TECHNICAL ARTICLE SERIES

Fluoropolymers & Custom Engineering Solve Bromine Pumping Problems

ARTICLE # TL-112

INDUSTRY: Chemical

ENTITY: Various

SOLUTION(S) PUMPED: Bromine

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

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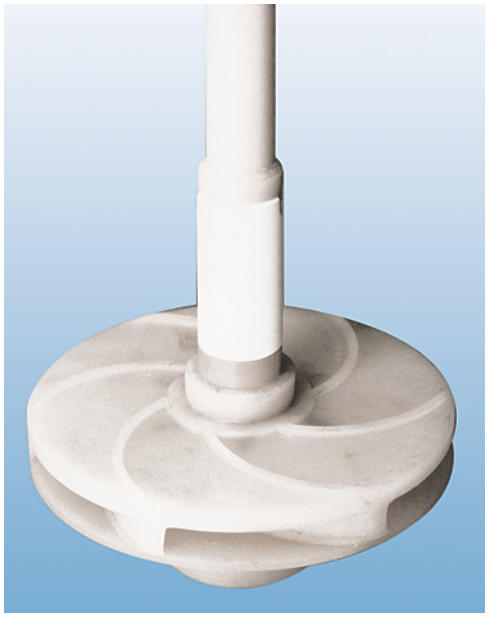
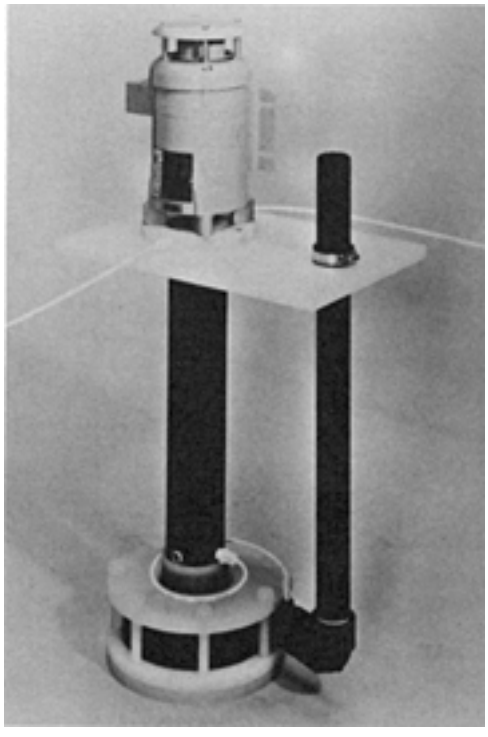


Shaft/impeller assembly of Vanton Sump-Gard® vertical centrifugal pump showing thick sectioned PVDF shaft sleeve, ceramic bearing and key-driven PVDF impeller.



One of the early all-plastic Vanton sump pumps designed for outside tank mounting.

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Reprinted from CHEMICAL EQUIPMENT
By Edward Margus, VP of Engineering, Vanton Pump & Equipment Corp.

In the past 30 years, plastic pumps have come a long way in proving their economic and performance advantages to the CPI. An example of just how far pump designers have come in utilizing the latest advances in plastics can be seen in the development of a line of pumps which successfully and economically handle bromine liquid.

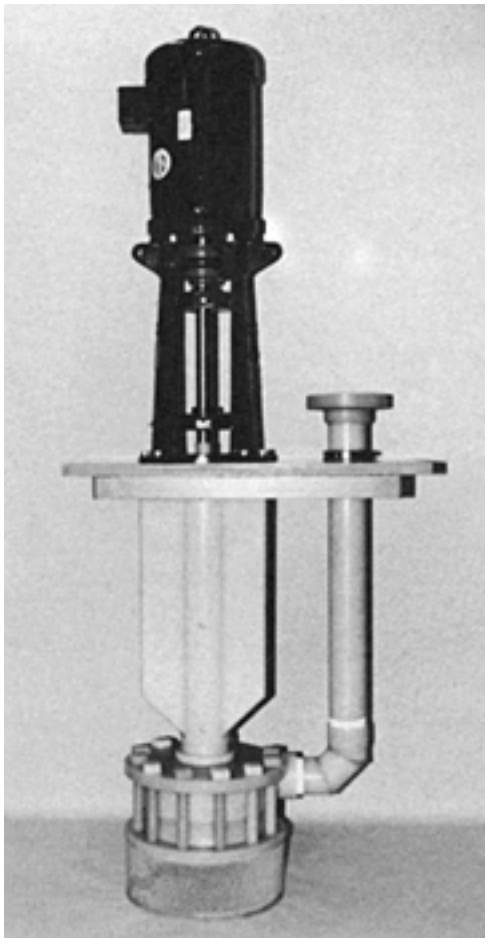
Bromine, a dark reddish brown liquid with a specific gravity of 3.11 indiscriminately attacks most metals including all of the Hastelloys®, sparing nickel only if it remains free of moisture. The bromine element, used in pharmaceuticals, gasoline additives, bleaches, fire retardants, photographic products and, more recently, in manufacturing carbonless copy paper is, perhaps, as good a test as any in demonstrating the versatility of industrial grade plastic pumps. Experienced process engineers, relying on conventional wisdom in specifying costly pumps made of nickel, encountered serious and often disastrous problems when bromine actually attacked the nickel components of these pumps. Although nickel pumps are theoretically resistant to bromine, they rarely lasted more than two months before requiring repairs, and as they aged, their service life between repairs dropped to several days.

The culprit was uninhibited nickel corrosion caused by bromine becoming wet by virtue of its deliquescent properties, which in turn caused it to absorb atmospheric water.

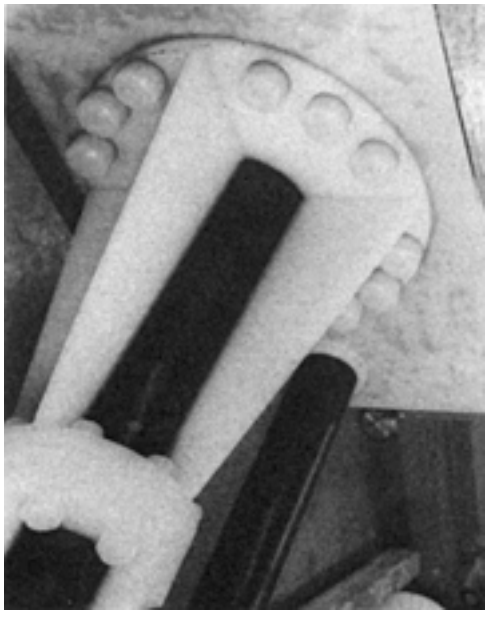
Repairing nickel pumps in itself was a challenge. Many components were difficult to procure and often had a delivery time of weeks or even months. Dismantling these pumps was a hazardous procedure due to their great weight, and the existence of many voids within which residual bromine could lodge only to be released as unsuspecting personnel dismantled the pump.

Adding to the maintenance problems was the tendency of bolts to freeze in their tapped holes or nuts, and the complexity of their designs. Fumes developing from splashing bromine have a potential of causing serious skin and lung injuries. Usually, the costly long-length nickel shaft had to be replaced. The quality of the hard-to-find barstock from which these shafts were machined has always been variable with respect to straightness, finish and dimensional accuracy, thereby creating the potential for destructive vibrations and premature shaft failures.

Nickel pumps were never fitted with shaft sealing arrangements that could effectively prevent the escaping of fumes past the pump shafts. Maintenance personnel in many plants took to improvising their own non-interchangeable sealing arrangements with limited success.



Vanton Sump-Gard® sump pump of bearingless design, with all-wetted parts made of solid PVDF material to resist the bromine.



Close up of PVDF caps which seal the metal threads of bolts to avoid contact with the liquid being handled.

When a bromine pump must be pulled from its tank for servicing, the procedure is long and arduous. A pump destined for repair must be slowly hoisted from the tank, taken in small steps, to permit the bromine to drain from the pump.

Large plastic sheeting is used around the exposed pump sections to reduce the amount of vapors escaping from the tank. This process alone takes about one hour. When the pump has been fully hoisted from the tank, it must then be supported over a shallow pool of water during disassembly. Entrapped bromine escaping from the pump as it is dismantled will fall into the water where it is rendered less harmful.

Obviously these heavy nickel behemoths were not the answer for pumping bromine. Indeed, escalating applications necessitated the development of a better pump. Some bromine-using firms, desperate for a viable alternative, tried pumps made of FRP. The results were disastrous to the extent that the pumps could not even be repaired after only a couple of hours of service.

In response to urgent requests from companies located in the US, Europe and the Mideast, Vanton accepted the challenge of developing and producing a line of sump pumps especially designed for transferring bromine. The resultant pumps were to be produced from solid virgin-grade PVDF, which was found after extensive research to be totally resistant to bromine. Other noteworthy physical properties of PVDF are its very high density, a relatively superior tensile strength, good machinability characteristics, and excellent weldability.

A PVDF characteristic, uncovered by Vanton engineers during the initial research phase, indicated a marked tendency of PVDF to sag or "bow" when fabricated or molded into long slender lengths typical of components used in manufacturing vertical sump pumps. A specially developed design technique, utilizing structural reinforcements, effectively coped with this inherent deficiency.

With the foregoing considerations in mind, Vanton engineers set out to develop a line of bromine pumps consisting of vertical sump pumps, outside mounted vertical pumps, as well as horizontal centrifugal pumps. For reasons of personnel and environmental safety considerations, the vertical sump pumps are preferred.

After evaluating the pumping application, the following features were deemed essential:

• Modular column construction where 30" column sections are bolted together, using solid PVDF bolts.
• Smooth outside surfaces and, more importantly, internal drainage holes to allow bromine to drain off from even the most remote areas.
• Complete sealing of discharge pipe by providing O-rings around its outside diameter where it passes through the pump mounting plate.
• Pump mounting plates that conform to ANSI flange configurations to provide positive closure of the opening of the bromine tank.
• Heavy-duty components to cope with the 3.11 specific gravity of bromine.
• One-piece gasket to be used under mounting plate.

Since the basic Vanton pump design limited contact of the fluid being handled to the selected thermoplastic material, this presented no

serious problem. All parts of the pump exposed to the bromine liquid were specified in solid-molded, extruded or machined PVDF. This included the casing, impeller, column, and other components such as bolts, nuts and washers. The stainless steel pump shaft would, of course, be encased in heavy-sectioned PVDF sleeving with all sleeving and the impeller welded together, then spark-tested to insure complete isolation of the shaft from the bromine.

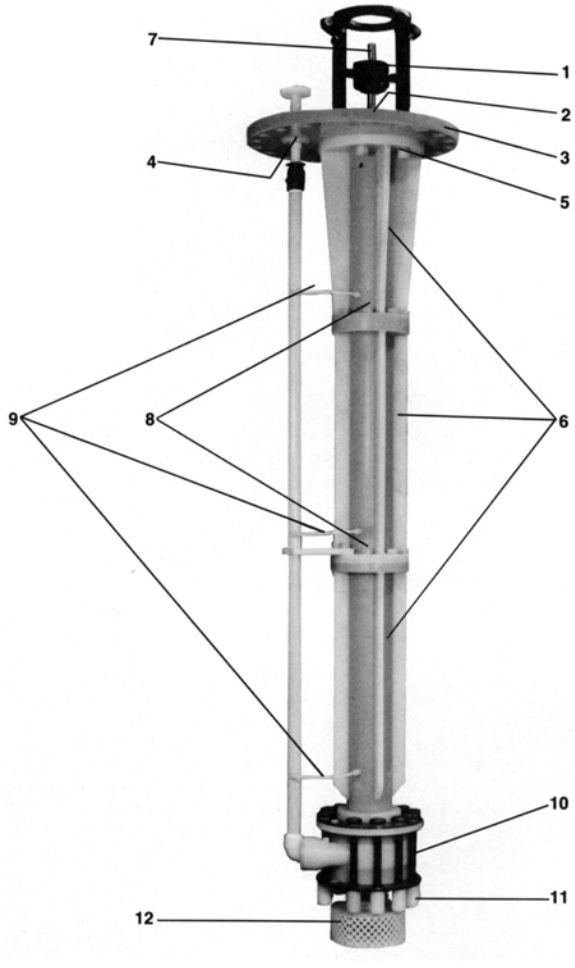
Vanton engineers then turned their attention to prevention of escaping fumes. A unique shaft-sealing arrangement was developed for positively retaining the bromine vapors within a tank or sump. It consisted of a specially developed solid PVDF stuffing box packed with woven Teflon® tetrafluoroethylene plastic which was fitted to the shaft where it emerged above the mounting plate. Naturally, cooling of the stuffing box was required. Since the usual water cooling cannot be tolerated in bromine pumping applications, highly compressed nitrogen gas was recommended for its refrigerant effect. Even so, nitrogen still cannot carry off heat as effectively as water. Thus generous amounts of radiation surfaces are provided within the stuffing box to assure adequate heat exchange. Controlled nitrogen leakage into the bromine tank assures a build-up of pressure to approximately 5 PSIG, inhibiting vaporization of the bromine.

The heavy weight of the bromine presented a mechanical problem; one of the applications called for an extremely large vertical pump with a shaft length of I2'. The pump was designed to deliver 20 GPM at 100' TDH, operating at 1750 RPM. This means that the pump has to operate against 135 PSI.

In this particular application, there would be 12,830 pounds of force over the cover area and each bolt would have to withstand 1200 pounds. There was no way to do this with PVDF bolts. Nor could the PVDF clamping flange resist ultimate buckling. Metal components would have to be used.

Another problem was protection of the cast iron bolts and steel clamping plates from the bromine liquid. To overcome this, each cast iron bolt was coated with 50 mils of ECTFE. This fluoropolymer, like PVDF, resists an extremely broad range of corrosive and hazardous materials, including bromine. It has high tensile strength, toughness and is impact-resistant. It is excellent as a coating material and was considered ideal for the application. But a problem arose as to what to do about sealing the cast iron bolt Acme threads, which cannot be coated. The designers created a series of specially-engineered PVDF sealing nuts. Internal O-rings isolate the threads from the bromine once it engages the ECTFE coated surfaces, thereby simultaneously sealing and tightening the bolts into position. The steel clamping plates holding the casing and casing cover were also coated with 50 mils of ECTFE.

KEY DESIGN FEATURES OF CUSTOM-ENGINEERED BROMINE PUMP



1. Heavy-duty ball bearings sealed with Viton external V-rings.
2. Nitrogen-cooled shaft seal.
3. CPVC cover plate with PVDF underlay contoured to fit ANSI 24" flange of bromine tank.
4. Discharge pipe "O" ring sealed through cover plate.
5. Steel bolts with nuts sealed off with PVDF caps.
6. Heavy-duty PVDF column reinforced with welded PVDF gussets.
7. Stainless steel shaft encapsulated in tank area with PVDF sleeve.
8. Modular designed columns bolted together with PVDF bolts.
9. Teflon product lubricating lines for ceramic/Vanel sleeve bearings.
10. Cast iron heavy duty bolts encapsulated with ECTFE.
11. PVDF sealing nuts to isolate cast iron Acme threaded area.
12. Solid PVDF strainer to user specification.