

**TECHNICAL
ARTICLE
SERIES**

Pump Material Selection Guide: Bromine

ARTICLE # TL-159

INDUSTRY: Chemical

ENTITY: Various

SOLUTION(S) PUMPED: Bromine, Sodium thiosulphate

PUMP TYPE(S): SUMP-GARD Thermoplastic Vertical Pump

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Pump Material Selection Guide: Bromine

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Guide to the selection of materials for pumping the halogen bromine

In this second of a series of articles on materials selection for pumping corrosive, abrasive and hazardous chemicals, George Black considers the problems presented by bromine. Dense, toxic and highly aggressive, its handling demands specialized pumping solutions, as illustrated by a look at some actual field installations.

Bromine

Bromine is a very dark, reddish brown, extremely heavy (specific gravity 3.11), corrosive and hazardous fluid derived from seawater and natural brines by oxidation of bromide salts with chlorine. It is used in the manufacture of ethylene bromide, a component of anti-knock mixtures, as well as for water treatment, as an intermediate for fumigants, a fire extinguisher fluid, and as bromide salts in pharmaceuticals, photography, catalysis, and precious metal extraction. Other applications include poison gas and shrink proofing wool. Its fumes are toxic and irritating and it indiscriminately destroys most metals including the stainless steels and exotic alloys, as well as most plastics. Best results have been secured with the fluoropolymers.

Case history applications

Nickel components failed

Experienced process engineers were surprised when the nickel pumps they specified for handling bromine provided an average of only two months service before they had to be repaired. According to the corrosion charts they used as guides, nickel is resistant to bromine as long as it remains free of moisture. The problem was uninhibited nickel corrosion caused by the bromine becoming wet by virtue of its deliquescent properties, which caused it to absorb atmospheric water.

The short life of nickel pumps might have been acceptable if not for two problems. One was the long and unreliable delivery time for the nickel components. The other was the hazards involved with dismantling the pumps. Pump designs involved many voids and cavities in which residual bromine might be trapped and released during dismantling. This danger, in combination with exposure to escaping fumes, demanded an alternative solution. Initial attempts to substitute FRP pumps proved disastrous. Service life was reduced to hours. The answer has been found with the standardization on specially designed vertical sump pumps with all fluid contact components made of solid virgin grade polyvinylidene fluoride (Kynar PVDF) (Figure 1). To minimize the danger from escaping fumes, a unique shaft sealing arrangement was developed. It consists of a solid PVDF stuffing box



Figure 1. Cutaway of a Vanton sump pump with all immersed components of solid homogeneous PVDF thermoplastic that is inert to the corrosive bromine.



Figure 2. Close-up of PVDF caps that seal the metal threads of bolts joining the CPVC cover plate, which is isolated from the bromine by a protective layer of PVDF material.



Figure 3. Steel clamping plates and cast iron bolts are completely isolated from the bromine by a 50 mil coating of ECTFE. The threads are then protected from the fluid by PVDF sealing nuts.



Figure 4. Installation of a seamless flexible liner rotary pump with speed-controlling air motor. This unit has provided many years of trouble-free service. Only two components are in contact with the bromine: the heavy-sectioned pump body of PTFE and the Viton fluoroelastomer flexible liner.

packed with woven Teflon (PTFE) fitted to the shaft where it emerges above the mounting plate. Since the use of water for cooling this stuffing box was out of the question, the use of nitrogen gas was required. The necessary cooling along with inhibiting vaporization of the bromine was accomplished with controlled leakage of highly compressed nitrogen gas into the bromine tank.

Solving the heavy weight bromine problem

The 3.11 specific gravity of bromine presents a major mechanical problem when large sump pumps are required. An application involved a vertical Kynar PVDF pump with a 12-foot stainless steel shaft completely isolated from the bromine by a thick PVDF sheath. Conditions of service included delivery of 20 gpm at 100 feet TDH, operating at 1750 rpm. This translates into operating against 135 psi, and more than 1200 pounds of force over the cover plate, the clamping flanges and the bolts. PVDF was out of the question for these components because tensile strength would not be sufficient to withstand the pressure. Here's how this problem was solved.

The cover plate was supplied in high strength chlorinated polyvinyl chloride (CPVC), but the underside, the surface in contact with the bromine, was provided with a thick liner of PVDF. Steel bolts were used to anchor the cover plate to the top flange of the pump, but they were sealed off from the fluid by special caps made of PVDF (Figure 2).

The clamping plates were furnished in structural steel, and the bolts in cast iron. Both the plates and the bolts were isolated from the fluid by a 50-mil coating of ethylene chlorotrifluoroethylene (Halar ECTFE). This fluoropolymer, like PVDF, resists the corrosive bromine and is an excellent coating material. The exposed threads of the PVDF-encapsulated cast iron bolts could not be satisfactorily coated, so they were isolated from the fluids with PVDF sealing nuts (Figure 3).

Long service life with peristaltic pump design

The facilities at a chemical company were designed for toll and contract bromination of organic chemicals. This required a self-priming pump that could safely transfer liquid bromine with minimal maintenance. A leakproof pump design was essential to protect plant personnel from fumes or direct contact with this corrosive fluid. In this application the bromine was pumped from drums of the nickel/copper INCO alloy (Monel) to a glass-lined steel reactor through a Kynar® (PVDF) piping system with a glass elbow in the line to observe the flow. The drum is scale-mounted to monitor flow rate and the amount of bromine added to the reactor. Air entering the drum during the pumping action passes through a drying column to remove moisture that could react with the bromine and form destructive hydrobromic acid.

The decision was made to use a flexible liner, rotary pump design, which transfers fluid by means of a gentle peristaltic action with minimal turbulence. The pump selected has only two components in contact with the fluid — a thick-sectioned Teflon® pump body and a readily replaceable Viton Fluoroelastomer flexible liner (Figure 4). Pumping action is by an eccentrically mounted rotor pressing against the inner surface of the liner and progressively moving the fluid trapped in the channel between the outer surface of the liner and the pump body. This unique sealless pump design eliminates leakage, toxic emissions and

similar problems associated with shaft seals, check valves, gaskets or stuffing boxes (Figure 5).

The pump was furnished with a rotary vane air motor to control the speed and regulate the flow of the bromine. In this application the motor is operated at 300 rpm providing a controlled pumping rate of 0.25 gpm or 5 lb/min of bromine. At the time of this report, the pump had been in service for five years, operating an average of 4.5 hours per day. At the end of each day's run, the pump is flushed with sodium thiosulphate. The low cost flexible liners are changed quarterly since over time changes in their resiliency affect the accuracy of the metering. Average maintenance time for liner change is reported to be approximately 30 minutes, and is done without the use of special tools.

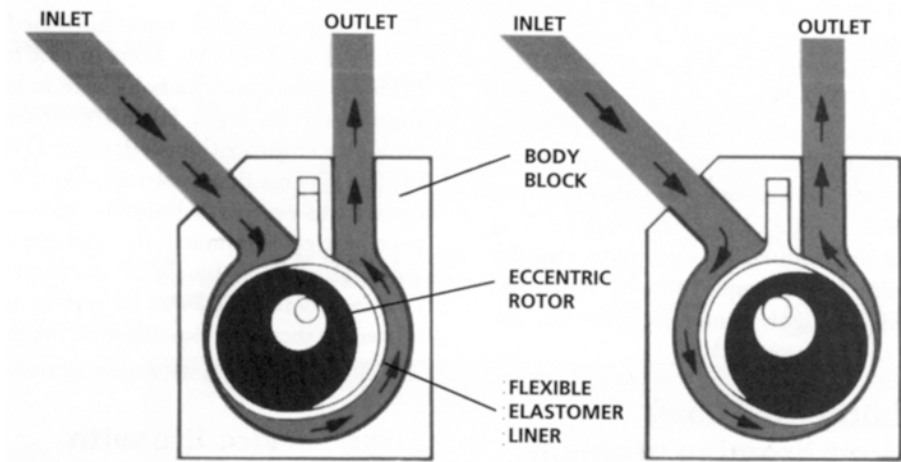


Figure 5. Sketch illustrating the peristaltic type flow generated by the pressure of the eccentric rotor as it progressively squeezes the fluid trapped in the channel formed by the inner surface of the pump body and the outer surface of the flexible liner.

TABLE 1: LABORATORY TEST DATA FOR CORROSION BY BROMINE METALS

	STAINLESS STEEL 303 & 304	STAINLESS STEEL 316	STAINLESS STEEL ALLOY 20	HASTELLOY B	HASTELLOY C	NICKEL	MONEL	TITANIUM
BROMINE LIQUID	NR at 70°F wet or dry	NR at 70°F wet or dry	A/NR at 70°F, dry; NR 70°F, wet	A to 140°F, dry; A to 120°F, wet	A to 140°F, dry; A to 120°F, wet	A to 138°F, dry; AB to 350°F, dry	A to 138°F, dry; AB to 150°F, dry	NR at 70-86°F
BROMINE WATER	NR at 70°F; NR dilute at 70°F	C/NR sat'd at 70°F; B/NR dilute at 70°F	AC at 70°F	A to 200°F; A dilute to 160°F	A sat	NR dilute to sat	NR dilute to sat	A to 212°F; A 3% to 200°F
BROMIC ACID	NR any conc at any temperature	NR any conc at any temperature	No data	No data	A to 70°F	No data	No data	No data
BROMINE GAS, DRY	NR at 70°F	A to 70°F	No data	A to 140°F	A to 150°F; B to 150-700°F	A to 70°F	A to 120°F	AB to 140°F; NR at 200°F
BROMINE GAS, WET	NR at 70°F	NR at 70-86°F	No data	B to 86°F	A to 70°F	C/NR at 70°F	C/NR at 70°F	A to 200°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 1: LABORATORY TEST DATA FOR CORROSION BY BROMINE PLASTICS

	FRP VINYL ESTER THERMOSET	PE (UHMW) POLY- ETHYLENE	PP POLY- PROPYLENE	PVC POLYVINYL CHLORIDE	CPVC CHLORINATED POLYVINYL CHLORIDE	PVDF POLY- VINYLIDENE FLUORIDE (KYNAR®)	ECTFE ETHYLENE CHLORO- TRIFLUORO ETHYLENE (HALAR®)	PTFE POLYTETRA- FLUORO- ETHYLENE (TEFLON®)
BROMIC ACID	AB to 100% to 150	No data	A/NR 70-180°F; NR at 212°F	A to 160°F, no stress; A to 150°F, stressed	A to 100% to 180°F, AB to 100% to 212°F	A to 100% to 212°F; B to 100% to 250-275°F	No data	A 100% to 500°F
BROMINE ANHYDROUS LIQUID	NR at 70°F	C at 70°F; NR to 140°F	NR at 70°F	NR at 70°F	NR at 70°F	A to 150°F; C at 212°F	A to 100% to 250°F	A to 450°F; -6% TS, 30 days, 130°F
BROMINE GAS, WET	AB to 100% to 100°F; AB vapour to 100°F	No data	NR any conc. 70°F	B/NR at 70°F; AB vapour to 140°F	NR at 70°F	A to 212°F	A to 70°F; B at 120°F	A to 500°F, permeable
BROMINE GAS, DRY	AB to 100% to 100°F; AB fumes to 160°F	No data	NR any conc. 70°F	NR 100% at 70°F; A to 25% to 140°F	NR at 70°F	A to 100% to 212°F; B 25% at 248°F; -5.3% TS, 6 mos. 73°F; +0.2% wt, 11 days, 75°F	A to 100% to 150°F; NR vapour at 250°F; -14% TS, 6 mos. 73°F; +1.4% wt, 11 days, 73°F	A to sat'd to 500°F, permeable
BROMINE WATER	AB 5-95% to 200°F	AC at 70°F	B/NR at 70-130°F	AB to 140°F, normal impact; NR at 70°F, high impact	C at 70-80°F; NR at 100-212°F	A to 100% to 210°F; B at 250°F	A to 100% to 250°F	A to sat'd to 500°F

SWELLING RATE FOR PLASTICS

A < 10% swelling (Excellent)
B < 15% swelling (Good to Fair)
C < 20% swelling (Poor)
NR > 20% swelling (Not recommended)

Source: Chemical Resistance Guide, Compass Publications
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*Laboratory test data should only be used as a guide, not as a substitute for experience.
Material variations and specific conditions of service significantly affect results.