



**TECHNICAL  
ARTICLE  
SERIES**

# **Pump Material Selection Guide: NaOH Sodium Hydroxide/NaOCl Sodium Hypochlorite**

**ARTICLE #** TL-161

**INDUSTRY:** Chemical, Metal Finishing, Wastewater Industrial

**ENTITY:** Various

**SOLUTION(S) PUMPED:** Caustic soda, Chlorine, Hydrochloric acid, Hydrogen

**PUMP TYPE(S):** CHEM-GARD Horizontal Centrifugal Pump, FLEX-I-LINER Sealless Self-Priming Peristaltic Pumps, Nonmetallic Tank Pump Systems, SUMP-GARD Thermoplastic Vertical Pump

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Figure 1. Overview of compact odour-scrubbing installation showing the six Vanton ANSI end-suction polypropylene pumps handling acid and alkaline solutions over the pH range from 3 to 12 at 650 gpm against a 38' TDH.



Figure 2. Two Vanton polypropylene sump pumps handling caustic soda and chlorine solutions.



Figure 3. This compact packed tower scrubbing system relies on two very different thermoplastic pumps: a flexible liner peristaltic type rotary pump to meter 50% NaOH on demand to the vertical in-tank circulating pump, which provides a continuous flow of 5% NaOH scrubbing fluid to the tower.

# Pump Material Selection Guide: NaOH Sodium Hydroxide/NaOCl Sodium Hypochlorite

Reprinted from World Pumps

## Guide to the selection of materials for pumping NaOH and NaOCl

This third article in an on-going series on the selection of materials for pumping corrosive, abrasive and hazardous chemicals considers the challenges presented by the caustic alkali sodium hydroxide and its close relative sodium hypochlorite. George Black looks at the problems and some practical solutions.

### Sodium hydroxide and sodium hypochlorite

Sodium hydroxide (NaOH) is a corrosive alkali, commonly called caustic soda or soda ash. It must be handled with care because it destroys organic tissue and requires protection of the skin and eyes. It is derived by electrolysis of sodium chloride, or by treating a solution of soda ash with a solution of lime. It is widely used in the manufacture of other chemicals, in the manufacture of detergents, pulp and paper, soap and textiles, for regeneration of spent process solutions and for neutralization of acidic wastewater.

Its sister chemical, sodium hypochlorite (NaOCl), is a salt generally derived from electrolysis of a cold dilute solution of seawater. It is unstable in air unless mixed with sodium hydroxide. NaOCl is usually stored in what is known as Labarraque's solution, and is readily recognized by its disagreeable, sweetish odour and pale green colour. It is widely used for the bleaching of paper, pulp and textiles, for water purification, for medicines and in conjunction with sodium hydroxide for treating and neutralizing wastewater. Although both of these chemicals are readily handled by polypropylene, temperature variations and wear-related service conditions often suggest the use of vinyls and fluoropolymers for pump construction.

### Scrubbing systems minimize obnoxious odours

The process design engineers at CH2M Hill were charged with the responsibility of providing this Miami, FL, facility with a multi-stage air scrubbing system that would achieve 99.9% H<sub>2</sub>S and odour removal. In addition, it would have to assure H<sub>2</sub>S discharge less than 0.1 ppm. In conjunction with this mandate, the new system was to be designed to cut maintenance and conform to the latest projected environmental regulations for plant emissions.

Pump selection and material specification were critical to dependable operation of the scrubbing towers and related equipment because in all



Figure 4. Close-up of one of the two sealless thermoplastic magnetically-driven centrifugal pumps automatically delivering the required volume of 25% NaOH on demand.



Figure 5. Polypropylene plastic tank and pump station with pneumatically-operated plastic valves, used in processing chlorine chemicals.

stages of the system, both chlorine and caustic additions were required. The chlorine feed was provided by sodium hypochlorite and the system incorporated the flexibility to adjust and control the 50% truck concentration down to 25% as needed.

The six recirculation scrubber pumps (Figure 1) were specified as ANSI horizontal centrifugals suitable for delivering 650 gpm against a 38' TDH over a temperature range from 55-110°F. To ensure that no metal would be in contact with the corrosive NaOH, NaOCl and H<sub>2</sub>S fluids required to handle the broad range of pH values from 3 to 12, all fluid contact pump components were to be furnished in homogeneous, chemically inert polypropylene or one of the fluoropolymers. The stainless steel shafts were to be isolated from the fluid by a thick sleeve of Kynar®, the PVDF fluoropolymer, and the mechanical seal was to be reverse mounted so that the metal component would be out of the fluid area. These pumps are driven by 25 HP, 1800 rpm, TEFC motors.

An additional ANSI PP horizontal centrifugal pump with the PVDF shaft sleeve was specified to recycle the NaOH caustic. This 4x3x10 pump was required to deliver 500 gpm against a 16' TDH. It is driven by a 15 HP, 1750 rpm, TEFC motor. The same requirement for no metal in fluid contact set for the other centrifugals applies to this pump.

The pumps required to transfer the 50% NaOH caustic soda and 12.5% NaOCl chlorine solutions from their 1500 gallon fibreglass (FRP) storage tanks are vertical centrifugal units designed to deliver 200 gpm against a 13' TDH at a temperature range from 50-90°F (Figure 2). These pumps are driven by 5 HP, 1800 rpm, TEFC motors. The basic pumps have all-wetted components in the pump head furnished in PP and the shaft sleeve in PVDF, but the vertical pump columns are also specified in PVDF. The wetted bearings are nonmetallic, consisting of Vanite and ceramic.

Since installation of the new scrubber system, the facility has been achieving 99.99% reduction in sulphide levels and 99.5% reduction in odour measured by inlet and outlet H<sub>2</sub>S and odour values (ED50).

### **Packed tower scrubber neutralizes sulphuric acid**

Field reports on the use of sophisticated Gaylord Foundry scrubbers in conjunction with resin bonded core mould operations indicated unusually high maintenance problems traced to pump failure under the severe corrosive and abrasive nature of the caustic and acidic fluids they had to handle. Not only did the wetted parts of the pumps have to be inert to varying concentrations of the sulphuric acid and the sodium hydroxide needed for neutralization, but they had to withstand impact and abrasion from sand particles as well.

In a typical operation, the SO<sub>2</sub> gas coming from the core machine flows upwards through a deep bed of polypropylene rings continuously wetted by a 5% by weight NaOH solution supplied from a fibreglass tank. In the original design, an externally-mounted centrifugal plastic pump was used for the continuous circulation. Repeated failure of the seals, and the messy cleanup required, led to a design change. When an in-tank polypropylene sump pump with an integral pump/motor shaft was designed into the system, the seal and cleanup problems were solved.

Here's how the revised Gaylord Foundry Equipment scrubbing system works. Two very different nonmetallic pumps are used to assure dependable delivery of the neutralizing caustic. Controlled feeding of 50% NaOH is provided by a flexible liner peristaltic type rotary pump, instrumented to respond on demand from the pH probe in the tank. The two components of this sealless pump in contact with the fluid are the Teflon® pump body and the Hypalon® flexible liner. Continuous circulation of the caustic solution in the tank is maintained by the polypropylene sump pump, which has no seals or sleeve bearings in contact with the fluid (Figure 3).

Automatic regeneration of the neutralizing solution so that the pH stays at 8.5 is maintained in this manner. A portion of the spent solution is discharged, energizing the caustic transfer pump to meter a controlled quantity of NaOH. Make-up water is then added to maintain the sump at its preset level. A similar Gaylord scrubber design for the foundry industry uses a sulphuric acid-based scrubbing solution. Since the pump materials are inert to both the acid and caustic, the same pumps provide satisfactory service.

### **Maintenance problems solved with CPVC/PVDF pump**

The Burbank Drum & Barrel Company of Glenside, TX, reconditions half-a-million 55-gallon steel drums per year. The process involves immersing the drums in a stripping solution of sodium hydroxide, steam flushing them with the same solution, and power rinsing them with 20% sulphuric acid. In addition to the required resistance to the chemicals, the pumps at the reconditioning station faced a number of wear factors that resulted in costly downtime for repairs.

Service factors included: chemical heat generated by the addition of acid and water makeup, frequent start/stop operation, and abrasion from oxide and scale. Here's how the problems were solved. The existing pump was replaced with a vertical centrifugal design that had the high wear components, the casing and impeller, made of precision-moulded polyvinylidene fluoride (PVDF, Kynar). The column and its welded vertical support gussets were provided in chlorinated polyvinyl chloride (CPVC).

This combination of cantilever design and high tensile strength engineered thermoplastics with superior abrasion resistance where needed did the trick. Pump downtime for repair has been completely eliminated.

### **Advantages of converting from hydrated lime to liquid caustic**

Ever since the Harpeth Valley Water Treatment facility in West Nashville, TN, switched their manual granular hydrated lime neutralizing system to an automated system based on the use of 25% sodium hydroxide, production has been up and costs have gone down. A critical factor in the success of the new system is the selection of magnetically driven, sealless ANSI centrifugal pumps with no metal in contact with the corrosive fluid (Figure 4).

These low maintenance pumps are tied into a completely computerized system that has eliminated arduous manual labour, reduced operating and reporting time, provided more accurate and timely operational information and records, and materially improved the workplace environment.

The 3x2 end suction magnet-drive pumps were provided with casing, casing cover and impeller precision moulded in PP. The inner magnet is completely encapsulated in the same thermoplastic, and the dual nonmetallic can has the wetted face made of polytetrafluoroethylene (PTFE), backed up by a rigid thermoset.

### **Processing chlorine chemicals without corrosion**

An industrial chemical plant in Louisiana needed a corrosion-proof pump and tank station to collect and mix a solution of sodium hypochlorite and other salts with hydrochloric acid. The purpose: to release useful free chlorine gas. The pumps were required to run continuously to simultaneously handle the NaOCl overflow from a neutralizing column and the HCl. The system installed consists of a polypropylene tank and two vertical centrifugal PP pumps designed so that no bearings are in the solution. The large diameter heavy-duty pump bearings are housed in a cast iron motor bracket above the cover plate. The bracket design supports the shaft and motor, and accommodates any standard NEMA flange-mounted motor (Figure 5).

A series of air-operated plastic valves automatically switches the flow from the circulation mode to the discharge line as the solution in the tank reaches the preset level. All wetted parts of the pumps, the valves and the controls were specified in polypropylene. The type 316 stainless steel shafts of the sump pumps were sheathed in polypropylene to isolate them from the corrosive fluid.

**TABLE 1: LABORATORY TEST DATA FOR CORROSION OF METALS  
BY SODIUM HYDROXIDE AND SODIUM HYPOCHLORITE**

	<b>STAINLESS STEEL 304</b>	<b>STAINLESS STEEL 316 &amp; 317</b>	<b>STAINLESS STEEL CARPENTER 20Cb-3</b>	<b>HASTELLOY B</b>	<b>HASTELLOY C HASTELLOY C-276</b>	<b>NICKEL</b>	<b>MONEL</b>
<b>SODIUM HYDROXIDE (CAUSTIC SODA)</b>	A to 100% to 125° F; A to 100% to 250° F; A to 80% to 175° F; B/NR 70 - 90% to 180 - 300° F; A to 60% to 212° F; AB 40 - 70% to 212 - 250° F; A to 30% to 250° F	AB 70 - 100% to 125° F; B to 100% at 347° F; NR 25 - 100% boiling; B/NR 70 - 80% to 160 - 212° F; AB 20 - 70% to 212° F; A to 20% to 248° F	NR 100% at 210° F; B to 100% at 300° F; A to 100% to 125° F; A to 80% to 70° F; B/NR 60 - 80% to 160 - 400° F; AB 40 - 50% to 330° F; A to 40% to 212° F; B to 40% 300 - 330° F	A to 100% to 200° F; NR 80 - 100% at 300° F, stress cracks; A 50 - 70% to 300° F; AB 50 - 70% to 300 - 380° F; A 16 - 50% to 300° F; AB to 15% to 230 - 300° F	A to 100% to 70° F; A 100% to 200° F; AB 50 - 80% to 170° F; BC 50 - 80% at 175° F; AB 5 - 80% at 200° F to boiling; A to 50% to 200° F; B 10 - 20% at 225° F; C 15% at 230° F; A to 5% to 217° F	A to 100% to 300° F; A to 80% to boiling	AB 100% to 70° F; A to 80% to 300° F; AB 40 - 60% 300 - 330° F; A to 20% to 330° F stress cracks 75 - 100% > 250° F
<b>SODIUM HYPOCHLORITE (BLEACH)</b>	C/NR sat'd at 70° F; C 6 - 20% at 70° F; C/NR 3 - 5% at 70° F; A to 1% to 212° F, pits & pits on drying	B/NR sat'd at 70° F; A sat d to 200° F, slightly alkaline; C 20% at 70° F; C/NR 16 - 20% 86 - 140° F; BC 10% at 70° F, pits; A 6.3% to 100° F, pits; A to 6% to 160° F, pits; A to 1% to 212° F, crevice corrodes	B/NR 100% at 70° F; C/NR 50% boiling; C 20% 70 - 140° F; A to 16% to 80° F; A to 6% to 100° F, pits on drying	AB sat'd to 140%; NR 5 - 11% 70 - 90° F	AB 100% to 200° F; A to 50% to 115° F; A to 20% to 140° F	NR 5 - 100% at 70° F; A to 500 ppm to 77° F	NR 10 - 100% at 70° F; B/NR 5% at 70° F; A 500 ppm to 77° F

**CORROSION RATE FOR METAL**

A < .002 in. per year (<.05 mm/yr.) (Excellent)

B < .020 in. per year (<.50 mm/yr.) (Good to Fair)

C < .050 in. per year (<1.27 mm/yr.) (Poor)

NR > .050 in. per year or explosive (Not recommended)

**TABLE 2: LABORATORY TEST DATA FOR CORROSION OF PLASTICS BY SODIUM HYDROXIDE AND SODIUM HYPOCHLORITE**

	THERMOSET VINYL ESTER	THERMOSET EPOXY	POLY-ETHYLENE (PE) Ultra High Molecular Weight	POLY-PROPYLENE (PP)	POLYVINYL CHLORIDE (PVC) Normal Impact and High Impact	CHLORINATED POLYVINYL CHLORIDE (CPVC)	POLY-VINYLIENE FLUORIDE (PVDF) (Kynar*)	ETHYLENE CHLORO-TRIFLUORO-ETHYLENE (ECTFE) (Halar*)	POLYTETRA-FLUORO-ETHYLENE (PTFE) (Teflon*)
SODIUM HYDROXIDE (CAUSTIC SODA)	AB 50% to 212° F, glass or graphite reinforced	NR 100% at 70° F; A to 80% to 140° F; A to 50% to 150° F; AB to 50% to 210° F; C 40% at 212° F; no chg. 2 yrs. 70° F; no chg. 1 yr., 70° F; 20 - 70% conc.	A to 100% to 170° F; NR to 100% at 604° F; -0.5% wt. 5 days, 70° F, 30% conc.	A to 100% to 125° F, no stress; A to 70% to 225° F, no stress; A to 70% to 180° F, stressed	A to 100% to 140° F; A to 70% to 160° F, no stress, normal impact; A to 70% to 150° F, stressed, normal impact; NR 5 - 40% at 212° F; A to 70% to 150° F, no stress, high impact; A to 70% to 140° F, stressed, high impact	A to 100% to 150° F; A to 70% to 225° F, no stress; A to 70% to 180° F, stressed	NR 80 - 100% at 70° F; A/NR 70% at 70° F; B/NR 70% at 104° F; NR 70% at 176° F; B 55 - 60% at 70 - 257° F; A to 50% to 70° F; B 50% at 100 - 120° F; C 50% at 140 - 150° F; NR 50% at 176° F; A to 20% to 104° F; B 20% at 140° F; C 20% at 176° F; NR 20% at 212° F; A to 15% to 176° F; C/NR 10% at 212° F; NR 10% at 230° F	A to 100% to 70° F; A to 80% to 175° F; A to 50% to 250° F; A to 15% to 300° F	A to 100% to 480° F; NR 100% at 604° F; A to 73% to 500° F; no chg. 1 yr 392° F 50% conc.
SODIUM HYPO-CHLORITE (BLEACH)	AB to 18% to 180° F, glass or graphite reinforced	A to 100% to 70° F, best grades; A to 20% to 140° F, best grades; Fail in 60 days, 70° F, 5% conc., standard grades	A to 100% to 170° F; +0.04% wt, 30 days, 70° F +0.21% wt, 10 days, 140° F, no change in appearance	A to 100% to 70° F; AB 100% at 70 - 120° F; BC 100% at 125° F; B/NR 100% at 140 - 225° F, no stress; NR 100% > 225° F; A 30% to 100° F; A 20% to 140° F; AB 15% at 122° F; B 15% at 150° F; C 12 - 13% > 70° F; NR 12 - 13% at 104° F; A to 5% to 120° F; NR 5% at 212° F	A to 100% to 150° F, normal & high impact; Some effect at 140° F	A to 100% to 190° F; AB to 100% to 212° F	AB to 100% to 275° F; A to 17% to 280° F	A to 100% to 300° F; no change; 30 days, 200° F, solution	A to 100% to 500° F

**SWELLING RATE FOR PLASTICS**

- A < 10% swelling, <15% loss of tensile strength, little or no chemical attack (Excellent)
- B < 15% swelling, <30% loss of tensile strength, minor chemical attack (Good to Fair)
- C < 20% swelling, <50% loss of tensile strength, moderate chemical attack (Poor)
- NR > 20% swelling, <50% loss of tensile strength, chemical attacked or dissolved (Not recommended)

Source: Compass Publications Corp. info@compasspublications.com

\*Kynar®, Atofina Chemicals Inc; Halar®, Ausimont; Teflon®, DuPont