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Introduction
Introduction

Sodium hypochlorite, also known as hypochlorite, hypo, bleach or NaOCl, is used in a wide range of industrial settings. Olin has long been regarded as a dependable source of sodium hypochlorite, and our recent innovation in distribution has established Olin as the clear lead supplier of industrial bleach in North America.

Historically, sodium hypochlorite was transported by tank trailer to nearby markets. Beginning in 2007, Olin initiated tank car service across North America for sodium hypochlorite, allowing for long-distance transportation. No longer is sodium hypochlorite distribution considered a local activity. This innovative transportation mode, along with production and distribution facilities located strategically across the United States and eastern Canada, has transformed Olin into the largest producer of sodium hypochlorite in North America.

Olin’s reliable supply of sodium hypochlorite offers you the quality you need in a wide variety of concentrations, and is backed by a customer support network that only Olin can provide. Check with your Olin representative for particular solution strengths available in your market.

Safety

At Olin, safety and quality are integral to everything we do. Our goal is zero when it comes to safety incidents, with a focus on preventing accidents, injuries, and chemical incidents not only within Olin, but also in the communities we touch. Olin has internal processes to foster continuous improvement in the areas of product quality, environmental protection, safety, and product stewardship.

Responsible Care®

Olin has a long-standing policy to ensure that its operations do not have an adverse impact on the community or the environment. Olin is committed to the guiding principles of Responsible Care®, a continuing effort by the chemical industry to improve the responsible management of chemicals.

As a Responsible Care® Company, Olin follows the 12 Guiding Principles and Codes of Management Practices that cover all aspects of research, development, manufacture, distribution, transportation, use, and disposal of products. These principles also extend to prompt reporting, customer counseling, community awareness, support of external research, and promotion of Responsible Care® worldwide.

Olin recognizes that no single entity can fully protect the quality of our environment. However, by working together on a global basis, the public, industry, and government can make the future brighter and safer.

The Chlorine Institute and Continuous Improvement

Olin has a long history of embracing and promoting chemical safety and is a founding member of The Chlorine Institute. The Chlorine Institute is a technical trade association of companies involved in the safe production, distribution, and use of chlorine, sodium and potassium hydroxides, sodium hypochlorite, and hydrogen chloride. Since its founding in 1924, Olin has supported The Chlorine Institute in promoting the continuous improvement in safety, protection of human health and the environment, and security associated with the production, transportation, handling, and use of sodium hypochlorite and other chlor alkali chemicals. As a Chlorine Institute member, Olin is committed to adopting the Institute’s safety and stewardship initiatives to achieve measurable improvement over time. A number of Chlorine Institute bulletins and pamphlets discussing the safe handling of sodium hypochlorite are referenced in this handbook.

Olin is also an active member of the American Chemistry Council (ACC), America’s oldest trade association of its kind. The ACC represents companies engaged in the business of chemistry who are committed to continuously improving the safety, health, environmental, and security performance of the chemical industry. In addition, Olin is an active member of the Chemistry Industry Association of Canada (CIAC). The CIAC is a trade association representing Canada’s leading chemistry companies adhering to the principles of the ACC-initiated Responsible Care® program, which is now a global initiative with a focus on sustainable stewardship. We incorporated the ACC’S Responsible Care® program and the CIAC’s standards into our business model at their introduction into the marketplace. Key aspects of the ACC’s and CIAC’s Responsible Care® initiatives include:

- Commitment made by the chemical industry to the safe, responsible, and sustainable management of chemicals through their entire life cycle, and for their intended end use.
- World-class performance initiative for the chemical industry.
- Companies who are industry leaders, bound together by a commitment to address challenges and continuously improve the performance of the chemical industry.
- Verifiable management systems to achieve Responsible Care® goals via third-party auditors.

Olin has a number of programs intended to foster continuous improvement with use of our chemicals. This handbook is intended to assist customers in understanding the chemistry, delivery, receipt, storage, and safe handling of sodium hypochlorite solutions – to help safeguard employee health, encourage safe working practices, and protect the environment when working with sodium hypochlorite. The handbook’s content primarily focuses on 12.5% by weight sodium hypochlorite, a predominant solution strength in North America, along with some information concerning Olin’s HyPure® Bleach.
Customer Notice

Olin strongly encourages its customers to review both their handling processes and their applications of Olin products from the standpoint of human health and environmental quality. To help ensure that Olin products are not used in ways for which they are not intended or tested, Olin personnel are prepared to assist customers in dealing with ecological and product safety considerations. Your Olin representative can arrange the proper contacts. Also, Olin product literature, including Safety Data Sheets (SDS), should be consulted prior to use of Olin products. For copies, contact your Olin representative or the Olin location nearest you.

Olin believes the information and suggestions contained in this manual to be accurate and reliable as of publication date. However, since use conditions and disposal are not within its control, Olin assumes no obligation or liability for such assistance and does not guarantee results from use of such products or other information herein. No warranty, express or implied, is given nor is freedom from any patent owned by Olin or others to be inferred.

Information herein concerning laws and regulations is based on U.S. federal laws and regulations, except when specific reference is made to those of other jurisdictions. Since use conditions and governmental regulations may differ from one location to another and may change with time, it is the customer’s responsibility to determine whether Olin’s products are appropriate for the customer’s use, and to assure that the customer’s workplace and disposal practices are in compliance with laws, regulations, ordinances, and other governmental enactments applicable in the jurisdiction(s) having authority over the customer’s operations.
At Olin, our Product Stewardship program is guided by our core values of Integrity, Customer Success, Innovation, and People. We are committed to the safe handling and use of our products – and enabling all of our collaborators throughout the value chain to do the same. As a Responsible Care® company, we assess the safety, health, and environmental information on our products, and then take appropriate steps to protect employees, public health, and the environment. Ultimately, the success of our product stewardship program rests with each and every individual involved with Olin products – from the initial concept and research to the manufacture, sale, distribution, use, disposal, and recycling of each product.
Manufacturing

Locations

Olin has multiple sites throughout North America that manufacture sodium hypochlorite solutions, commonly referred to as “bleach.” The capabilities of these sites are similar with slight differences in the grades of product available to meet specific market needs. Olin is uniquely positioned to service your sodium hypochlorite needs as a true integrated North American manufacturer with production facilities and terminals located throughout the United States and eastern Canada. Production sites are shown on the map included in this section. Through our network of manufacturing facilities, shipping equipment, and terminals, we can ship just about anywhere within the United States and North America. For more information about your specific needs, contact an Olin representative.

Product Grades

Sodium hypochlorite solution grades are typically defined by differences in product assay and/or alkalinity content. From an industrial perspective, Olin offers a variety of different product strengths depending on industries served and local market demands with 12.5 and 15.5 weight percent as NaOCl solutions being the most prevalent. Olin production facilities incorporate additional blending systems that provide the ability to customize the assay and alkalinity component concentrations to meet particular application requirements.

Olin also manufactures a high-strength, low-salt sodium hypochlorite solution known as HyPure® Sodium Hypochlorite or HyPure® Bleach (HPB), which has an assay of up to 23 weight percent as NaOCl. HyPure® Bleach is not available in all North American markets (for example, western U.S. and west-Canada provinces) and may not be suitable for your process. Contact your Olin representative for further discussions of HyPure® Bleach and its availability in your market.
(KAc) and water.

1 mole of iodine (I₂), 1 mole of salt (NaCl), 2 moles of Potassium Acetate

Equation 2 shows the oxidation of 2 moles of potassium iodide (KI) with 1 mole of sodium hypochlorite in a solution of acetic acid (HAc) yields one mole of iodine (I₂) and 2 moles of salt (KCl).

Equation 3 shows the oxidation of 2 moles of potassium iodide (KI) with 1 mole of chlorine yields one mole of iodine (I₂) and 2 moles of salt (KCl).

In other words, a mole of sodium hypochlorite will oxidize the same amount of iodide as will a mole of chlorine. The molecular weight of NaOCl is 74.5 (23 + 16 + 35.5); the molecular weight of chlorine (Cl₂) is 71 (2 × 35.5). The term “available chlorine” was coined to describe this relationship in the sodium hypochlorite context. The ratio of molecular weights (74.5/71), or 1.05, quantifies this relationship.

To relate gallons of sodium hypochlorite solution to pounds of chlorine, the hypochlorite’s strength as expressed in units of available Cl₂ must be converted to the equivalent pounds of chlorine to answer the question above using the equation:

Equation 4:

\[ \text{Avail. Cl}_2 \text{ g/L (A) X 3.785 liters/U.S. Gal X 2.205 lbs./1000 grams = lbs. Avail. Cl}_2/\text{U.S. Gal solution} \]

For example, 120 g/L available Cl₂ X 3.785 X 2.205/1000 = 1 pound available Cl₂/gallon of solution. Expressed differently, one gallon of sodium hypochlorite solution having 120g/L available chlorine provides the equivalent oxidizing power of one pound of chlorine, (120 g/L available Cl₂ = 1 lb. chlorine per gallon of solution). The unique one-to-one ratio provides a convenient basis point when other hypochlorite solution strengths (in grams per liter of available Cl₂) are considered.

When evaluating other hypochlorite solutions for chlorine equivalency using available chlorine, always divide the grams per liter available chlorine by 120 g/L. For example, (150 g/L available Cl₂ /120 g/L avail. Cl₂) = 1.25.

In this example, one gallon of 150 g/L available Cl₂ solution yields the equivalent of 1.25 pounds of chlorine gas. This ratio will then indicate how much more (or less) equivalent chlorine is present in a given hypochlorite solution compared to a fixed amount of chlorine gas. Similar calculations can be performed using wt% NaOCl provided the solution density is known.
Importance of Density

Density is a prevalent analytical tool used in petroleum and some chemical industries to quickly identify contaminations and correlate product quality without the use of expensive laboratory instrumentation or performance of time-intensive “wet chemistry” tests. Appropriate applications for use of density determination in sodium hypochlorite should be well-understood and judiciously chosen. When determining weight-based calculations, performing an actual density analysis is critical to predicting the most precise assay value for a just-collected sample. However, the unique nuances associated with chemical composition and production, as well as the decomposition attribute of sodium hypochlorite, can lead to erroneous conclusions when density is incorrectly used to predict hypochlorite solution assay. The specific gravity/density of a solution of chemical compounds is a function of the compounds (what and how much) that make up the solution. HyPure® Bleach solutions have significantly lower concentrations of sodium chloride as compared to the same strength of standard bleach solutions and therefore have a lower specific gravity/density.

Sodium hypochlorite density is affected by a variety of factors. It is important to remember that the correlation between sodium hypochlorite concentration and density is not exact because all bleach solutions are a mixture of a number of chemical compounds, such as sodium chloride, sodium hydroxide, etc. Therefore, a small change in one of these compounds will alter the density without changing the sodium hypochlorite concentration. For example:

- **Density Effect on Flow Measurement**
  - Flow measurement instruments such as mag meters that are affected by changes will have to be adjusted for this density difference. Devices that use volume displacement device (rotameters, metering pumps, vortex meters, etc.) will not be affected.

- **Level Measurement**
  - Level instrumentation that relies on pressure (pressure gauges, differential pressure cells, etc.) will need to be recalibrated based on the new density.

- **Converting Between Volume and Weight Units**
  - The density difference must be accounted for when converting between weight and U.S. gallons.
  - Converting shipping container net weight to gallons.
  - Filling bottles by volume and then weighing the finished goods.

- Conversion between weight % and grams per liter (GPL) or trade %. The ‘Sodium Hypochlorite Solution Stability and Density at 70°F’ graph illustrates how density affects this conversion.

**Graph 1: Bleach Stability and Density at 70°F**

![Graph 1: Bleach Stability and Density at 70°F](image)

Note: See Appendix for larger graph

Sodium hypochlorite strength is time dependent, with all solutions starting to lose assay immediately after production. Unlike hypochlorite strength, density will remain unchanged over time. For immediately produced product, density will generally correlate with assay. However, the correlation will continue to change as the solution ages and will yield increasingly erroneous conclusions the older the hypochlorite solution is. Other factors such as metallic content of the hypochlorite, temperature exposure, and solution age become increasingly critical with time because product assay is significantly affected by these contributors. These attributes provide the rationale explaining why an aged hypochlorite solution will have a significantly different assay than a freshly produced one, but density of the solutions will remain unchanged. As a result, **hypochlorite solution density (or specific gravity), should not be specified in chemical purchase specifications or acceptance criteria because it is not a reliable predictor of sodium hypochlorite strength. When precision is required for determining strength, assay titration is preferred.**

For applications where density must be determined, there are several different test methodologies available, including density meters, hydrometers, or use of a pipette-and-weigh combination. When determining density via meter or hydrometer, the results will need to be temperature-adjusted to yield the most accurate results. Facilities that have an analytical balance accurate to four decimal places often favor the pipette-and-weigh method. In this method, a 10mL sample is pipetted into a sample bottle and weighed. The corresponding weight is then divided by the sample volume (10mL) to obtain the solution density.

**Decomposition**

All sodium hypochlorite solutions continually decompose on standing after they are produced. Decomposition cannot be avoided, but the rate of degradation can be slowed. The effects of time, temperature, hypochlorite/ionic strength, and exposure to trace metals are significant contributors.
Decomposition rates will be affected by impurities and handling conditions. Equation 5 depicts the temperature-controlled decomposition reaction. The thermal decomposition route primarily results in production of chloride and chlorate ions.

**Equation 5:**

\[ 3 \text{NaOCl} + \text{Temperature & Time} \rightarrow 2 \text{NaCl} + \text{NaClO}_3 \]

The presence of trace metals catalyzes the sodium hypochlorite decomposition according the following equation, which produces oxygen and salt. Small bubbles of the gas will emanate from these particles and rise to the surface provide telltale evidence of this problematic reaction. Many times, these gas bubbles are barely visible to the naked eye or require use of a microscope to see. Small amounts of nickel, cobalt, and copper are particularly reactive even at parts per billion (ppb) levels. Oxygen generation and the corresponding loss in assay (NaOCl) will continue until all hypochlorite has been decomposed or until the trace metal has been removed from the solution. Operational and safety concerns are associated with this reaction (Eq.6). In some situations, oxygen content may be significant.

**Temperature Impact on Stability**

In most situations, the temperature and concentration at which the sodium hypochlorite solutions are stored have the most impact on their stability because decomposition is slowed as concentration and temperature decrease, assuming all other conditions are similar and unchanged. As a general rule, lower concentration solutions are more stable than higher strength solutions, assuming that other conditions such as temperatures, pH and metal ion concentrations are similar. Studies of sodium hypochlorite solutions have shown that the decomposition rate increases by a factor of approximately two to four times for every 10°C (18°F) temperature rise. See the adjacent decomposition charts. In order to determine your best option for minimizing product decomposition, each application should be reviewed based on hypochlorite strength, storage temperature, and storage time. Closely related to temperature exposure is ultraviolet light-induced decomposition. Shielding of storage systems and qualification samples from sunlight exposure can eliminate this variable.

HyPure® Bleach (see adjacent Decomposition Graphs) exhibits different decomposition characteristics as compared to standard sodium hypochlorite solutions. Concentrated HyPure® Bleach will actually degrade at a faster rate than other sodium hypochlorite solutions as a result of the additional amount of active ingredient.

However, once diluted, HyPure® Bleach exhibits a slower decomposition rate compared to a standard sodium hypochlorite solution of equal product assay. We can look at this two different ways:

- At the same assay and temperature, HyPure® Bleach is about 40% more stable than standard bleach.
- At the same temperature, a 20% stronger solution of HyPure® Bleach will have the same stability as standard bleach.

The total amount of all chemical compounds dissolved in any bleach solution is a major factor in determining how stable the bleach is.
The higher the purity of the bleach solution, the more stable it is. By removing salt in the manufacturing process, Olin manufactures a more pure product, which once diluted, offers greater stability of the solution.

For example:

- A 12.5% (wt% NaOCl) solution of sodium hypochlorite will decompose to about 11.1% when stored for 20 days at 70°F. The same concentration of diluted HyPure® Bleach will only decompose to about 11.9% in the same conditions.
- A 15.5 wt% NaOCl solution of sodium hypochlorite will degrade to approximately 12.5 wt% NaOCl over 20 days at 70°F. The same concentration of diluted HyPure® Bleach will be at approximately 14.0 wt% NaOCl after 20 days at 70°F.

**Equation 6:**

\[ 2 \text{ NaOCl} + \text{ Metals} \rightarrow 2 \text{ NaCl} + \text{O}_2 \]

**Metals Impact on Stability**

Exposure to certain metals can also affect stability of both sodium hypochlorite and HyPure® Bleach. Nickel, cobalt, copper, and iron have the greatest impact, respectively.

**Graph 5: Metal-Induced Assay Loss (g/L) vs. Time (Hours)**

![Graph showing metal-induced assay loss](image)

Note: See Appendix for larger graphs

The Metal-Induced Assay Loss graph depicts the significance of trace metallic exposure to hypochlorite stability. While cobalt is particularly reactive with sodium hypochlorite solutions, it is rarely found in day-to-day operations and shipments, and therefore is typically not a significant contributor in most applications. On the other hand, nickel is often encountered since stainless steel are used in many chemical handling applications. Simply transferring sodium hypochlorite through an unlined stainless steel hose connector can initiate the decomposition reaction because of the presence of the nickel component in stainless steel.

The major sources of metallic contamination are the quality of caustic soda and dilution water used in the manufacturing process, and the exposure to metals during delivery and handling. Many manufacturing processes incorporate various types of filtration to control and/or remove metallic contamination. However, for certain applications such as product bottling, additional filtration steps may be required to further reduce metallic contents. Customer-controlled exposure opportunities encompass all areas of product handling beginning at the unloading process and continuing through to product formulation and use. Because of the potential significant impact to product quality, a rigorous management of all handling processes will be required to ensure all wetted surfaces are metals-free (except for titanium and tantalum).

Solution pH also can affect sodium hypochlorite stability. For most sites receiving inbound sodium hypochlorite, pH is not a significant stability factor as the importance of alkalinity (the ultimate source of pH) is well-understood by most commercial producers. Because of this, adequate alkalinity (and the resulting pH level) is added at the point of manufacture. However, alkalinity levels can become an important consideration for customers who significantly change the solution composition, such as in major product dilution, formulation, or during spill neutralization activities. Stability can be adversely affected by either too little or too much alkalinity. An alkalinity level of at least 0.1 weight % as NaOH is the typical minimum alkalinity needed for stability. Your process may dictate the need for a higher alkalinity.

**Dilution**

Dilution of sodium hypochlorite is often chosen by customers to slow the rate of product decomposition while in storage or to meet assay-specific applications. Although many sources of water can be used for sodium hypochlorite dilution, the most important aspects to consider when choosing a dilution water source are generally hardness and metals content. Hard water (high calcium and magnesium content) can cause precipitates and scaling to occur in sodium hypochlorite solutions. Exposure of sodium hypochlorite to dissolved metals in dilution water can accelerate product decomposition similar to physical contact with metallic components and/or may alter the color of the hypochlorite solution. In general, as water quality improves, product scaling and precipitation are reduced and decomposition rates decrease.

The dilution water should be analyzed to develop an impurity profile. Depending upon impurities, a treatment system may be required to upgrade water quality to help minimize quality problems with the diluted product. A reputable water treatment specialist can determine the best treatment method and capacity to generate purified water for your particular application. Table 1 summarizes typical water impurities of concern when diluting hypochlorite solutions. For bottling operations, additional water treatment and product filtration may be required. Consult your Olin Technical Representative if additional information is needed.
Properties

Table 1: Typical Dilution Water Impurities

<table>
<thead>
<tr>
<th>Component</th>
<th>Nickel</th>
<th>Copper</th>
<th>Cobalt</th>
<th>Iron</th>
<th>Silica</th>
<th>Conductivity</th>
<th>Total Dissolved Solids</th>
<th>Total Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Dilution and Excess Residual Alkalinity**

Another consideration for significant strength dilutions is the excess alkalinity in the diluted product. For minor dilutions, the excess actual sodium hydroxide content in the product should be sufficient to maintain the minimum level of about 0.1 wt% to ensure product stability. With more significant dilutions, a small addition of caustic soda (sodium hydroxide) may be required to achieve the minimum level necessary for a stable product. The quality of the caustic soda added can also negatively impact sodium hypochlorite quality, especially in the areas of trace metals and salts.

Unlike dilution of hypochlorite with water which is non-exothermic, addition of significant quantities of caustic soda will result in a temperature gain of the solution. Solution cooling capabilities may be required for large volume alkali additions to minimize temperature-induced product decomposition.

All sodium hypochlorite solutions require residual alkalinity, particularly sodium hydroxide, to ensure product stability and to avoid generation of chlorine gas. Sodium hydroxide and sodium carbonate are the typical alkalinity sources. Sodium carbonate is not as effective in stabilizing hypochlorite solutions, and is typically not intentionally added to achieve higher alkalinity contents. Alkalinity determination becomes particularly important in dilution activities or in chlorine-scrubbing applications where dilute sodium hypochlorite is being produced. Review the Residual Alkalinity Analytical Testing section for more information.

**Crystallization Points**

The freezing or crystallization temperature for bleach solutions is generally a function of the hypochlorite concentration. Since sodium hypochlorite solutions can contain varying amounts of several dissolved salts, the ability to accurately predict the crystallization point of the solution can be difficult. The amount of crystallization and the exact temperature at which these attributes begin to appear are composition-specific and may vary noticeably. For example, identical solution “grades” of product supplied from different manufacturers or production facilities will probably exhibit differing crystallization properties when subjected to the same temperature conditions. Solutions with higher concentrations of hypochlorite and/or the other dissolved salts will generally begin to crystallize at higher ambient temperatures than solutions containing lower concentrations of hypochlorite and/or the other salts.

Frozen hypochlorite solutions can be thawed and used; however, care must be exercised to avoid excessive heat application that will initiate temperature decomposition of the solution. In some instances, the crystallization process may result in precipitation of suspended materials that will not easily dissolve upon thawing. Crystallization effects typically first appear on the solution surface or in small diameter piping/tubing subjected to no or low-flow conditions.

**Table 2: Crystallization Points (Chlorine Institute Data)**

<table>
<thead>
<tr>
<th>Weight % NaOCl</th>
<th>Crystallization Point (°F)</th>
<th>Crystallization Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.0</td>
<td>28</td>
<td>-2.2</td>
</tr>
<tr>
<td>15.5</td>
<td>-21.5</td>
<td>-29.6</td>
</tr>
<tr>
<td>12</td>
<td>-3</td>
<td>-19.4</td>
</tr>
<tr>
<td>6</td>
<td>18.5</td>
<td>-7.5</td>
</tr>
</tbody>
</table>

Care should be taken to prevent any bleach solution from freezing. At higher hypochlorite concentrations, the crystals that form when the solution freezes are very corrosive to skin and eyes and should not be handled. These crystals can also cause plugging in piping and equipment. To prevent the material from freezing, tank cars, tank trucks and piping should be unloaded/drained promptly in cold weather. In extremely cold climates, strong bleach solutions could be diluted to lower the freezing point, which will also increase the stability of the material.
Several of Olin’s manufacturing sites produce chlorine and sodium hydroxide solutions that provide the raw materials for sodium hypochlorite production at all manufacturing sites. Sodium hypochlorite is easily produced in batch and continuous processes by the introduction of chlorine into a diluted sodium hydroxide solution. The ratio of chlorine addition to the amount of sodium hydroxide is controlled to allow for the excess caustic necessary to stabilize the final product. Automated blending equipment allows for meeting various customer quality and strength requirements depending on the final application. Once chlorination is completed, product is filtered to remove suspended impurities and then chilled before being sent to storage or shipping container loading. By incorporating filtration and cooling steps as integral components at our continuous manufacturing process, customers receiving Olin-produced sodium hypochlorite are provided an inherent advantage, as these two practices play important roles in minimizing product decomposition.

Olin’s HyPure® Bleach is manufactured using proprietary technology, which produces a super concentrated, low-salt hypochlorite product. As the name implies, HyPure® Sodium Hypochlorite is higher in purity due to the lower sodium chloride content. As a result, once it is diluted to a solution strength comparable to standard sodium hypochlorite, it is more stable. HyPure® Bleach is manufactured at concentrations up to 23 wt% NaOCl and then undergoes further processing to remove additional trace metals and salt (NaCl). This increased purity means a slight difference in the physical and chemical properties of the product when comparing HyPure® Bleach to standard sodium hypochlorite.

This special product has limited availability in North America. Contact your Olin Sales representative for details.
### Concentration Units

**Concentration**

Strength or concentration of sodium hypochlorite may be expressed in a number of different ways in supplier certificates of quality, invoices, product labels, dosage rates, or bid requirements. As a result, it is always critical to specify the units of concentration when referencing product strength. The table below illustrates the importance of specifying assay units. A 12.5 weight percent NaOCl solution (a common industry strength standard) is considerably different from a 12.5 trade percent solution. Additionally, a 12.5 weight percent solution is not the same as a 12.5 solution having units of volume percent. ALWAYS specify units of concentration!

**Table 3: Concentration of Sodium Hypochlorite**

<table>
<thead>
<tr>
<th>wt% NaOCl (g NaOCl/100 g soln)</th>
<th>Wt% AvCl2 (g AvCl2/100 g soln)</th>
<th>g/L AvCl2 (g/L soln)</th>
<th>Trade %</th>
<th>Equivalent Cl2 Soln. (lb Cl2/ gal soln)</th>
<th>Density (Theoretical) g/ml</th>
<th>lb/gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.25</td>
<td>5.0</td>
<td>54</td>
<td>5.4</td>
<td>0.45</td>
<td>1.0793</td>
<td>8.99</td>
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<tr>
<td>6</td>
<td>5.7</td>
<td>62</td>
<td>6.2</td>
<td>0.52</td>
<td>1.0904</td>
<td>9.09</td>
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<tr>
<td>7</td>
<td>6.7</td>
<td>74</td>
<td>7.4</td>
<td>0.62</td>
<td>1.1053</td>
<td>9.21</td>
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<tr>
<td>8</td>
<td>7.6</td>
<td>85</td>
<td>8.5</td>
<td>0.71</td>
<td>1.1204</td>
<td>9.34</td>
</tr>
<tr>
<td>9</td>
<td>8.6</td>
<td>97</td>
<td>9.7</td>
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Note 1: The conversion between wt% NaOCl, g/L AvCl2 and Trade % will change depending on the density used in the calculation.

AvCl2 = Available Chlorine Soln. = Solution
g/L = gram per liter or gpl

One of the complicating factors in converting units involves the role of the density in the calculation. Some units of measure, such as weight percent (wt%), compare the weight of NaOCl (gram) to the solution weight (100 grams) while other units, such as grams per liter (g/L), compare the weight of the NaOCl (grams) to the solution volume (liter).

When converting between these units, the density of the solution must be used in the calculation. Because there is no direct relationship between density and concentration for sodium hypochlorite solutions, the conversion between weight % and trade % can never be precise unless density of the particular solution in question is measured.

Within a given context, such as a company department, a manufacturer’s production and customer service group, or the order between a customer and a specific supplier, the communication of concentration may be well understood. For clarity when dealing with others outside that context, units should always be clearly defined and mentioned in the communication.
Shipping

Hazardous Materials Transportation System

The safe transport of hazardous materials such as sodium hypochlorite involves different organizations:

- Regulatory Agencies (Department of Transportation, Transport Canada, Federal Railroad Administration, etc.)
- Manufacturer (Olin)
- Carriers (Railroads & Trucking Companies)
- Receiving Customer

Each of the organizations plays an important role in the safe shipment of hazardous materials.

Table 4: Shipping Organizations

<table>
<thead>
<tr>
<th>Shipping Mode</th>
<th>Enforcement Agency</th>
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<tbody>
<tr>
<td>Rail</td>
<td>Federal Railroad Administration (FRA); Transport Canada</td>
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<tr>
<td>Roadway</td>
<td>Department of Transportation (DOT); Transport Canada</td>
</tr>
<tr>
<td>Pipeline</td>
<td>Department of Transportation (DOT); State Regulatory Commission; Transport Canada</td>
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</table>

The regulatory agencies are the governing bodies in the transportation arena that oversee the safe movement of all hazardous materials whether by land, air, or water. They define and enforce the rules for the safe handling and transport of hazardous materials. Each regulatory agency has an enforcement arm to assure compliance with record-keeping and equipment regulations. Penalties including fines and imprisonment can be imposed for violations applicable of regulatory requirements.

While the U.S. Department of Transportation (and Transport Canada for Canadian shipments) regulates the movement of hazardous materials by rail, road, and pipeline, enforcement of these regulations is carried out by different agencies depending on the mode of shipment.

Olin’s responsibility in the hazardous materials transportation system includes the safe operation of its loading facilities as well as maintaining transportation equipment in good working order for shipment whether owned, leased, or contracted by Olin. A number of inspection and maintenance activities are performed during the loading process to ensure safe and defect-free shipping containers. Olin’s goal is to ensure the safety of our personnel and, to the extent possible, all those who come in contact with a shipment of sodium hypochlorite, while effectively using our fleet and complying with all applicable laws.
Shipping

The carriers’ (rail and trucking companies) responsibility in the hazardous transportation system is to safely move the sodium hypochlorite shipping containers from Olin to the customer. The carriers must comply with a variety of regulations governing the movement of hazardous materials from agencies including the Department of Transportation, Transport Canada, the Association of American Railroads, and individual state governmental agencies. Carriers (rail and truck) rely on the shipper (Olin and/or the customer) to provide them with clean, safe, and secure sodium hypochlorite shipping equipment.

The customer’s responsibilities in the hazardous materials shipping process are similar to Olin’s. Customers must follow the appropriate regulations in the handling and unloading of sodium hypochlorite containers, and in the case of tank cars, prepare them for shipment back to Olin. A customer’s goal is to safely handle and unload sodium hypochlorite containers, comply with all regulatory requirements, and where applicable, prepare the container for safe shipment back to Olin. It is important to note that in the case of tank cars, the customers or end-users become the shipper of record when they offer the sodium hypochlorite container for shipment back to Olin.

Sodium Hypochlorite Shipping Containers

Sodium hypochlorite solutions are shipped in a wide variety of container sizes, bulk and non-bulk, to meet customers’ needs. Olin ships product only in tank trailers and tank cars.

Tank Trailers

Olin contracts with trucking companies to deliver sodium hypochlorite solutions by tank trailer, also known as cargo tanks. In some areas of the United States, Olin operates its own trucking fleet for delivery of the product. Tank trailers used in sodium hypochlorite service must meet standards issued by the regulatory agencies (U.S. DOT, Transport Canada) and include equipment that conforms to the Department of Transportation (DOT) or Motor Carriers (MC) designations, which as of the year 2017 were MC-307, DOT-407, MC-312, and DOT-412 designations. While tank trailer capacities can vary significantly, they usually contain about 5,000 gallons of product based on over-the-road weight limitations. The two major trailer constructions are rubber-lined steel and fiberglass reinforced plastic (FRP) tanks with a compatible resin corrosion barrier. Product unloading configurations include bottom discharge or a top-unloaded dip-leg arrangement.

Olin sodium hypochlorite trailers typically have a double-valve arrangement on the outlet port. The internal valve is pneumatically or hydraulically operated and can be closed remotely in case of an emergency. The unloading connections on each tank trailer are typically located at the rear. A specification plate specifying tank fabrication, inspection, and other regulatory information is typically located on the driver’s side of the trailer frame near the front. Transport regulations require these trailers to be inspected on a scheduled frequency, including internal and external visual inspections as well as leak, thickness, and pressure testing. These inspection dates are stenciled on the front head or on the front driver side of the trailer. Tank trailers can be unloaded by the driver or by properly trained employees (DOT/Transport Canada function-specific) at the customer’s or end user’s facility. Delivery tractors are equipped with an air compressor for pneumatic product transfer. Pumps are not provided with delivery equipment for unloading.

Tank Cars

In 2007, Olin added tank cars (railcars) to its modes of shipment. This proprietary fleet of specially lined and designed tank cars maintains sodium hypochlorite quality throughout the shipment cycle. The tank cars in Olin service for sodium hypochlorite meet DOT Spec 111A100W5. This Olin innovation, along with process capabilities, has allowed the creation of a bulk distribution paradigm to reach distant marketplaces effectively. The typical shipping volume by tank car is approximately 17,500 gallons.

Numerous important regulatory, environmental, safety, and health informational items are available on each tank car. Tags and stenciling display required regulatory, car maintenance, and operating information as well as safety, spill mitigation, and first-aid information along with emergency response contacts.

Olin’s entire rail fleet is designed for top unloading only. The specific unloading method and additional requirements are described in separate Technical Bulletins available for reference and future discussions.
Written Procedures

Establishment of robust unloading procedures should occur before product is received and then be reviewed on a periodic basis or revised when operational practices dictate. Unloading procedures will be unique to each facility, receiving area, and delivery mode. However, well-written unloading procedures include a number of common attributes and components. Although the primary focus of the unloading procedure is to ensure the correct product is safely delivered into the storage facility, it also should be written to address personnel safety, unexpected events such as spills, or other potential incidents. All procedures should be documented with periodic training provided to ensure personnel understand the procedure requirements. Verbal procedures for unloading should be avoided as they can foster inconsistency between staff members.

Checklists

Use of pre- and post-unloading checklists offers the advantage of physically carrying the key elements of the unloading procedure to the work area for review/completion. Checklists help ensure all key unloading items are reviewed and inspected, fostering consistency between different staff members. Typical components include:

- A review of paperwork (bill-of-lading and certificate of quality) to verify they match the shipping container placard, seal numbers, and receiving pipeline label
- Delivery address and purchase order numbers are verified
- Adequate tank inventory exists to safely receive the entire shipping container contents
- Eyewash and safety shower units have been identified in the area and verified that they are operational
- PPE has been inspected and put on prior to any connection activities
- Visual and mechanical inspections of the shipping container and transfer hose(s) have been completed

Training

Since sodium hypochlorite is a hazardous material, all U.S. personnel, who, in the course of their employment directly affect hazardous materials transportation safety, must be properly trained or “qualified” in accordance with 49 CFR 171-180 US DOT). An employee, whether full time, part time, or temporary, who performs any portion of the hazardous materials transportation, (loading or unloading of the hazardous material, providing directives or guidance regarding the loading or unloading process), must comply with the Hazardous Materials Regulations. For Canada, this would be classified under the Security and Transport Canada Transport of Dangerous Goods Act S.C 1992, c. 34 (Canada). 29 CFR 1910.120 provides guidance for training of employees who are expected to handle hazardous material spills. Additionally, federal regulation (DOT-49CFR 177.834 (i) and Transport Canada (CSA B622) require shipping containers to be continuously monitored during the entire unloading process by a qualified person located within 25 feet of the transfer.
General Unloading System Requirements

Unloading stations for receipt of tank trailer and tank car shipments should be designed with safety and operational efficiency in mind. In general terms, either delivery mode requires appropriately located safety shower and eyewash stations, adequate lighting for possible nighttime work, filtered pad gas, adequate secondary containment, chemically compatible transfer hoses and connectors, and a source of rinse water to facilitate product residue removal. The ideal site design will minimize the length of hose required for shipping container unloading as well as the pipe run for delivery of product to the storage tank.

Connection points should be clearly identified to eliminate the possibility of connecting the transfer hoses to the wrong unloading line or system. For maximum effect, receiving pipelines should be clearly identified near the delivery hose attachment point and include the words, “Sodium Hypochlorite” and “UN 1791.” This label terminology incorporates the information found in bills-of-lading and other delivery paperwork, and therefore allows the delivery driver and site unloading staff to compare delivery documents against the receiving pipeline label and shipping container placard. Consult The Chlorine Institute’s bulletin, “Avoiding Accidental Mixing of Sodium Hypochlorite,” at www.chlorineinstitute.org for additional details.

Tank Trailers

Tank trailer unloading stations should be laid out to provide easy access to the receiving pipeline connection. Where possible, drive-through unloading stations are preferred over backing of the trailer into the unloading station. In-plant street access should be designed to accommodate tractor-trailer combinations and incorporate wide intersections. Reinforced concrete unloading pads sloped to a containment device such as a dedicated sump or French drain can provide a hard surface for trailer parking and an effective means to collect and contain product drippings that might occur during the unloading process. Where multiple chemicals are received in the same area as sodium hypochlorite, engineering and/or procedural provisions should be incorporated to avoid mixing of incompatibles.

Receiving pipelines for tank trailers are typically installed at hip level (approximately 3 feet above grade). A two-inch male, quick-connect fitting is standard for customer receiving locations and should include a block valve to prevent possible chemical drain-back when the delivery hose is disconnected. Placement of a drain valve in the receiving pipeline can facilitate safe sample collection during the unloading process. Quick-connect fittings should be made of fluoropolymer-lined stainless steel or a compatible plastic such as PVC, high-density polyethylene, or glass-filled polypropylene. Installation of the receiving connector at a 45-degree downward angle is a preferred installation technique to reduce torque stresses induced during unloading. Angled receiving connectors are especially beneficial when plastic components are used. Since plastic fittings lack the mechanical integrity of lined steel fittings and can easily become worn or damaged, they should be inspected frequently and placed on a replacement cycle that will prevent failure.

Tank Cars

Tank car unloading stations should incorporate level track to maximize product transfers. An elevated platform and gangway system should be provided for safe egress and access from the top of the tank car. The platform should incorporate fall protection devices such as protective cages, or equivalent fall arrest systems. The pad gas filtration device and hose connection, as well as the receiving pipeline are typically located within arm’s reach of the unloading platform, which limits hose length and associated clutter, while maximizing convenience for component access.

Tank cars require a three-inch, four-bolt flanged connector to attach to the product outlet valve. Because of the elevated potential for “mechanical hammer” and other unloading stresses, the transfer hose should have a robust support system in place to limit stresses on the tank car connection. Because of these unloading stresses, a fluoropolymer-lined, flanged metal connector is preferred for tank car unloading.
Pad Gas System

Experience has demonstrated that the gas padding systems can be a significant source of product contamination in the delivery container and that even a good system can fail. For this reason, an additional engineering control should be installed at the end of the fixed pad gas piping (hose connection point) to avoid introduction of rust and particulates into the shipping container. This engineering control requires the following components to be appropriately designed and installed and that good operating practices be in place:

- Point-of-use filter designed to remove moisture, particulates, and oil delivering pad gas quality meeting ISO Class 1 of the ISO STANDARD 8573 – 1
- Safety Features: Pressure regulator, pressure gauge, pressure relief valve, check valve, and purge/vent valve for safe line evacuation prior to disconnection
- Dual isolation valves
- Piping made of compatible material of construction downstream of the point-of-use filter (point in which chemical vapors may be present)
- Pad gas connector hose made of product compatible material of construction
- Effective pad gas system maintenance program

Because of the sensitivity of sodium hypochlorite to pad air contaminants, all system components including the air compressor, air cooling and water drainers, pre- and after-filters, air drying and point-of-use filters/condensate drainers should be evaluated to determine appropriate equipment upgrades. System operation also should be evaluated because oil/water/particulate loading can vary under start/stop conditions. The minimum requirement for sodium hypochlorite shipping container pad air is ISO STANDARD 8573 – 1 (ISO Class 1) noted in the ‘International ISO Standards ISO 8573-1’ document. Note that the air does not have to be “dry” to a specific dew point, only “water droplet free.”

Corrosive Liquids Pad Gas Quality at Point of Use

NOTE: The diagram above represents components within a properly designed pad air system. Although those listed appear to be at the point of use, we understand portions may be at the compressor, and others near point of use. It should be known that the objective of this diagram and information within is intended to minimize any and all contaminates from entering the car during use. Therefore, any piping exposed to the vapors of solutions being offloaded should be of chemical compatible materials of construction and a filter as close to the container shall be installed as a last means to prevent particles from entering the shipping vessel.
High-pressure pad air can over-pressurize the shipping container, resulting in activation of the container’s safety relief device and chemical leakage. The pad air should be regulated to a maximum of 25 psig for both tank car and tank trailer unloading activities and be protected with a pressure relief device downstream of the regulator. The pressure relief device provides important over-pressurization protection to the shipping container should the regulator fail.

The primary isolation valve (see ‘Corrosive Liquids Pad Gas Quality at Point of Use’ diagram above) marks the piping specification breakpoint between components designed for standard pad air service and components designed for sodium hypochlorite vapor, and should be constructed of lined steel as discussed below. All components downstream of this valve must be designed to accommodate possible exposure to sodium hypochlorite vapors.

Downstream of the point-of-use filter, lined metallic piping or titanium must be used. Iron, galvanized steel, copper or other common pad air piping materials will corrode and re-introduce contaminants downstream of the filter. These materials should be avoided in their unlined versions downstream of the point-of-use filter location. For a lined piping system, the liner offers the chemical resistance needed while the metallic piping provides the structural strength. Liners such as polyethylene, Teflon® polymer (PFA, FEP, PTFE), PVDF (fluorinated polyvinylidene or Kynar® polymer) and PVC/CPVC (polyvinylchloride/chlorinated polyvinylchloride), etc., are compatible with sodium hypochlorite. A careful evaluation of material of construction compatibility with sodium hypochlorite should be completed during the liner selection process because product vapors can potentially back feed into the pad air piping system under certain conditions.

Tank cars are equipped with a four-bolt flanged ‘air’ valve for pressure padding and venting of the tank car. A two-inch flanged connection rated for pressures of 150 psig should be permanently affixed to the pad gas supply hose. A flanged adapter equipped with a quick-connect fitting for attachment to the pad air hose is a variation that may be a desired alternative. Fluoropolymer-lined stainless steel fittings are preferred as they offer enhanced mechanical strength, are chemically compatible, and can safely manage stored energy and stresses. Tank trailers are typically connected to the pad air supply hose via a one-inch “crow’s foot” connector (or Chicago coupling) appropriately pinned to ensure a secure connection.
Transfer Hoses

Bulk shipments of sodium hypochlorite will require a flexible hose to connect the shipping container to the storage tank’s receiving pipeline. Although most tank trailer serviced customers rely on the carrier to provide the transfer hose, use of customer-provided hoses remains an option. Tank car deliveries require customers to supply the transfer hose.

Hoses should be constructed of sodium hypochlorite-compatible materials and be rated to withstand the working pressures expected during the transfer process. Hose construction must avoid any wetted metallic surfaces, such as pipe nipples or quick-connect fittings, because of the corrosive nature of sodium hypochlorite and the sensitivity of this product to experience metallic-induced decomposition. From a mechanical integrity standpoint, metallic connector components that have a fluoropolymer or HDPE lining on the wetted surface are the preferred construction. Polyethylene, including the Ultra-High Molecular Weight Polyethylene (UHMWPE or UHMW) subset and polypropylene are common lining materials of construction. The choice of material should be discussed with your hose vendor regarding expected service conditions including, but not limited to, strength of sodium hypochlorite and likely temperature ranges to be experienced throughout a calendar year. The potential for external surface abrasion can also influence the type of protective sheath, if any, chosen for the hose.

As with all expendable components, hoses and hose connectors should undergo a visual inspection prior to each use to identify and prevent potential failures. Use of an inspection checklist by a knowledgeable inspector trained in defect identification helps maximize inspection effectiveness. The Association for Rubber Products Manufacturers’ bulletin, IP-11-7, (www.arpminc.com) can provide added details regarding maintenance, testing, and inspection of chemical hoses.

Pumps

Pumps are typically selected based on service. Centrifugal, diaphragm, canned, and magnetically driven pumps are more common for high-volume transfers or for recirculation-type activities. Regardless of application, all internally wetted components must be constructed of sodium hypochlorite compatible materials, and the use of all metals except titanium must be avoided. Non-metallic materials such as Teflon®, Tefzel®,...
Halar®, or Kynar® polymers, and polyvinylchloride are common internal components for pumps.

Design features are influenced by the type of pump selected. Positive displacement pumps should incorporate a pressure relief device to protect against ‘dead-heading’ situations whereas mechanically sealed centrifugal pumps should employ a seal-shaft gland to help prevent potential seal leakage from being slung onto nearby personnel or equipment. A low-amp cut-off switch should be considered for magnetically driven pumps to protect against “burn-out” resulting from operating under damaging low or no-flow conditions.

Although piston, gear, and peristaltic positive displacement pumps are most frequently used in metering situations, all pump styles have been used successfully in these situations. The overriding factor in determining which type of pump to use may lie in past plant experience. The pump type most familiar to maintenance personnel and for which spare parts are readily available may be the best choice. A centrifugal pump coupled with a measuring device (rotameter, mag meter, or mass flow meter, etc.) may prove easier to calibrate and more compatible with automated control systems than metering pumps. Without an independent flow-measurement device, metering pumps require routine calibration to ensure accurate output.

“Vapor lock” caused by entrained gas can be a problem with centrifugal, diaphragm, and peristaltic pumps, especially in low-flow metering applications. Typically, entrained gas is a result of trace-metal induced product decomposition (oxygen gas formation), so efforts to eliminate the source of such contamination would be the preferred solution. However, this problem can be minimized by sloping pump intake piping so that entrained gas bubbles move away from the pump suction or by employing other means of separating entrained gases before liquid reaches pump suction.

Valves

Valve type selection will depend on the intended application. Materials of construction range from fluoropolymer-lined steel valves to plastic. Where cavity valves, such as ball or plug designs are used, a vented valve design should be used to prevent pressure buildup and potential valve or piping damage resulting from metallic-induced decomposition of sodium hypochlorite and associated buildup of decomposition gases. Vented valve body designs will also be critical in pipe runs wherein sodium hypochlorite liquid or residues may remain trapped between closed valves. Storage tank outlets should be equipped with positive shut-off capability and avoid the use of “butterfly” designs. Flanged or glued valves are preferred over threaded valves as they eliminate the threaded connection, which is a potential leakage point.

Piping

When making initial decisions about piping, it is critical to select the appropriate material of construction because sodium hypochlorite is incompatible with all metals except titanium and tantalum. Use of non-metallic materials throughout is often embraced when only economic and compatibility perspectives are considered. However, the role of external stresses in pipe life, effective means to mitigate their detrimental effects, and the mechanical capabilities of the organization’s maintenance personnel should be evaluated before choosing pipeline materials. Exposures to direct sunlight and wide temperature extremes, to identify just two common examples, are external stresses that can weaken non-metallic piping and lead to premature component failure. Threaded pipe should be avoided as the pipe wall section containing the threads is thinner and more prone to failure or leakage. For flanged pipe installations in close proximity to personnel or equipment, installation of flange guarding should be considered. All piping systems should undergo scheduled integrity inspection, regardless of material of construction utilized. Non-metallic piping typically requires even more frequent inspection and replacement cycles.

Piping Materials of Construction

There are a number of acceptable materials of construction for sodium hypochlorite piping systems. Each material of construction presents unique attributes, and in some instances requires special care in installation and inspection to help ensure successful long-term use. Structural strength, chemical resistance, and operational conditions are important factors to consider when selecting piping materials of construction.

Because of their superior structural strength, metals are widely used in piping service for many alkali chemicals. However, unlike many alkalis, sodium hypochlorite is highly reactive with most metals and metal alloys and is compatible only with titanium or tantalum metal. Lined-steel piping using thermoplastics such as polypropylene, polyvinylidene fluoride (PVDF or Kynar® polymer) or polytetrafluoroethylene (PTFE or Teflon® polymer) as the liner is often used as an alternative pipe material for portions of the systems where mechanical stresses or impacts are expected. Lined metal is often chosen for the initial portion of the receiving pipeline, especially near the hose connector where external stresses are expected to be more significant.

PVC and CPVC are chemically compatible, non-metallic materials often used in lower mechanical stress applications. Certain specialty grades of polyethylene also have been successfully used in sodium hypochlorite service. Pipe specifications should be at least schedule 80 or higher for most applications. Mechanical impact from hazards such as liquid/gas mechanical hammer, temperature expansion/contraction cycles, pressure surges from pump start-up and operation, sunlight/ultraviolet light degradation, and potential foot or vehicular contact should be carefully considered when selecting PVC/CPVC for sodium hypochlorite service. PVC/CPVC materials are sensitive to these types of external stresses and if not properly installed, supported, and inspected, can often fail unexpectedly during use.

For end-use applications such as dosing meters, small diameter PVC/CPVC piping is often used. As with larger diameter piping, proper support is required. A protective enclosure such as a conduit or equivalent device should be used where foot or vehicular traffic is likely.

Most polyvinyl chloride monomers have recommended temperature ranges that should not be exceeded. In many instances, ambient conditions exceed these recommendations and elevate the risk of fracture. A related factor is ultraviolet damage as a result of long-term sunlight exposure. Repeated sunlight exposure will weaken monomer bonds, making the pipe more prone to fracture. Consult with your pipe vendor for added guidance.
Fiberglass reinforced plastic (FRP) has been used successfully in hypochlorite service, but it requires extreme diligence in carefully managing all aspects of fabrication and installation. Successful service is typically dependent upon fabricator experience (those specializing in manufacturing pipe expressly intended for sodium hypochlorite), selecting the correct resin composition and the curing process (avoiding cobalt napthenate chemical cures), and using certified installers that employ stringent quality assurance methods, to name several critical aspects.

Piping Installation

Where possible, pipe runs should be installed to eliminate the presence of low points because product left standing in pipelines can experience decomposition (oxygen generation and chlorate formation) when not in use. Where low points cannot be avoided, installation of drain valves discharging to a suitable containment system should be considered. Piping feeding metering pumps creates a special situation wherein oxygen gas formation can result in pump vapor lock. Installation of suction piping sloped up away from the pump can minimize gas collection and associated cavitation concerns. For underground pipe installations, pipe should be placed in an impermeable trench with removable inspection covers.

Piping Support

Adequate pipeline support is important regardless of material of construction. However, support becomes increasingly critical for non-metallic systems as they generally have lower structural strength and require additional support consideration. Proper spacing of the support system (e.g., hangers, trays, or clamps) will be influenced by the pipe size, operating temperature range, and the weight load of the filled pipe. Special care is required with hangers, support devices, and clamps to ensure a smooth contact surface, free of rough edges. They should not compress or distort the pipe but should allow axial movement resulting from changes in thermal expansion and contraction. Because of these factors, use of a continuous support system should be strongly considered for non-metallic pipe runs. If non-continuous support systems are chosen, consult your pipe vendor for recommended support spacing.

Pipe Glues

Sodium hypochlorite will attack the fumed silica additive used as a thickening agent in some glues or cements intended to join PVC/CPVC (polyvinyl chloride and chlorinated polyvinyl chloride) components. Because of the likelihood of joint separation or leakage, only glues/cements that are fumed silica-free should be used. Containers for these glues typically indicate their compatibility with oxidizers and alkalis. Proper preparation of the surface and application techniques for the primer and cement are important, but often overlooked, aspects of pipe installation. Proper preparation of the glued joint is critical to long-term performance. Diligently follow the glue manufacturer’s guidance for all assembly steps.

Pipeline Identification

Labeling of pipelines provides critical information regarding the intended contents and associated product hazards. General pipeline labeling indicating the product and flow direction can be especially helpful when performing line-tracing activities. The labeling of receiving pipelines is particularly important because it can provide an additional layer of protection against accidental delivery of the wrong chemical by providing a visual reference of intended contents for delivery and unloading personnel. The ASME/ ANSI A13.1 standard for pipe marking, requires an employer to use labels that state what a pipe contains and what possible hazards are related to that substance. Always review all federal, state, county, city/municipality labeling requirements.

Pipe systems should undergo scheduled inspections on a regular basis. Although the entire pipeline system should be inspected, special focus should be given to joints, sags, support systems, and connectors. Pipe joints and flanges should be inspected for evidence of product drippage indicating a softening of the joint glue. Evidence of pipe sags, which can develop over time if inadequate support system spacing was chosen, should be reviewed. Pipe supports, hangers, and clamps should be closely inspected for loose pipe (pipe movement) or evidence of wear at the contact point. The connecting surfaces of plastic, quick-connect hose fittings are prone to wear or cracking and should also be an inspection component. Inclusion of detailed training for your inspector will be critical to maximizing inspection results.

“Invisible” stresses inherent to the pipe system such as temperature extremes, embrittlement, or external torque applications are not detected by typical visual inspection practices. By assigning a scheduled replacement cycle before failure occurs, system reliability can be maximized.

Storage Tanks

The tank selection process has a number of important components to consider. While many are obvious, others are not intuitive because of the unique attributes of sodium hypochlorite. Tanks should be located to minimize piping runs, accommodate shipping container movement for inbound deliveries, and be installed in secure areas to avoid tampering/vandalism concerns. Local, state, province, and federal environmental regulations should be reviewed before tank installation. Local building codes and fire regulations also may influence tank farm construction and location.

A part of the process of the purchase and installation of a new storage tank should be planning for future inspection and replacement. Accurate records about the particulars of the tank design (drawings and notes) and materials of construction should be provided to those responsible for ongoing maintenance and inspection of each tank. The tank vendor should be asked to supply recommendations for initial inspection scheduling and tank life expectancy. Proper replacement timing should always be intended to replace the vessel well before the end of its expected useful life.
Storage Equipment

Materials of Construction

Titanium

There are a limited number of materials that are chemically compatible with sodium hypochlorite. These materials can be categorized into metallic and non-metallic systems. Titanium and tantalum are the only chemically compatible metals and offer the longest lifetime. Their high cost generally limits use to critical applications such as reactor vessels and internal components of pumps, meters, valves, etc.

Rubber-Lined Steel

Rubber-lined steel tanks are often selected for high-capacity vessels or ones that are subjected to multiple fill/discharge cycles. The lining should be of a 100 percent chlorobutyl rubber composition. Rubber-lined storage tanks require a simple, but specialized mechanical integrity test (IP-4-13 “Procedure for Spark Testing Elastomeric Sheet Lining”) to evaluate lining integrity on a periodic basis. Exposure of lining to the product can result in integrity on a periodic basis. Exposure of lining to the product can result in a UV inhibitor for outdoor installations.

Poly tanks have excellent chemical resistance and are often chosen for smaller volume vessels. Lateral expansion and contraction of the tank wall is a significant concern with poly tanks as the walls will tend to flex depending upon the product level inside the tank. The mechanical hammer associated with compressed air chemical deliveries, automated valve cycling, and pump operations that introduce structural stress on poly tanks are other significant factors affecting tank service lifetimes. Additionally the use of bulkhead type fittings may significantly shorten the life of the tank because of the tendency to experience stress cracking around the cutout for this type of fitting. As with FRP, poly vessels are sensitive to ultraviolet (UV) degradation and should incorporate the use of a UV inhibitor for outdoor installations.

Long-term contact with hypochlorite causes embrittlement of the polymer so that a sudden mechanical shock can cause a catastrophic failure of the tank. As with other non-metallic piping and tank materials, an inspection and replacement plan should be developed for poly tanks so they are replaced before failure occurs.

HyPure® Bleach can be stored and handled in the same equipment as standard sodium hypochlorite solutions. Consult with your tank manufacturer to ensure the tank is of adequate design to handle the increased corrosivity and oxidation associated with this concentrated product. Insulation and cooling may be needed if the material is held at high concentrations for long periods of time.

Fabricator Evaluation

The fabrication and lining processes are critical to long-term success when storing sodium hypochlorite. Industry experience has shown merely utilizing chemically compatible material alone is not a guarantee for lengthy tank service lifetimes. The aggressiveness of sodium hypochlorite dictates that special evaluations of the fabricator and the material of construction should be performed, regardless of the type of construction chosen. Fabricators should be selected based on

1. Their experience in fabricating tanks intended for this product
2. The performance record of their tanks in sodium hypochlorite service
3. The fabrication process used.

Once a fabricator is determined, it is important that the manufacturers’ recommendations on usage and preventative maintenance are strictly followed. Capital, tank location, and desired service life will dictate the choice of the material of construction. However, if the storage tank is properly specified and maintained, useful lifetime can be maximized.

Design Considerations

Poly Tanks

High-density polyethylene (HDPE), cross-linked (XHDPE) and linear (HDLPE), have been successfully used in sodium hypochlorite service and are typically known as poly or plastic tanks. However, fabricator experience, resin, product strength, mechanical hammer, temperature, sunlight exposure, and pipe connection methods are important variables influencing vessel performance. If cross-linked HDPE is used, it is important to confirm that the resin chosen is suitable for sodium hypochlorite. Additionally, tanks should comply with ASTM D-1998, “Standard Specification for Upright Polyethylene Storage Tanks.”

Sizing

As part of the storage system strategy, the vessel should be large enough to easily accommodate a full inbound bulk shipping container and compensate for likely transit times and tank heels. A general rule of thumb is to size the tank at least 1.5 times as large as the full bulk shipping container to maximize freight savings and have ample room to avoid tank overflows during filling. However, consumption rates also should...
be considered because of the decomposition nature of the product. For low-volume requirements or where the tank is subjected to high ambient temperature and sunlight exposure, a smaller tank volume might be appropriate. Vertical tank designs, rather than horizontal, are preferred.

**Venting**

Adequate venting is critical for ensuring a rapid release of air surge when tanks are filled via pneumatic transfer. The tank will be subjected to a nearly immediate, large volume of compressed air at the end of the shipping container unloading process using pad air as the motive force. Compressed air surges approaching 1200 SCFM, (Standard Cubic Feet per Minute) are typical from tank trailers, for example. Without an adequately sized vent, the tank will temporarily act as a pressure vessel, which can lead to tank wall flexing to accommodate the pressure load. Repeated flex cycles can weaken tank walls and could lead to catastrophic tank failure.

As a general guide, tank vent diameters should be at least twice (2X) the size of the inlet piping diameter. Factors such as the length of the vent piping and number of turns can impede the release of compressed air and will require further up sizing of the vent. It is important to consult the manufacturer on the type of venting system that should be designed to support your bulk unloading system.

**Overflows**

If the tank becomes over-filled, overflow nozzles allow chemical that normally would spray out of the tank vent or man-way opening to be safely channeled via directional piping into the containment system. Overflow nozzles and directional piping are generally sized at least 1.5 times (1.5X) larger than the inlet pipe to ensure adequate capacity. Overflow nozzles should be installed below the roof line and on the sidewall of the tank. This overflow piping should discharge near ground level in an area and direction away from the typical area occupied by personnel. Consult your tank fabricator for additional design guidance.

**Receiving Pipeline**

Two-inch piping is typical for tank trailer-serviced locations with short pipe runs, while three- or four-inch diameter pipelines are often used for tank car unloading to facilitate rapid product transfer. Pipe diameter guidance will vary depending on site layout.

**Filtration**

Filtration of the product, whether it be from the shipping container to the storage tank or from the storage tank into your process should be considered. There are several filtering technologies available for sodium hypochlorite bulk unloading handling – from bag and cartridge, to vacuum, or pressure filters. The sensitivity of your process will determine the level of need for a filtration system.

**Outlet Nozzles**

Selection of tanks with a low-point drain should be considered. Low-point drains offer the benefits of complete product heel removal for applications that are sensitive to product decomposition byproducts, such as chlorate. Low-point drains also facilitate periodic internal tank inspection and cleaning activities.

**Flexible Connections and Piping Support**

Non-metallic tanks are also easily stressed from axial and lateral forces originating from factors such as the act of tank filling and the expansion/contraction of attached discharge piping as ambient temperatures change.
Unsupported discharge piping connected to a heavy valve can exert significant torque on the tank’s outlet fitting area that can culminate in sidewall cracks/damage. Rigid connections tend to concentrate these stresses in the nozzle area of the tank. Installation of proper piping support and/or use of flexible connectors may help eliminate many of these potential tank stressors. Tank nozzles on non-metallic tanks should never be used for support of valves and piping. Consult your tank vendor for specific guidance.

Level Measurement

A level measurement system is important for maintaining process operation and for avoiding a possible overflow condition during inbound delivery. Gauging systems range from simple visual readings to complex remote readouts. Under certain scenarios, the inventory may be read directly from the “shadow” of a translucent, clear-tinted poly tank equipped with markers molded into the side wall. External “sight glasses” can provide effective level indications. However, similar to reading inventories from the “shadow” of a translucent tank, use of external “sight glasses” may also lead to erroneous readings under certain lighting conditions. External “sight glasses,” such as polyethylene or polypropylene tubing, also present an opportunity for catastrophic loss of tank contents upon “sight glass” failure or damage. Differential pressure or electronic level indicators are frequently used for tank level measurement. Level indicators that are not immersed in the product typically perform best, but all electronic level transmitters should be assigned a scheduled, periodic recalibration cycle to ensure accurate readings over the long term. Equipping the indicator to activate an alarm or automatic shutoff at preset inventory levels can provide an important additional layer of protection against accidental tank overflow conditions. The reliability of the high level alarm or automatic shutoff can be enhanced by using an activation device independent of the regular level transmitter (redundancy).

Posting the maximum allowable storage tank volume in a location clearly visible to unloading personnel will facilitate calculation of available volume for incoming chemical. This, coupled with a local level readout, will allow the unloading staff (and delivery driver for tank trailer shipments) to monitor tank levels more effectively during unloading.

Tie Downs

Tanks should be adequately secured using tie downs installed from the factory to prevent tank movement from high winds or seismic activity.

Storage Tank Identification

Tanks should be clearly labeled to identify chemical contents. Labels or stencils noting the entire, formal product name, e.g. “sodium hypochlorite,” are preferred and especially beneficial to contractors and others not intimately familiar with the tank farm. Avoid use of “chlorine” or “liquid chlorine” for identification as these terms are inaccurate and confusing. A misunderstanding may lead to unnecessary or inappropriate precautions being taken by emergency response personnel in an actual chemical incident. Such distractions and confusion can prevent prompt action to address the emergency condition to which they have responded. Labels should comply with OSHA’s HAZCOM Standard, CFR 1910-1200 or with Canada’s WHMIS (Workplace Hazardous Materials Information System) for Canadian sites. Certain local regulations, codes, or agencies may also dictate label content.

Storage Tank Preventative Maintenance

Cleaning

Tank cleaning frequencies will be affected by factors such as the purity of the incoming product, consumption volumes, and internal tank inspection cycles. Tank rinsing may be desired for removal of sedimentation that can occur over time, as well as removal of residual metallic contaminants that may adhere to tank walls after the product has been consumed. Tanks purchased with a ‘full drain’ nozzle will foster complete cleaning and flush activities. Tanks equipped with ground-level man-ways can facilitate cleaning activities by providing convenient vessel access without the use of ladders and scaffolding.

Inspection

A periodic, scheduled inspection should be performed regardless of material of construction chosen. Personnel performing inspections should be given specific guidance regarding areas to inspect and the types of failure/damage to identify. Detailed criteria and photos can be useful inspection aids. Use of a checklist has been found to be particularly helpful to ensure inspection consistency between different personnel. For non-metallic tanks, the exterior of the tank should be inspected for evidence of drips or seepage, side-wall or roof bulges, and surface cracks or crazing, to name several key attributes and areas for inspection.

To enhance the efficacy of tank inspections, detailed records of previous inspections that include photos and notes about the location of minor flaws or routine wear will be extremely helpful. This information can be used in determining the progress of wear and tear on the vessel and/or liner or corrosion barrier. Over time these comparisons can improve the accuracy – and the economy – of future inspection and replacement scheduling. Without an understanding of the performance characteristics of a particular material of construction and tank design under your specific storage conditions, it is difficult to make wise decisions about the timing of future tank inspections and replacement. Your tank vendor’s initial recommendations for the frequency of these activities should be followed.

Storage Tank and Unloading Station Containment Systems

A well-designed handling system should incorporate an effective secondary containment system to contain potential drips or spills in product storage and unloading areas. Secondary containment regulations often vary by location, so it will be important to review local codes/city ordinances, as well as province, state, and federal requirements when considering storage of sodium hypochlorite, whether the tank is indoors or outdoors. As a general guide, containment systems should be capable of holding at least 110 percent of the largest tank capacity found in the contained area. Appropriate containment must be designed to address the most likely quantity of sodium hypochlorite that would be discharged from the primary containment system (e.g., container, equipment), such that the discharge will not escape secondary containment before cleanup occurs. In determining the most likely quantity, the facility owner/operator should consider factors such as the typical failure mode (e.g., overflow, fracture in container wall, etc.), resulting sodium hypochlorite flow rate, facility personnel response time, and the duration of the discharge. In addition, the system designer should identify any bottlenecks.
Incompatible Chemicals During Unloading

The oxidizing property of sodium hypochlorite requires that special care be taken to avoid incompatible chemical contact, also known as accidental mixing. Accidental mixing may result in personnel injury or environmental damage as a result of introducing sodium hypochlorite residues to a wide variety of incompatible chemicals. Although reactions vary depending on the chemical composition, sodium hypochlorite will generate chlorine gas when exposed to acids, acid residues, or other chemicals that may lower the pH of the hypochlorite solution. Production of oxygen gas and significant amounts of heat may accompany other reactions with sodium hypochlorite.

The opportunities for incompatible chemical contact at a storage facility are many and variable but typically can be grouped into three categories:

1. The shipping container unloading process
2. Secondary containment for unloading and storage
3. Small-containers, such as drip collection devices

The Chlorine Institute (www.chlorineinstitute.org) bulletin, “Sodium Hypochlorite Incompatibility Chart,” provides a list of chemical families that are incompatible with sodium hypochlorite. Design considerations to help prevent accidental mixing are discussed in the ‘Unloading Station’ section of this manual and the SDS.
Personal Protection

Safety Data Sheets

Always review the SDS before handling sodium hypochlorite.

Sodium hypochlorite is a corrosive and reactive compound. To prevent personnel injuries and environmental exposure, this manual and the most current Safety Data Sheet (SDS) should be reviewed and understood. Personnel should be prepared to deal with both normal and abnormal situations. Never handle any sodium hypochlorite solution before you have read the relevant SDS. Each SDS contains information for handling particular solution strengths of sodium hypochlorite and has the most current detailed information on health effects, handling precautions, and first aid, as well as, additional sodium hypochlorite information this is not contained in this manual. The SDS must be readily accessible to all persons where the product is being used. The most up-to-date SDS, provided by the supplier, should be available to and understood by all employees who work with sodium hypochlorite. The most current SDS can be obtained from Olin at www.olinchloralkali.com.

Personal Protective Equipment

Sodium hypochlorite is a corrosive material that can cause serious health hazards if improperly handled. It is corrosive to the skin, eyes, mucous membranes, and respiratory tract, and it may cause severe chemical burns to the eyes and skin. Bodily attack will vary with solution strength and duration of exposure. Personal protective equipment (PPE) requirements will vary by task and surrounding work environment. A formal PPE hazard assessment should be performed to evaluate the appropriate PPE gear necessary for a given task. Typically, such a risk analysis will result in different levels of PPE based on work duty. When work duties include line-breaking activities such as transfer hose connection/disconnection or maintenance work, use of full PPE, including chemically resistant jacket and pants, chemically resistant boots and gloves, goggles and a face shield are required. Consult the Chlorine Institute Pamphlet 65 for additional details.

Clothing can be damaged upon contact with this material. Flame resistant clothing (FRC) may have a higher rate of attack from sodium hypochlorite than non-FRC cotton materials, especially at higher solution strengths. Consult your PPE manufacturer for additional guidance.
First Aid Procedures

General Guidelines

Prompt response to personal exposures is critical to minimize potential injurious consequences. Ensure that medical personnel are aware of the chemical(s) involved if exposure or injury occurs. Always review the most current Safety Data Sheet (SDS) on what to do should there be eye contact, skin contact, ingestion, or inhalation of sodium hypochlorite and provide it to medical personnel administering care to injured persons.

Safety Shower and Eyewashes

A safety shower and eyewash station provide an important line of defense against chemical injury should bodily contact with sodium hypochlorite occur. Safety shower and eyewash units should fully comply with the most current version of the American National Standards Institute (ANSI) Z358.1 standard, which addresses items such as equipment performance requirements, accessibility, and testing.

In general, safety shower and eyewash units should be located in areas that have the potential for chemical exposure, such as unloading, pumping, or sampling locations. The safety device should be easily accessible and highly visible to expedite a user’s ability to locate and reach the device quickly. In some applications, multiple safety shower and eyewash stations may be required to provide unimpeded access to the safety device under “normal”, “abnormal”, and emergency conditions. Typical guidance includes locating a safety shower and eyewash unit within 10 seconds of unobstructed access to a potential source of exposure. Unobstructed access requires the safety appliance to be located on the same level as the hazard and be void of impediments such as containment walls, steps, doors, etc., which can interfere with the ability to reach the safety appliance quickly.

Locating and operating the safety shower and eyewash unit at the onset of area work is encouraged as it provides the greatest assurance of device operability. In addition to scheduled device activations to verify water flows, safety shower and eyewash inspections should focus on changes that have recently occurred affecting access and visibility, such as the “temporary” storage of work equipment or materials near the device. Workers should always be reminded that access to safety equipment must never be compromised for convenience or improved efficiency.

Responding to Emergencies

Each facility should maintain current procedures for handling emergencies occurring both on-shift and after hours. If your facility meets the requirements of 29 CFR 1910.38 and external personnel will be expected to resolve the emergency, then you must have an Emergency Action Plan (EAP) which describes how employees will respond to different emergencies. Sites with 10 or more employees must maintain a written EAP, although a written EAP is always desirable. Periodic drills should be conducted to verify employees know the EAP and can carry out the duties identified in the EAP. In general, an EAP should address:

- Means of reporting fires and other emergencies
- Evacuation procedures and emergency escape route identification
- Procedures for operating critical controls prior to evacuation
- Accounting of all employees
- Rescue and medical duty assignments
- Names with corresponding job titles to contact in emergencies

An Emergency Preparedness Plan (EPP) is to be maintained for sites that meet the requirements of 29 CFR 1920.38 (Emergency Action Plan) and 29 CFR 1910.120 (Emergency Response Plan under the Process Safety Management Standard) wherein site employees will also act in a First Responder role. The EPP has additional detailed procedures that specifically address First Responder roles such as training, emergency recognition and prevention, PPE and emergency equipment, decontamination procedures, and establishing incident command, to name several components. The EPP should be periodically reviewed with your Local Emergency Planning Committee (LEPC) to ensure compliance with local, province, and state requirements. Like EAP’s, it is important to conduct frequent plan drills. Including your LEPC or outside responder in facility drills can provide important insight into plan strengths and weaknesses, and can also strengthen relationships with the community.
Spills and Leaks

General Guidelines
In general, when encountering a leak or spill, the primary focus should be to always maintain your personal safety as well as those around you. Consult your EAP or EPP regarding specific actions to take when encountering a spill event. Ensure that you follow all state, province, local, and municipal regulations pertaining to spills and spill response. This would include the proper training required by personnel who are expected to do the clean-up activities.

How to Respond to Spill Events
Step 1 - Evacuate and Activate
- Evacuate all personnel from the area and restrict access.
- Maintain safe refuge away from and upwind of the spill area.
- Activate the site’s Emergency Plan.

- If external personnel will perform response duties, activate the Emergency Action Plan.
- If facility persons will perform response duties, activate the Emergency Response Plan.

Step 2 - Suit Up and Remediate
THESE STEPS SHOULD BE PERFORMED BY TRAINED, KNOWLEDGEABLE PERSONNEL ONLY!
- Suit up with appropriate PPE per SDS and never respond alone.
- Isolate and contain the spill with the use of inert materials (e.g., sand, dirt, etc.).
- Recover as much chemical as possible for re-use.
- For unusable material, transfer liquids and residues to an approved Hazardous Waste container for proper disposal.
Spills and Leaks

- Manifest and dispose of unusable materials, residues, and their containers consistent with all local, province, state and federal regulations.
- Neutralize affected area avoiding use of acids and low pH neutralizing agents until all available chlorine has been neutralized. Consult Neutralization section and SDS for additional details.
- Decontaminate all equipment, PPE, and materials.
- Launder any clothing or jewelry prior to re-use.

Step 3 – Report

- Immediately report spills in accordance with local, province, state, and federal regulations.

Consult the SDS to determine the Reportable Quantity (RQ) threshold for this material. Federal law requires that if the spill is greater than the RQ it must be immediately reported to the National Response Center (NRC) at 800-424-8802. Consult local, province, state, and federal regulatory agencies for specific requirements unique to your location. Additional regulatory reporting requirements may vary by jurisdiction.

Special Considerations

Special care must be exercised when attempting to contain, neutralize, and dispose of sodium hypochlorite spills. The strong reactive power dictates that any absorbent material must be chemically inert to sodium hypochlorite. Avoid use of items such as sawdust and rags, which can react with sodium hypochlorite under certain conditions, and materials such as “floor dry,” which typically contain organic components. Spill collection equipment, such as shovels or recovery drums, should be verified clean and void of incompatible residues.

Never introduce sodium hypochlorite to local sanitary treatment plants or bodies of water without proper approvals. Sodium hypochlorite can irreparably disrupt the biological processes of sewage treatment operations and will result in harm to aquatic life. Chlorine gas also might be released at the treatment plant if acidic waters are encountered by the hypochlorite. Processing and containment area drains should be periodically reviewed to ensure protective features such as engineering and procedural controls are in place to prevent automatic release.

Neutralization

Neutralization is often favored for larger quantity spills, those which are heavily contaminated and cannot be re-used, or in situations where the resulting neutralized solution will be sent to a waste water treatment plant. Neutralization methods for spill events described in this publication are not intended to treat bodily exposures. Although the result of neutralization is a less hazardous material, the process itself involves other chemicals, rapid reactions, and in some instances the potential to generate other gases and hazards. When neutralizing hypochlorite solutions, safety must be an integral component throughout the process. Because of the potential for aggressive reactions, only well-trained personnel should attempt neutralization. Completing a hazard analysis before work begins will help identify the critical engineering and procedural controls necessary for safe neutralization.

There are a number of chemical options for neutralizing sodium hypochlorite, including sodium sulfite, sodium bisulfite, sodium thiosulfate, hydrogen peroxide, and sulfur dioxide. Regardless of the method chosen, the sequence of neutralization steps is critical. To prevent generation of chlorine gas, always neutralize the hypochlorite active ingredient before lowering solution pH.

Disposal

Proper clean-up and disposal requires that liquids, residues, and neutralized materials are handled, stored, transported, and disposed in accordance with local, province, state, and federal regulations.
Analytical Guidelines

Importance of Accuracy

The accurate determination of sodium hypochlorite assay is influenced by many factors including: sample point selection, sample technique, sample handling, analytical methodology, and analytical equipment and technique. The assay of sodium hypochlorite will continually decline over time at a rate determined by a variety of factors including: sodium hypochlorite concentration, temperature, residual sodium hydroxide levels, and exposure to UV light and trace metals such as nickel, copper, and iron. This manual describes a number of important guidelines to improve the accuracy of assay determination of sodium hypochlorite in the shipping container (tank truck or tank car). The steps and guidance presented should be thoroughly reviewed for applicability at a particular site with a hazard review covering the site specific functions to identify the best procedures and personal protective equipment (PPE) for the health and safety of site personnel and the environment. Refer to the Safety Data Sheet (SDS) for sodium hypochlorite for additional information on appropriate PPE.

Sample Collection

Whenever possible, the sample should be collected directly from the shipping container using a clean and appropriately designed sample collection device. Steps should be taken to avoid contaminating or damaging the shipping container during sampling. If a shipping container sample cannot be safely obtained, a properly designed sample point should be installed directly on the unloading piping where there is flow through the sample point. Procedures should be in place to ensure the sample point is purged sufficiently to provide a representative sample of the shipping container. Consult the SDS for appropriate PPE to be worn during sample collection activities.

Sample Handling

All wetted surfaces of sample collection equipment (thief, bottles, and bottle cap inserts) should be non-metallic. Sample bottles should be cleaned and flushed with the sample media. Fill the bottle no more than two-thirds of its capacity to avoid over-pressurization, leakage, or bottle bulging which may be induced as the product warms in storage. The sample should be identified and analyzed as soon as practical after collection—typically within two hours when stored at room temperature. Prior to analysis, the sample should be kept away from heat sources and out of direct sunlight or other UV exposure as these factors will increase the decomposition rate of the product. If there is going to be a significant delay in analysis, the sample should be cooled/refrigerated until analysis is possible.

Analytical Method

The most common analytical method used to determine assay of sodium hypochlorite solutions is a titration with a standard sodium thiosulfate solution. The titration is based on the principle of ion substitution in a pH-buffered environment, where the substitution element (iodine) is more easily titrated than the hypochlorite ion. In this method, a sample is treated with excess potassium iodide, neutralized with glacial acetic acid, and the liberated iodine is titrated with sodium thiosulfate. The titration endpoint is determined using a starch indicator solution. The following equations describe this method:

Equation 7:
\[ \text{NaOCl} + 2 \text{ KI} + 2 \text{ HAc} \rightarrow \text{I}_2 + \text{ NaCl} + 2 \text{ KAc} + \text{H}_2\text{O} \]

Equation 8:
\[ \text{Cl}_2 + 2 \text{ KI} \rightarrow \text{I}_2 + 2 \text{ KCl} \]

Equation 9:
\[ \text{I}_2 + 2 \text{ Na}_2\text{S}_2\text{O}_3 \rightarrow \text{Na}_2 \text{ S}_4\text{O}_6 + 2 \text{ NaI} \]

The Chlorine Institute’s Pamphlet 96 “Sodium Hypochlorite Manual” is a good reference document for the step-by-step procedure of this method. This document is available for download from the Chlorine Institute’s website (www.chlorineinstitute.org) after registering with the site.
Analytical Guidelines

Note for HyPure® Sodium Hypochlorite Users
When using the above reference procedure for the analysis of HyPure® Sodium Hypochlorite at concentrations greater than 17 wt% NaOCl, the volume of the aliquot of the sample should be reduced by a factor of 2 in order to maintain an acceptable titration volume, due to the much higher NaOCl concentration in this product. An adjustment to the calculation below should be made by replacing 0.04 by 0.02.

Important Procedural Considerations

- The order of addition in sample preparation is important to follow as instructed (sample aliquot, then distilled water, then potassium iodide, followed by the acetic acid prior to titration). If the acid is added prior to the potassium iodide, chlorine could be released from the solution, creating an inaccurate analysis and possible safety hazard.
- Glacial acetic acid solution must be used at the listed quantity to ensure complete neutralization of the sample. If too little or too weak an acid is used, complete neutralization will not occur and the analysis will result in a low assay.
- The normality of the sodium thiosulfate used in titration should be standardized on a regular basis to ensure accuracy in calculation. A minimum of a monthly frequency should be considered. The thiosulfate solution will degrade over time and will not give an accurate analysis if an incorrect normality is used in calculations.
- If a potassium iodide solution is being used in lieu of the crystals, the solution should be remade on a regular basis as well as it too, will degrade over time.
- This procedure includes the use of a starch indicator to clarify the end point of titration. This indicator use is very important in maintaining the accuracy of the analysis. The endpoint of the titration is very difficult to see without the use of the starch indicator and results will be inconsistent without its use.
- Distilled or deionized water should be used throughout the analysis. The use of lower quality water sources (such as tap water) can lead to inaccurate results.
- Final points of consideration in this procedure are using the appropriate quality equipment in the analysis (including Class A pipettes and certified weigh scales with 4 decimal place accuracy) and properly training personnel in proper lab techniques, the procedure, and the hazards involved.

Discussion of Units

This calculation below determines the strength of the sodium hypochlorite solution in weight percent NaOCl as shown below for the sample size described in the Pamphlet 96 analytical reference.

\[
\text{wt}\% \text{ NaOCl} = \left( \frac{\text{ml Na}_2\text{S}_2\text{O}_3}{0.040} \times \text{Normality} \times 3.723 \right) / \text{weight of original sample}
\]

Hyponochlorite strength can be expressed in other units. Because the density of the solution changes with a variety of factors including caustic concentration, salt concentration, temperature, etc., it is critical to use a measured density (or specific gravity) in the following calculations for conversion.

\[
gpl \text{ available chlorine} = \text{wt}\% \text{ NaOCl} \times 10 \times \text{SG}/1.050
\]

\[
\text{trade % available chlorine} = \text{wt}\% \text{ NaOCl} \times \text{SG}/1.050
\]

\[
\text{wt}\% \text{ available chlorine} = \text{wt}\% \text{ NaOCl} \div 1.050
\]

\[
\text{wt}\% = \text{weight percent}
\]

\[
gpl = \text{grams per liter of solution}
\]

\[
\text{SG} = \text{specific gravity}
\]

\[
\text{NaOCl} = \text{Sodium Hypochlorite}
\]

It is also important to communicate the full units when reporting sodium hypochlorite strength to ensure everyone is aware of the measurement being reported.

Best Practices

- The use of an autotitrator can increase the accuracy and precision of the analytical results when measuring Sodium Hypochlorite strength. Please contact Olin Technical Service personnel for additional assistance with autotitration systems.
- Starting the analysis using a weighed sample can improve the accuracy of the analysis by removing the error introduced by measuring the density of the solution.

NOTE: The density will still need to be used to convert the result to other units.

- A study, such as a Gage R&R, should be used to determine the variation in results expected from the method and the analyst. The study examines measurement system errors in terms of repeatability, or equipment variation, and reproducibility, or analyst to analyst variability. It is important to gain an understanding of the site’s capabilities in terms of accuracy and precision as well as the factors that are influencing these results.
- Good laboratory practices and techniques should be included in the training for all personnel analyzing samples in order to improve consistency from person to person. Good laboratory practices would include a robust training program, documented procedures that utilize validated test methods, and the use of statistical controls on equipment and reagents.

Residual Alkalinity Analytical Testing

Once the available chlorine has been neutralized with hydrogen peroxide, a simple acid–base titration is performed to determine alkalinity. If the determination of amount of sodium hydroxide and sodium carbonate is needed, the titration is essentially the same but has two endpoints. Use of pH testing to determine alkalinity levels is not recommended because of the inability of pH test methods (probes or litmus papers) to yield accurate, reproducible test results. Alkalinity test methodology can be found in The Chlorine Institute’s Pamphlet 96. Like the assay analysis, this test can be performed by manual or auto titration.
Additional Information and Emergency Contacts

For Additional Information

The Chlorine Institute
1300 Wilson Blvd.
Suite 525 Arlington, VA 22209
(703)-894-4140
www.chlorineinstitute.org

- Pamphlet 96, “Sodium Hypochlorite Manual”
- “Avoiding Accidental Mixing of Sodium Hypochlorite” bulletin
- “Sodium Hypochlorite Incompatibility Chart”

The Association for Rubber Products Manufacturers
7321 Shadeland Station Way
Suite 285
Indianapolis, IN 46256
(317)-863-4072
www.arpminc.com

- IP-11-7 “Manual for Maintenance, Testing & Inspection of Chemical Hose”
- IP-4-13 “Procedure for Spark Testing Elastomeric Sheet Lining”

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428
(877)-909-2786
www.astm.org

- Standard Specification for Upright Polyethylene Storage Tanks

Emergency Contacts

In the event of an accident or chemical incident, refer to your site’s emergency preparedness plan and the most current Safety Data Sheet (SDS). Should a chemical leak or spill occur, immediately contact the applicable regulatory agency and implement your site’s Emergency Action Plan or Emergency Preparedness Plan.

In the U.S.: Call CHEMTREC (toll-free) (800) 567-7455
In Canada: Call CANUTEC (collect) (613) 996-6666

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Graph Appendix

Graph 1: Bleach Stability and Density at 70°F

Graph 2: Estimated Decomposition of 12.5 wt% Sodium Hypochlorite Solution
Graph Appendix

Graph 3: Estimated Decomposition of 15.5 wt% Sodium Hypochlorite Solution

Graph 4: Estimated Decomposition of Standard and HyPure® Bleach
Graph Appendix

Graph 5: Metal-Induced Assay Loss (g/L) vs. Time (Hours)
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