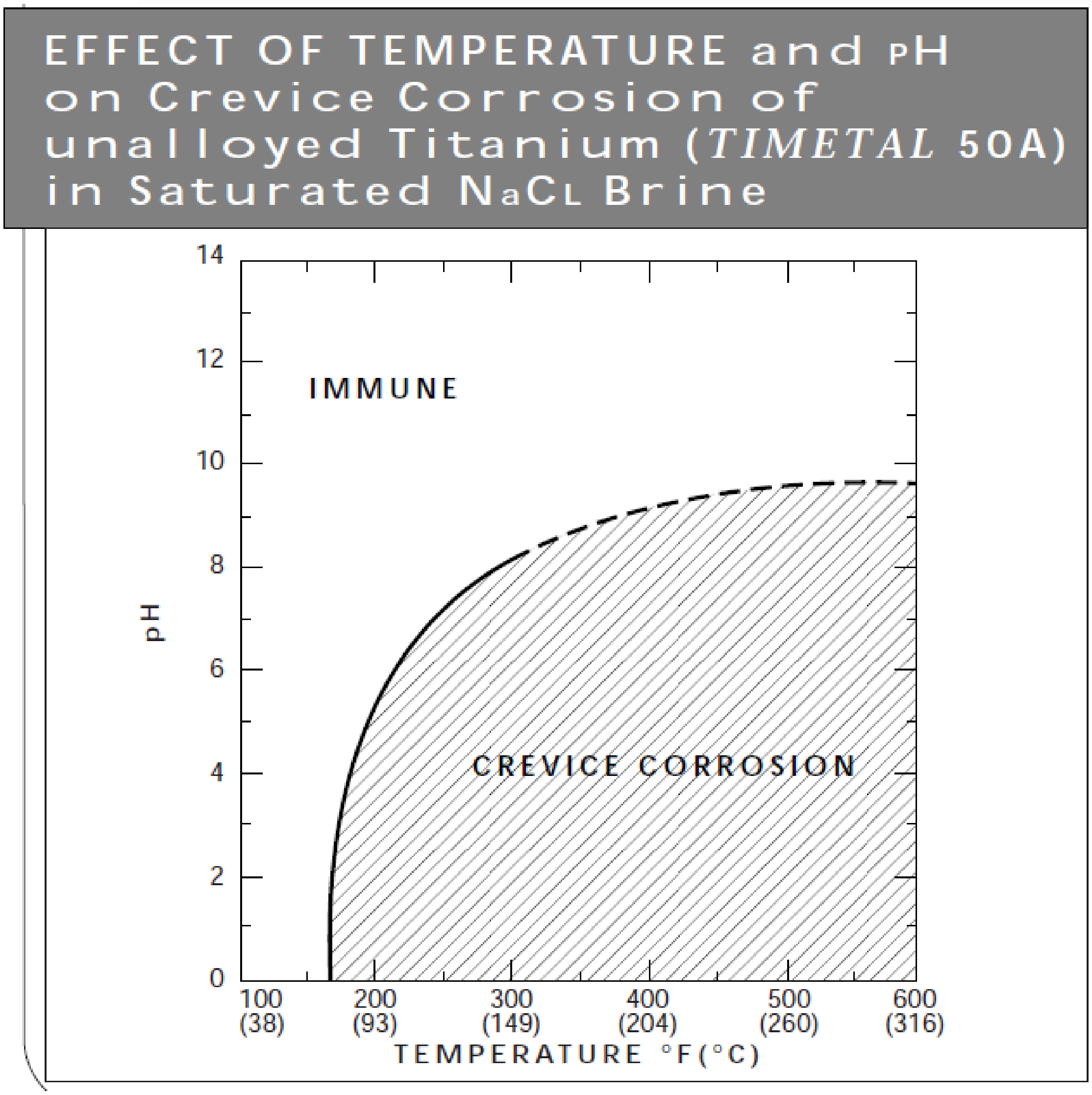
[1] Corrosion Resistance of Titanium, titanium Metals Corporation, 1997.

[2] Technical Data Sheet, Corrosion Resistant Titanium Alloys, Allegheny Ludlum Corporation, 1999.

- Ensure Good Weld Quality: Make sure that welded joints achieve full root penetration and avoid undercuts or cracks.
- Minimize Complex Weldments: Simplified designs reduce the risk of creating small, inaccessible spaces where crevices can form, improving weld quality overall.
- Avoid Stagnant Zones: Ensure that the pressure vessel design avoids areas where fluids could become stagnant, as this is a primary factor in crevice corrosion. This can include ensuring proper drainage and avoiding dead zones in the design.

If crevices are unavoidable, another approach is to upgrade to a more corrosion resistant alloy in those areas. For example, titanium Grade 7 is generally more resistant to crevice corrosion compared to Grade 2. So, on a titanium Grade 2 vessel design, Grade 7 material can be used in areas where at risk for crevice corrosion:

- Grade 7 material for lap rings/stub ends on all body flange and nozzle connections.
- Grade 7 filler metal in all process-wetted Grade 2 vessel weld joints.
- Grade 7 material for all vessel internals that have crevices where process fluid may sit or become stagnant.
- Use PGMA (Platinum Group Metal Applique techniques to provide protection in at risk areas.



## Fabrication Considerations

As mentioned in the engineering design section of this document, poor fabrication practices can impact titanium's probability of success in sodium hypochlorite service. Welding of reactive metals like titanium is highly specialized and should be done by a qualified shop to achieve highly reliable equipment.

It is recommended that ASME Section IX requirements for welding procedures and welder qualifications are followed. An additional reference which is invaluable and can be used to ensure a fabrication meets minimal quality expectations is AWS G2.4/G2.4M:2021, Guide for Fusion Welding or Titanium and Titanium Alloys.

## Operational Considerations

Atmospheric storage tanks require venting to avoid overpressure and/or building a vacuum during filling or emptying. This venting needs to be properly sized and maintained so that is remains clear and functional.

Contaminants entering the tank either with the sodium hypochlorite or through other mechanisms may affect the titanium, even in small amounts. As an example, titanium is incompatible with fluorides, even in parts per million levels. Consider the compatibility of any chemicals introduced into the tank for compatibility with titanium before proceeding.

Running outside of the operational limits considered in design of the tank could result in corrosion damage to the tank. Temperatures over 180 deg F, if not considered in design, could result in crevice corrosion. Similarly, pH below 3 or above 12 could result in crevice corrosion.

## Maintenance Considerations

Any cleaning and/or neutralization chemicals, temperatures, as well as cleaning methods for tank prep must be evaluated to ensure no damage to the titanium. Titanium has great chemical resistance to a wide range of chemicals, but short exposures to the wrong one could do significant damage, even over a short time period.

Do awareness training with maintenance personnel and anyone who may be entering the titanium storage tank. Like any reactive metal or non-metallic material of construction, steps must be taken to avoid damage to the tank material. Cover any metal buckles or clips on safety harnesses with several layers of tape. Check boot soles for cleanliness before entry. Keep hand tools in a soft bag that are handed/lowered to the person in the tank rather than carrying them with you as you enter. Do not grind, impact, cut or otherwise mar the titanium surface with steel tools or tooling that has been used on steel in prior jobs. Do not allow weld spatter to fall onto titanium. Do not allow persons who are not trained in titanium to modify or repair the tank. Embedment of small particles of steel or some other alloys can result in pitting corrosion of titanium in service by creating a small galvanic cell. This is why good fabrication practices like segregation of metals are very important for this type of equipment.

## Conclusion

Titanium is quite often the optimal material for storage of sodium hypochlorite when all of the costs over the lifetime of the plant needs are considered. However, this success only comes as a result of a good engineering design, excellent fabrication practices, and solid maintenance and operating procedures once it is in the plant.

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