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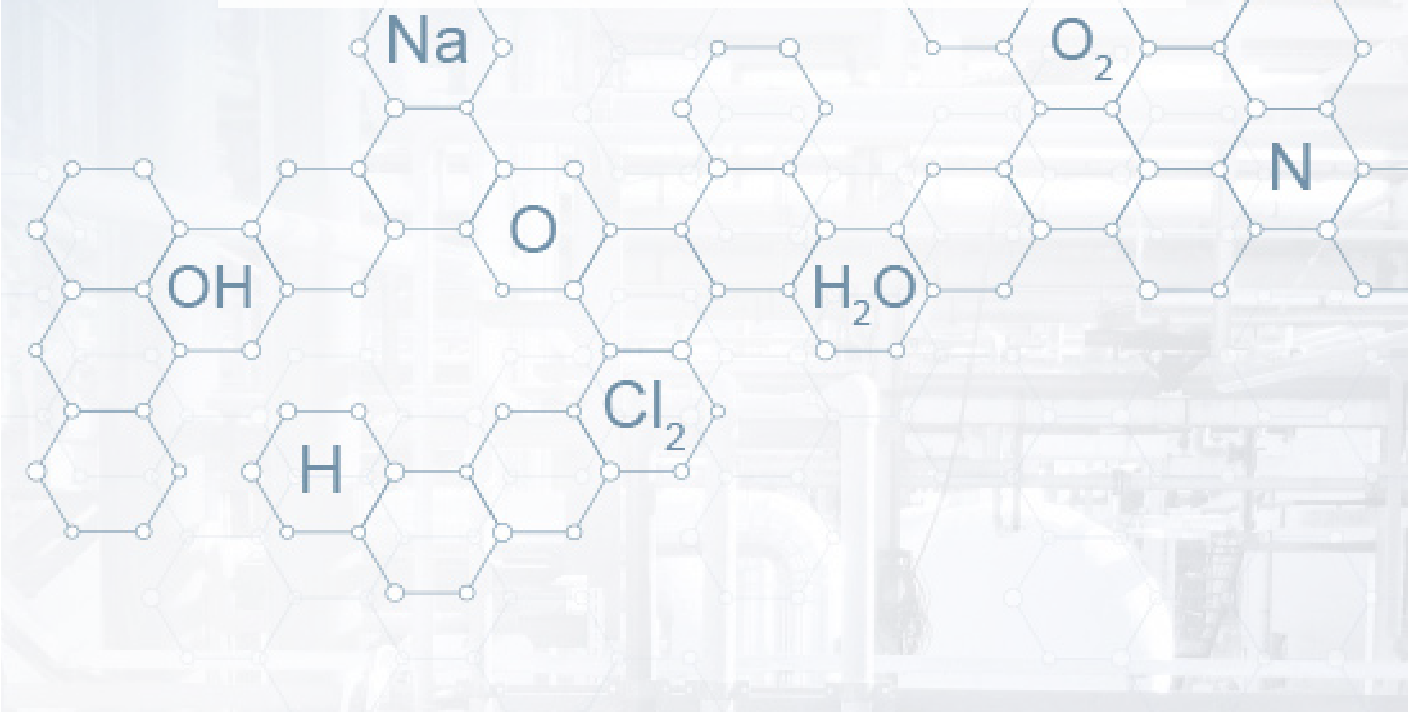

SODIUM HYPOCHLORITE

GENERAL INFORMATION HANDBOOK

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Chemistry of Sodium Hypochlorite

It is important for the consumer to understand sodium hypochlorite from a chemical and handling perspective. This information summarizes the product. Its intention is to assist you to buy the best product, and correctly store and handle it.

Reacting chlorine and sodium hydroxide will produce sodium hypochlorite.

$$Cl_2 + 2\ NaOH = NaOCl + NaCl + H_2O$$

Oxidizing Power of Chlorine & Sodium Hypochlorite

Many consumers are replacing chlorine with sodium hypochlorite as the oxidizing agent. A calculation must be performed to determine how much sodium hypochlorite is required to replace element chlorine.

If sodium hypochlorite is used to oxidize iodide in a solution of acetic acid, the following reaction occurs:

$$NaOCl + 2KI + 2HAc = I2 + NaCl + 2KAc + H_2O$$

If chlorine is used to react with the same amount of iodide, the following reaction occurs: $Cl_2 + 2KI = I2 + 2KCl$

Therefore, a molecule of sodium hypochlorite will oxidize the same amount of iodide as a molecule of chlorine.

Five widely used sodium hypochlorite strength unit definitions are:

Grams per Liter Available Chlorine

The weight (in grams) of available chlorine in one liter of sodium hypochlorite solution. Analysis determines this. Testing methods are available from many sources. You can find our preferred method by *Clicking Here*.

Grams per Liter Sodium Hypochlorite

The weight (in grams) of sodium hypochlorite in one liter of sodium hypochlorite solution. The calculation is converting the grams per liter available chlorine into its equivalent as sodium hypochlorite by multiplying the ratio of their respective molecular weights:

g/L available chlorine x $NaOCl/Cl_2$

or x 74/71 which is 1.05 = g/L sodium hypochlorite

Trade Percent of Available Chlorine

A term used to define the strength of commercial bleaches. It is identical to grams per liter of available chlorine except the unit of volume is 100 milliliters, not one liter. The result is one tenth of the grams per liter.

Trade % Available Chlorine = g/L available chlorine / 10

Weight Percent Available Chlorine

Dividing the trade percent by the specific gravity of the solution gives weight percent of available chlorine. Density measurements will cause errors of 0.5 to 1.0% (i.e. 10% could be 9.90-10.10%) when converting from g/L available chlorine to weight % available chlorine.

Weight % available Chlorine

$$= \frac{\text{g/L available } Cl_2}{(10 \times \text{specific gravity})} \quad \text{or} \quad = \frac{\text{Trade \% Available } Cl_2}{\text{specific gravity}}$$

Note to measure the specific gravity at the same temperature as the bleach sample used in the bleach strength test.

Weight Percent Sodium Hypochlorite

Weight percent sodium hypochlorite is the weight of the sodium hypochlorite per 100 parts of solution. You calculate this by converting the weight percent available chlorine into its equivalent as sodium hypochlorite by multiplying by the ratio of their respective molecular weights:

Note that measuring specific gravity at the same temperature as the bleach sample temperature used in the bleach strength test.

Weight % available chlorine x $NaOCl/Cl_2$ or x 74/71 or 1.05 = weight % NaOCl

Weight % sodium hypochlorite

$$= \frac{\text{g/L available chlorine} \times 1.05}{(10 \times \text{specific gravity})}$$

$$\text{or} = \frac{\text{trade \% Available } Cl_2 \times 1.05}{\text{specific gravity}}$$

or = weight % available chlorine x 1.05

Since sodium hypochlorite sells based on the strength of the product, it is critical to specify which term is used to define the strength of the product.

Ratio of Gallons of Sodium Hypochlorite to Pounds of Chlorine Used

In order to calculate the volume and the strength required to replace the oxidizing power of existing chlorine applications, the strength of the sodium hypochlorite purchased must be converted to the equivalent pounds of available chlorine.

For example using the definition of g/L available chlorine (weight of available chlorine in one liter of bleach) the following conversion is useful:

120 g/L available Cl_2 x 3.785 liters/gallon x 2.205 pounds/1,000 grams = 1 pound/gallon available Cl_2

Each manufacturer will produce sodium hypochlorite with a different specific gravity because of the variation in the amounts of excess caustic, chlorates, and salt. All test procedures by both the producer and the consumer should calculate the bleach strength in grams per liter available chlorine. If using g/L available chlorine. This unit of measure is not dependent on the accuracy of the specific gravity measurement of the product.

Therefore, one gallon of sodium hypochlorite at 120 g/L available chlorine strength will have the same oxidizing power as one pound of chlorine.

Chemistry for < 200 g/L Available Chlorine

Chlorine and sodium hydroxide react to form sodium hypochlorite, sodium chlorate, and water. The strength of the sodium hydroxide determines the strength of sodium hypochlorite produced. Oxidation-reduction potential measurement is used to control the amount of chlorine added to ensure that a slight amount of excess sodium hydroxide is left in the solution to produce a stable product (typically 0.5% by weight).

The salt produced in the formation of the sodium hypochlorite will remain soluble in the solution until the concentration of the sodium hypochlorite reaches 200 g/L available chlorine. Above this concentration, the salt will precipitate out of solution which could cause issues in a production system not designed to handle these solids.

Chemistry for < 200 g/L Available Chlorine

An interactive tool is available to calculate the raw materials required to produce a given strength of sodium hypochlorite Click Here. This tool will work well for sodium hypochlorite that contains the normal amount of salt in solution and is not a "Low Salt" product. If the product is low salt, the density will be lower than traditional sodium hypochlorite.

Ionic strength, pH, temperature, and transition metal content all affect the decomposition rate of sodium hypochlorite. We offer two programs for predicting the decomposition rate. Click Here to view the programs. The online tool will only work for strengths up to 16.5% by weight sodium hypochlorite. Both programs contain data for unfiltered and filtered sodium hypochlorite. In these programs, the unfiltered sodium hypochlorite is ~400 ppb of nickel and 65 ppb of copper, and the filtered production calculation is at ~10 ppb of nickel and copper.

Chemistry for > 200 g/L Available Chlorine

Our patented process produces sodium hypochlorite production at 380 g/L available chlorine with only ~8% by weight NaCl. This process chlorinates a mixture of 50% caustic and sodium hypochlorite. The effective strength of the caustic chlorinated is ~39%. This reaction produces salt crystals in the solution. This salt is removed from the solution and can be used in a chlorine plant or sold as a high purity salt product.

Removing the salt will reduce the ionic strength of the solution and thus significantly increases its half life by as much as a factor of two.

To learn more about the sodium hypochlorite high strength low salt process, please Click Here. If you desire a comparison of traditional hypochlorite bleach versus low salt bleach, we offer a decomposition chart to assist you. Click Here to view the chart.

Low salt hypochlorite offers increased half-life, reduced chlorate and perchlorate concentrations, lighter weight, improved formulations and reduced shipping cost.

Sodium Hypochlorite Decomposition

The consumer must understand the reasons for decomposition of sodium hypochlorite to successfully purchase and utilize the product and eliminate "oxygen locking" and piping systems plugging. There are two major decomposition pathways for sodium hypochlorite. The dominant pathway is as follows: $3NaOCl = 2NaCl + NaClO_3$

Decomposition by Chlorate Formation Path #1

During sodium hypochlorite production, the reaction between chlorine and caustic can produce low pH areas in the reactor which form hypochlorous acid which in turn will form sodium chlorate. See References.

Production methods most common in the 1950's and 1960's used batch systems that produced high sodium chlorate levels due to reaction inefficiencies. Since the 1970's, most manufacturers have converted to continuous production of sodium hypochlorite resulting in excellent control of the pH at the reaction point and thus reduced chlorate formation. However, note that within the continuous sodium hypochlorite manufacturing type, individual methods of operation will affect the levels of chlorate produced during the reaction. For example, traditional packed towers can produce high sodium chlorate levels if the excess caustic in the column drops below ~1.5% by weight excess.

The strength of sodium hypochlorite produced during the reaction will also affect the levels of chlorate. Regardless of the method used in the sodium hypochlorite production.

Decomposition by Chlorate Formation Path #2

Sodium hypochlorite will naturally decomposed due to ionic strength, pH, storage temperature, sunlight, and contaminants such as transition metals (nickel, copper, and iron), and solids such as calcium and magnesium.

The normal rate of sodium hypochlorite without salt, sunlight, transition metals and contaminants with a pH of 11.86-13 can be expressed as:

Rate = $K2\,(OCl^-)^2$ where K2 is a rate constant that varies based on temperature and ionic strength.

We offer two programs for predicting the decomposition rate. *Click Here* to view the programs.

Three Methods to Reduce Sodium Hypochlorite Decomposition Chlorate Formation Path #2

1

As shown, the sodium hypochlorite decomposition formula has a 2nd order rate of decomposition. This means that a 200 g/L available chlorine sodium hypochlorite solution without salt will decompose 4x faster than 100 g/L available chlorine sodium hypochlorite if all other factors are the same.

Understanding the rate of decomposition is important. Sodium hypochlorite is sold at varying strengths in certain regions. It is important to remember that sodium chlorate concentrations will increase more quickly in stronger solutions. Since sodium chlorate concentrations can be regulated in sodium hypochlorite solutions, the lowest practical strength that can be purchased cost effectively should be used.

Another option would be to reduce the strength of the stored product. The product could be diluted with softened water. Hard water contains contaminants that could increase the decomposition rate. Dilution of the product on site could also allow the purchase of a higher concentration product which would reduce the transportation cost of the product.

2

Some small installation systems only have one storage tank of sodium hypochlorite. Mixing old hypochlorite with new is not recommended.

For this example, assume:

- Storage tank is 8,000 gallons in volume.
- 2,000 gallons remaining in tank
- Original strength was 120 g/L
- Current strength is 100 g/L
- 5,000 gallons of product is added at a strength of 120 g/L

After mixing of the two solutions, the final mixed solution will be ~114 g/L available chlorine with higher levels of chlorate because of decomposition. Assume a week later (remains at the same ambient conditions as the previous week) 2,000 gallons remains. Now the 2,000 gallons will be lower than 100 g/L (for example 95 g/L) since it was lower to start with due to the dilution of the old with the new. The end user should always have two tanks for storage plus alternate the tanks for the best results.

3

In many countries it is common to ship strong sodium hypochlorite very long distances in tropical climates and store for lengthy periods of time. If this is a common practice, this will result in increased bleach decomposition. This is not an acceptable practice.

All bleach decomposition depends on temperature. For any temperature, the higher the strength, the faster it decomposes. To understand the decomposition of bleach regarding strength versus temperature, please refer to the AWWA research document "Minimizing Chlorate when Hypochlorite is the Chlorinating Ion." In summary, for every 10°C increase in storage temperature, the sodium hypochlorite will decompose at an increased rate factor of ~3.5.

Another relative sign of decomposition is the rate constant (K2) of sodium hypochlorite decomposition. Below is a table to show these rate constants of decomposition regarding strength and temperature. The data shows that storage of bleach at ~60°F (15°C) will reduce the decomposition. Therefore, if decomposition is a problem in storage and shipping, cooling the stored bleach before shipping should solve the problem.

Chill the product at the production facility with a chilled water system and heat exchanger. This may be costly at the end user site. Therefore, chilling the product in an air conditioned room is a lower cost option. To determine your best option, review each application based on bleach strength, storage temperature, and storage time.

Sodium Hypochlorite (NaOCl) Weight %					
Temperature (°C)	15.89	13.46	10.82	7.93	4.74
55	250	189	138	98.2	65.5
45	80.7	58.7	43.9	30.2	19.3
35	23.1	17.0	12.2	8.43	5.45
25	6.33	4.68	3.22	2.19	1.58
15	1.65	1.15	0.80	0.53	0.30

Minor Decomposition for Sodium Hypochlorite

Oxygen created by the decomposition of sodium hypochlorite is a major problem for the consumer of bleach, however it is a minor decomposition pathway. This pathway is: $2NaOCl = 2NaCl + O_2$

This oxygen formation will occur and is a problem if the transition metals in the sodium hypochlorite are not removed immediately after the production.

The most common reason for this decomposition pathway is poor quality sodium hypochlorite supplied by the producer. If transition metals (such as nickel and copper) are not removed after production, the oxygen pathway will exist in relatively high amounts. Increasing strength and temperature, decreasing pH, and exposure to light with heavy metals will increase both the rate of this oxygen formation and the loss of the sodium hypochlorite.

Avoid poor quality sodium hypochlorite because it creates oxygen formation. The purchase of high purity and quality bleach is accomplished by writing detailed product specifications and enforcing these specifications once you purchase the product.

Oxygen causes major problems. If it forms in pump casings when the pump is inoperative, then an "oxygen lock" occurs. This is similar to when a pump is not primed and air remains in the casing. It will not operate until the casing is vented. Pumping systems are not designed to easily vent and operate without liquid present.

Piping and instrumentation systems can also become "oxygen locked" when the product is not flowing. If the oxygen cannot migrate to the high points of the system and vent, it can cause loss of flow.

Oxygen formation can also cause PVC ball valves to rupture when the valves are closed. It creates extremely high pressure inside the PVC ball during decomposition. It occurs often enough that PVC ball valve manufacturers offers a "blowout proof" bleach ball valve. The valve has a hole drilled on the upstream side of the ball valve. **To eliminate the potential safety problem, it is best to purchase bleach that is filtered and contains low levels of transition metals.**

Oxygen formation is also an issue when hypochlorite is in seal containers. The containers can build pressure caused by the oxygen formation. This pressure can cause the bottom of the container to bulge.

Sodium Hypochlorite Quality

Quality is a major concern when purchasing sodium hypochlorite. The purchaser can have control over the product quality and strength. Specifying high quality sodium hypochlorite with only trace amounts of nickel, copper and suspended solids, and using correct storage and handling procedures achieves the following benefits:

- Low chlorate levels upon delivery
- Reduces decomposition which in turn reduces future chlorate formation
- Eliminates the settling of the suspended solids in tanks, pumps, piping, and instruments
- Produces negligible amounts of oxygen
- Improves safety of PVC piping systems
- Existing insoluble compound coatings will be reabsorbed in the sodium hypochlorite feed solution and it eliminates future problems.

The following items must be tested during the quality inspection of the product received:

Strength

Chemical titration is used to determine strength. See the *Reference* section document. Since delivery strength affects the chlorate levels, the purchaser must consider this when specifying the sodium hypochlorite. It is important for the purchaser to use grams per liter available chlorine when specifying the strength of the product.

Excess Sodium Hydroxide

The strength of the excess caustic or alkalinity of the solution is determined by titration. See the *References*.

The minimum amount of excess caustic in normal applications is 0.3 g/L, which is ~11.86 pH. If the specific gravity of the sodium hypochlorite were 1.20, the 0.3 g/L excess caustic would be 0.025% by weight. Any amount of excess caustic below the 11.86 pH will cause the pH of the solution to drop over time and will result in a much faster rate of decomposition.

If the sodium hypochlorite will be diluted and stored after the consumer receives it, the pH must be higher than the 11.86 pH since dilution will decrease the pH of the solution. However, in practice this should never be a problem due to the amount of excess caustic in the sodium hypochlorite from the producer.

Higher levels of excess caustic above 13 pH or 4.0 g/L will produce a slightly higher rate of decomposition than excess caustic levels from 11.86 to 13.0 pH. The 4.0 g/L relates to 0.35% by weight excess caustic if the specific gravity of the sodium hypochlorite is 1.20.

Specific Gravity

The specific gravity of the solution is the ratio of the weight of the solution relative to water. If the product has a specific gravity of 1.2, a gallon of this sodium hypochlorite weighs 10.00 lbs. The specific gravity of the bleach with the same strength may vary because of the amount of excess caustic in the solution.

Most older data will show higher excess caustic concentrations and thus a higher specific gravity number relative to newer data. This is due to improved production methods.

Older tables will show 120 g/L available chlorine with 0.73% by weight excess caustic, which results in a specific gravity of 1.168 at 20°C. A solution with ~0.2% by weight excess sodium hydroxide will have a specific gravity of 1.160 at 120 g/L. These numbers assume the salt resides in the bleach and tiny levels of chlorate exist in the solution. Titration procedures are available in the *Reference* section.

Sodium Carbonate

Sodium hypochlorite typically contains sodium carbonate, but does not adversely affect the quality in low concentrations. Its presence can actually make the product more stable. Sodium carbonate comes from some sodium hydroxide depending on the manufacturing process used. It forms when air comes in contact with sodium hydroxide.

Sodium carbonate concentration may be a problem if the solution already contains a significant amount of other suspended solids. Then the sodium carbonate will help to collect the suspended solids into large enough particles to drop from the solution and coat the bottom of the tank, pumps, and piping with insoluble compounds. Over time, this will cause a system to need servicing because of plugged pumps, piping and instrumentation. Concentrations of sodium carbonate up to 1% by weight would not be a reason for rejection since sodium carbonate in bleach is in solution and will not precipitate unless the levels are very high. Please refer to the suspended solids testing.

Suspended Solids & Transition Metals Removal

Suspended solids in the product at the time of delivery are typically not visible and don't change the color an appreciable amount. During storage and pumping, these suspended solids will become larger and drop out of solution into the storage tanks and onto the pumps, piping, valves, and instrumentation. Over time, it can make the feed systems non-functional, which causes costly maintenance to remove them.

A test for suspended solids is available by *Clicking Here*. One liter of product is filtered through 0.8 micron filter paper under 20 inches of mercury vacuum. If the product is able to pass through the filter paper in less than 3 minutes, the product contains a negligible amount of suspended solids.

The high quality product is produced by either filtering it with a high efficiency filter system able to filter out sub micron particles or by using high quality raw materials typically only produced by a membrane cell chlor-alkali plant.

Parts per Million of Chlorate

The typical limit of chlorate in the delivered bleach is 1500 mg/liter (1500 PPM). Typically this testing is performed by a qualified laboratory. See the *References* section.

The producer can control the amount of chlorate formed during production by limiting the final strength of the product, temperature of production and controlling pH during reaction. The producer can also help control the chlorate by delivering the product a short time after production. Chlorate concentrations are minimized if the product is of high purity with low levels of suspended solids and transition metals. It also minimized by product strength and temperature reduction during storage.

Parts per Million of Nickel & Copper

Typical specifications of nickel and copper are 50 PPB (Parts Per Billion) or less. Unless the manufacturer has a high purity product, these levels will not be achieved. As discussed above, these transition metals will decompose the product. If the bleach is extremely well filtered, typical nickel and copper content will be less than 10 PPB each.

Nickel is typically found in the 50% sodium hydroxide used in production. Some methods of production for sodium hydroxide result in higher levels of nickel and therefore carry over to the final product.

Copper is typically introduced in the sodium hypochlorite from copper water lines used for process water piping or dilution water. Avoiding the use of copper reduces its presence in the final product.

Since the transition metals can be filtered out with submicron filter aided filter systems, the purchaser can specify the amounts of transition metals in the delivered product. A low transition metal content is usually an indication that very little suspended solids are in the final product. However, the level of suspended solids must also be tested.

Parts per Million of Iron

Typical specifications of iron are for less than 0.5 PPM. The iron levels found in the normal product are not a factor in the decomposition of the product. However, if the iron levels exceed more than ~1 PPM, the sodium hypochlorite will start to turn a slight red brown color. The higher the iron content, the more pronounced the color change.

Specifying low iron concentrations is another method the purchaser can use to obtain high quality product. High iron content in bleach can be reduced by filtering using submicron filter aided filter system.

Materials of Construction

Many different types of materials are used for construction of storage tanks for sodium hypochlorite. Two main types of materials used are linear and crosslinked polyethylene and fiberglass reinforced plastic (FRP). Other choices include chlorobutyl rubber lined steel and titanium.

The choice of materials depends on available capital, tank location, and required service life. Some tanks may only last 3-5 years, however, higher quality tanks that are properly specified and maintained, could last 10-15 years. The only material known to provide over 30 years of service life is titanium.

Compatible

Titanium is the most common metal used for process equipment in contact with sodium hypochlorite. Tantalum is used for electrodes in magnetic flow meters and diaphragm seals. Silver and platinum are used for electrodes to measure oxidation-reduction potential. There should be no other metal in contact with sodium hypochlorite except in rare, special applications where platinum/iridium and titanium/palladium combinations will be used. For non-metallic materials in contact with sodium hypochlorite, the list includes CPVC, PVC, Teflon®, Tefzel®, Kynar®, Halar, polyethylene, FRP and copolymers.

Many non-metallic materials are used as liners inside metals or FRP. The non-metallic material provides the corrosion protection and the metals provide the structural strength. Any non-metallic material exposed to the sun must have a UV barrier on all exterior components. A paint system designed for UV protection is the least expensive. Since these paint systems or gel coats will deteriorate over time, they must be reapplied as required.

Incompatible

If the incorrect metallurgy is used in any portion of the process system, contamination of the product will occur resulting in accelerated decomposition and potential additional oxygen formation. All metals should be avoided except titanium, tantalum, silver, gold, and platinum. Metals such as stainless steel, Hastolley®, Monel®, brass, or copper should be avoided. These incompatible metals can be found in pumps, pump seals and water flush lines, electrodes in magnetic flow tubes, diaphragm seals for gauges and switches, temperature wells, and common piping elements such as hose connections and valves.

Although copper piping is typically used for industrial applications for water supplies and the discharge piping from water softeners, this piping should not be used for dilution water in either the bleach production or the consumer facility for dilution of caustic or bleach. Very small amounts of an incompatible metal will result in large amounts of product decomposition and oxygen formation. The consumer must review each component in the pumping and piping system including all instruments to ensure no incompatible materials are used.

Installation & Design Considerations

There are many design considerations for a successful installation. Some of these considerations are as follows:

- Mount the tank on a properly designed foundation or support system designed for the total load.
- Design each tank installation for the seismic, wind and snow load.
- Properly anchor the tank to the foundation.
- Install flexible connections to all sidewall tank outlets before connecting to permanent piping systems and allow expansion for piping systems on top nozzles.
- Review tank level indication and alarm requirements and supply as required.
- Review tank overflow and vent requirements and design as required.
- Review tank manway, handrails, and ladder requirements and design as required.
- Provide sufficient lighting for safe working conditions.
- Provide all storage vessels with containment for liquid l leaks as required.

Storage & Handling Sodium Hypochlorite

Polyethylene

Tanks can be of linear or cross-linked polyethylene construction and are vertical cylindrical construction with a flat bottom and domed top. Some manufacturers have a special resin for sodium hypochlorite. Outside tanks are white and have UV protection.

Polyethylene tanks are typically low initial cost, however, the service life is typically only 5-7 years. Therefore, design consideration must be given to allow the tank to be easily replaced.

Fiberglass Reinforced Plastic

Using fiberglass tanks for storage of sodium hypochlorite is common and if designed properly can be one of the best choices for storage of the product. However, if improperly specified and constructed, it can be one of the worst choices. A well-specified and properly constructed FRP tank can last 10-15 years or more with proper inspections and repairs. Improper design and construction will cause corrosion barrier failure and structural damage in 3-5 years requiring complete replacement of the tank.

Typical specifications for FRP tanks would include hand laid up or “ortho wound” construction. We do not typically recommend filament wound tanks. This is due to the potential failure mode caused by sodium hypochlorite attacking the corrosion barrier and wicking around the structural portion of the tank. This could cause a catastrophic failure of the tank.

Use vinyl ester resin for the both the corrosion barrier and structural layers of the tank with the inside of the tank (corrosion barrier) starting with 2 nexus veils. Do not use the corrosion barrier for structural design. Catalyze the corrosion barrier with a BPO/DMA catalyst system and a 4 hour post cure.

There has been success with dual laminate FRP tanks using PVC and other materials for the corrosion barrier. If using this method of construction, it is best to ask the manufacturer for recommendations. There are optional methods to detect a liner failure. Use only hand laid up or ortho winding for the FRP vessel. The construction requirements of the FRP portion of the tank should match the recommendations listed above to prevent a catastrophic failure if the tank experiences a liner failure.

Rubber Lined Steel

Using rubber lined steel tanks for sodium hypochlorite storage with chlorobutyl 1/4” thickness lining is acceptable. These linings require a skilled applicator and heat curing. Depending on the rubber and skill of the applicator, the service life is 3-6 years at which time the liner may require total replacement. However, the sodium hypochlorite will attack the steel if a liner failure is not required in a timely fashion.

Titanium

Titanium grade 2 storage tanks are the best choice of material for sodium hypochlorite. However, the use of titanium could be cost prohibitive.

Transportation

It is important to also consider the transportation of the product to the consumers site.

Tanker Trailers

Tanker trailers are tanks mounted on a frame with wheels and a king pin connected to a truck tractor. These trailers are used to deliver large volumes of bleach to the customer's site. Most of the equipment used is capable of delivering from 4,000-6,000 US gallons. These tankers can be of many different designs and the structural tank can be of steel or fiberglass reinforced plastic (FRP). However, all materials in product contact must be compatible with sodium hypochlorite.

There are many different materials of construction used as the corrosion barrier to eliminate damage to the structural tank and to eliminate contamination of the product. Some of these liners include rubber, PVC, Halar®, Tefzel®, and other non-metallic material. FRP tanker trucks are very successful for hauling sodium hypochlorite when the entire container is made of FRP with correct construction methods. However, steel tankers lined with FRP should not be used due to the differences in expansion rates with respect to temperature changes. In the US and Canada, FRP tank trailers are replacing rubber lined steel as the material of construction due to the long life of the FRP trailer. Properly constructed FRP trailers are known to last 30 years.

Since failure of any of these liners will result in damage to the tanker, the owner of the tanker will be inspecting the liners on an annual basis. If required, repair and replacement of the liner will be done.

If a liner should start to fail between inspections, the purchaser may notice two changes in the product received. First, if the tanker is steel with a liner, the iron content of the bleach will increase over time. Second, failure of a liner may result in an increase in suspended solids.

A liner failure may not necessarily result in a major problem, however, the owner of the tanker should be notified of any changes of product quality that may be a result of a defective liner so repairs can be made to the trailer.

The purchaser should specify that the tankers be cleaned if the tanker is contaminated. The tanker may become contaminated if it is used to haul other products, such as sodium hypochlorite.

Flat Bed Trailer Tanks

In some countries the sodium hypochlorite is hauled long distances, but the customer may only require 2,000-3,000 US gallons and require 2,000-3,000 US gallons of sodium hydroxide. In these cases 2,000-3,000 US gallon tanks can be built on skids and two can be mounted on the same flat bed trailer.

The materials of construction of these tanks are the same as the tanker trailers. The same information applies to the to the flatbed trailer tanks.

DOT Exempt Polyethylene Tanks

In the US, polyethylene tanks of 300-600 gallons (with or without structure steel frames) are used to ship sodium hypochlorite. These tanks are typically shipped instead of enclosed trailers or on flat bed trailers. If the customer needs only 500-600 gallons per week, these are very useful containers for shipment.

55 Gallon & Smaller Containers

Sodium hypochlorite is also transported in small quantities in various plastic containers ranging from small ½ gallon bottles to 55 US gallons. In these size containers, it is usual for the container to be constructed with the plastic having UV protection. Some of the small containers will have vented caps to allow oxygen to be vented, however, small household bleach bottles are usually non-vented and the bleach must be of high quality and filtered with a submicron filter aided filter system.

Regardless of the type of container, if it is returned to the manufacturer for refilling, high quality bleach that has been filtered will reduce the amount of washing required.

Components for Sodium Hypochlorite Handling

Pumps

There are typically two types of pumps used for sodium hypochlorite, centrifugal and positive displacement. In all applications, the only metal acceptable is titanium. However, many use non-metallic pumps with or without the structural metal or FRP component.

One of the best centrifugal pumps for sodium hypochlorite is a titanium pump. However, these pumps are expensive compared to other choices and the design cannot avoid the use of seals. There are many good seals available for these pumps and the purchaser should refer to the manufacturer for detailed recommendation. However, any good seal will only last 3-5 years and will require replacement.

A less expensive alternative is a magnetic drive centrifugal pump. These type of pumps typically have Teflon® or Tefzel® lined ductile iron casings. These pumps may only last 3-7 years, however, the initial capital cost is much lower than a titanium pump. The use of a power monitor is recommended to prevent pump damage should the flow of liquid be interrupted.

There are many diaphragm pump choices with small flow applications. The diaphragms can be of Teflon® or some rubber compounds. However, if you use rubber compounds, Viton® is the preferred choice. EPDM is durable but may have a reduced service life.

There are other types of pumps available for special applications. Follow the manufacturer's recommendations for pump choices.

PVC & CPVC Piping

Typical choice for low-pressure piping is PVC or CPVC Schedule 80 socket welded pipe and fittings. Do not use threaded joints for sodium hypochlorite connections if possible. Overtime, a threaded joint will have a tendency to leak. In addition, threading the pipe reduces it structural integrity.

Using PVC or CPVC piping for high pressure (over 50-60 pounds) results in failures and can cause potential injury. If high pressure is required, use soft start motors on pumps. Automated valves require slowly opening and closing to start and stop flows. Velocities in PVC or CPVC piping systems should be 5-7 ft/sec. Use an industrial grade cleaner and glue for the PVC or CPVC and follow the manufacturer's installation instructions. PVC or CPVC installed outside must have UV protection.

Polyethylene Piping Systems

Asahi offers a polyethylene piping system named PE100-RC. This piping system is rated to 150 PSIG and offers a good selection of fittings. We consider this piping system when designing sodium hypochlorite systems.

Lined Pipe

Lined steel piping systems offer the best pressure rating and service life. The preferred lining is typically PTFE. The use of expansion joints is recommended where applicable. These systems are expensive but can provide a service life of 20-30 years. Other liners such as Kynar® and Tefzel® can be used but considering cost, service life, and successful applications, PTFE is the best choice.

Titanium Piping

A light weight schedule 5 or 10 titanium piping system is also an excellent option. Properly designed welded systems will include expansion joints. In large piping systems, titanium is a cost effective method compared to lined piping with better performance because it avoids flange joints.

FRP Piping

Take caution when using FRP piping systems. These systems must be properly constructed with the correct materials, corrosion barriers, and catalysts systems.

If FRP is the piping system of choice, a qualified FRP piping manufacturer should be used. The specifications for the piping are similar to FRP tanks.

Valves

Valve materials should be similar to the materials used in the piping system. A high quality valve is recommended on tank outlet nozzles. Gear drive actuators are recommended in high torque applications to reduce stress on the tank nozzles.

Many types of valves are successful in sodium hypochlorite service, however, seals should be Teflon® with the rubber compounds being Viton® for O-rings and diaphragms.

Gaskets

Non-metallic piping system with low torque ratings typically require the use of low torque gaskets such as Viton® or expanded Teflon®. Hard Teflon® gaskets are not recommended for these applications.

Because of cost considerations, plate-and-frame heat exchangers with use EPDM plate gaskets have been used with acceptable results.

Instrumentation

There are many types of instruments used for sodium hypochlorite service. Most plastic or plastic lined materials such as PVC, CPVC, Teflon®, Tefzel®, Halar, and other materials will work well for the instrumentation construction. However, when using metal in any part of the construction, only use titanium or tantalum components in contact with the sodium hypochlorite. For pH, ORP and magnetic flow meter electrodes, silver, platinum, gold, tantalum, or titanium are the only acceptable materials.

Since even slight amounts of nickel will decompose sodium hypochlorite, never use Hastelloy®. Most corrosion resistance guides will list Hastelloy® as an acceptable choice for sodium hypochlorite. However, nickel in the Hastelloy® will decompose the product. Understand that corrosion tables show corrosion rates for the metal in a product, and it provides no consideration for the effect on the product.

Magnetic flow meters are typically the preferred method for flow measurement. Mass flow meters are used if high accuracy measurement is required. However, please note that density measurements cannot predict the strength of sodium hypochlorite strength due to reasons previously stated.

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