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TECHNICAL ARTICLE SERIES

How to Select a Non-Metallic Pump

ARTICLE # TL-114

INDUSTRY: Pollution control, Wastewater Industrial, Wastewater

ENTITY: Various

SOLUTION(S) PUMPED: Wastewater

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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How to Select a Non-metallic Pump

Reprinted from POLLUTION ENGINEERING
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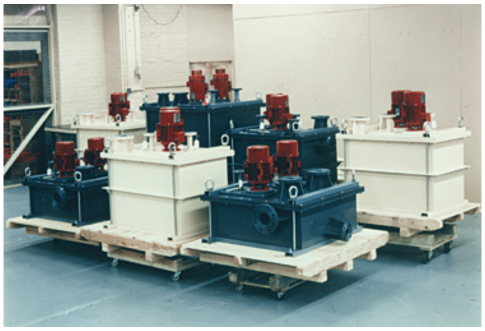


A skid-mounted PVC pump/tank system is headed for a wastewater treatment plant for plating wastes.

Centrifugal pumps transfer sodium hypochlorite from storage to day tanks for an odor control system.

Polypropylene centrifugal pumps feed sodium hexametaphosphate from storage tanks to an injector in an influent pipe.

Pumps constructed of various non-metallic materials are widely used in wastewater and other pollution control applications.

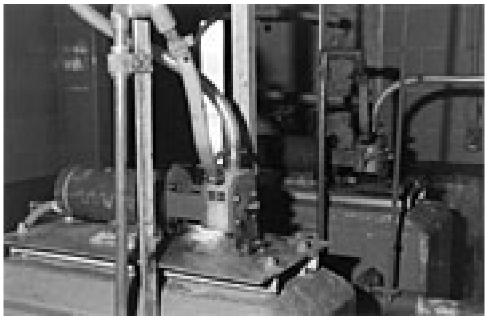
The use of non-metallic pumps for applications involving water and wastewater treatment, pollution control and other related services has been expanding at a dramatic rate for a variety of reasons. Some of these reasons are related to the growing awareness of the need to protect our environment and natural resources. Others are mandated by government regulations. Still others are associated with the development of new and superior engineered plastics and the corresponding economic need to extend equipment life and improve performance.

The information presented here is based on the answers to a questionnaire sent to consulting engineers, system designers, plant operators and plant managers, querying them on pump types, construction materials and applications in the environmental industry.

Non-metallic pumps for environmental use

Although pumps trace their origin to early civilization, plastic designs for industrial and similar heavy-duty service are relative newcomers. The first such pumps were developed in the post World War II period, coincident with the advent of synthetic materials. Because of their chemical inertness, the pumps were widely used in the chemical process and manufacturing industries.

Where are non-metallic pumps used in the environmental industry? The overwhelming majority, more than 97 percent of the respondents, indicated non-metallic pumps are used in their facilities in water, wastewater treatment and other environmental applications. Respondents also were asked what pump types are used at their facilities. Using partially aided recall, the questionnaire listed three basic pump types —centrifugal, vertical (sump) and rotary. Several "other" pump types also were identified by respondents (Table I).



Flexible liner pumps, driven by variable speed motor, automatically feed sodium hypochlorite into wastewater.

Types of Non-metallic Pumps Used

Pump type	Number of mentions
Centrifugal	116
Vertical sump	74
Diaphragm	37
Rotary	29
Magnetic drive	4
Progressive cavity	3
Peristaltic	3
Metering	2
Piston	2
Drum	1
Gear	1

Table 1

Non-metallic materials of construction

To simplify response to the question about which non-metallic materials of construction were used for the wet-end components of pumps used in wastewater and related service, the seven materials most commonly used were listed. The participants in the study doubled the number of materials listed (Table 2).

Materials Used for Wet End Components

Materials of construction	Number of mentions
PVC	78
Polypropylene	61
PVDF (Kynar)	50
CPVC	40
FRP/GRP	33
Polyethylene	26
Teflon	9
ECTFE (Halar)	4
Viton	3
Buna-N	2
Hypalon	2
Nordel	2
Neoprene	2
Tefzel	1

Table 2

Selecting the most effective material for a given application is extremely important. There is no substitute for experience in material selection. Engineered plastics have greater tolerance for a broader range of corrosives. Unlike metals, which have a corrosion rate for given chemicals, engineered plastics are usually either totally resistant or incompatible.

Detailed information on the usefulness of individual plastics is available from the materials manufacturers. This information, normally resulting from static immersion tests, should be consulted for new applications. However, data available from pump manufacturers is very significant since it represents a dynamic test, and the wet end of the pump is where the material gets its most severe exposure.

When dealing with plastics, one of the major parameters is service temperature. Manufacturers tend to be conservative when it comes to the working temperatures for which they will recommend their pumps. The plastic components must be able to retain their shape and maintain the mechanical strength requirements at the temperature level.

Several materials are used in engineered pumps for water, wastewater and related environmental applications. Some of the most common are:

POLYVINYL CHLORIDE (PVC). Perhaps the most common thermoplastic material used in pump construction, PVC is a relatively low cost material characterized by high physical properties and resistance to corrosion and chemical attack from a broad range of acids, caustics and salt solutions. PVC tends to be attacked, however, by solvents such as ketones, chlorinated hydrocarbons and aromatics. PVC is generally used at ambient temperatures and is not recommended for pump service above 140°F.

CHLORINATED POLYVINYL CHLORIDE (CPVC). CPVC has physical properties and chemical resistance similar to PVC. The major difference is its higher useful temperature limit, which for pumps is 210°F, and its correspondingly higher pressure ratings at these elevated temperatures. CPVC is suitable for corrosive liquids at elevated temperatures as well as for low temperature liquids.

POLYPROPYLENE (PP). Polypropylene is the lightest of the industrial grade plastics, having a specific gravity or density of 0.90. This popular polymer offers an excellent strength-to-weight ratio and is recommended for pump service at temperatures to 185°F. In addition to resisting acids and alkalies, polypropylene is also highly resistant to organic solvents. Polypropylene is not recommended for use with strong oxidizing acids, chlorinated hydrocarbons or aromatics.

POLYVINYLIDENE FLUORIDE (PVDF). PVDF is a strong, tough and abrasion resistant fluorocarbon material. Because of its high density, it resists distortion and retains its strength at elevated temperatures. PVDF can be used over a wide range of temperatures, from -40°F to 300°F. In terms of chemical resistance, PVDF is inert to most solvents, acids and alkalies, as well as wet and dry chlorine, bromine and other halogens. Its high hardness and low coefficient of friction make it ideal for abrasion resistant applications. PVDF is recommended for use with ultrapure water and reagent grade chemicals, as well as other applications where freedom from contamination is important.

POLYETHYLENE (PE). This ultra high molecular weight (UHMW) material is impermeable to water and resistant to organic solvents, acids and alkalies. PE is very similar to polypropylene and retains good physical properties at low temperatures and also up to 200°F. Its hard smooth surface makes PE useful for abrasive solutions.

FIBERGLASS/GLASS REINFORCED POLYESTER (FRP/GRP). These thermosetting materials are polyesters reinforced with glass or other fibers to provide additional strength. They are closer to metals in their structural properties than the thermoplastic materials, but are not as chemically resistant. Since FRP/GRP is a composite material rather than a homogeneous polymer, there is potential for forming capillary passageways that result in wicking. This limits the application of these materials, particularly if the same pump is to be used for different chemicals. It also limits their use in abrasive service. Maximum service temperatures for pumps made of these materials is 230°F.

ETHYLENE CHLOROTRIFLUORETHYLENE (ECTFE). This material resists an extremely broad range of acids including oxidizing types, the alkalies, and most other corrosive and abrasive fluids. ECTFE is very similar to PVDF. It offers excellent barrier properties suitable for ultrapure water and similar fluids where contamination could be a problem. ECTFE has extremely high tensile strength as well as impact resistance. It is recommended for temperatures to 300°F.

POLYTETRAFLUORETHYLENE (PTFE). This material is most commonly referred to as Teflon. It is one of, if not the most inert of the thermoplastics available. PTFE retains useful mechanical properties at temperatures as high as 500°F. It offers excellent impact and abrasion resistance. Compared with the other fluoropolymers, however, its tensile strength and creep resistance are low.

The above covers the rigid materials generally used for pump construction. Other materials mentioned by respondents refer to elastomeric components, primarily gaskets, O-rings, flexible liners and other parts that require corrosion and impact resistance combined with flexibility.

Why plastic pumps are selected

Plastics represent a large family of synthetic materials with a number of common characteristics. They share the same basic molecular structure, and being manmade, they can be readily modified and compounded to achieve a wide variety of physical properties and behavior patterns. The term "polymers" frequently used in relation to plastics refers to their molecular structure. They consist of very large chain-like molecules, made from various organic substances called monomers. The chemical reaction used to link and form the monomers into polymers is polymerization.

Although thousands of plastic compounds exist, the reasons for selecting specific ones for pump construction are summed up in Table 3.

Why Plastic Pumps Are Selected

Reason for selection	Number of mentions
Corrosion resistance	108
Price	23
Abrasion/erosion resistance	20
Contamination avoidance	19
Light weight	17
Design	9
Weathering	5

Table 3

Corrosion resistance, not surprisingly, was listed as the primary reason for selecting plastics for pump construction. We were somewhat surprised, however, to see the relatively high position of "price" since pumps made of engineered plastic are similar in cost to pumps made of type 316 stainless steel.

Engineered plastic pumps, built to the standards required for resisting corrosives or for use in rugged service offer advantages over metal pumps in terms of longer service life and lower maintenance, but not necessarily in terms of original price. They are, however, less expensive than pumps of exotic materials such as Alloy 20, Hastelloy, Nickel or Monel.

Other reasons for using plastic pumps mentioned by respondents were purity, environmental protection, flexibility and non-sparking in an explosion-proof environment. Another reason for specifying engineered plastics is low maintenance. Plastic parts do not gall or seize the way metal parts do. Nuts and bolts and other hardware are easy to remove and threaded plastic components can be unscrewed readily and reused. Plastic pumps are easy to keep clean and do not need to be painted since they don't rust.

Non-metallic pump applications

Approximately 100 specific applications for nonmetallic pumps in wastewater and pollution control service were listed by the respondents (Table 4). These applications fall into several basic groups:

- Transfer chemicals from bulk storage to day tanks.
- Metering chemicals and polymers.
- Chemical feed to scrubbers and condensate pumping.
- Odor control systems.
- Groundwater remediation and landfill leachate treatment.
- Lift station collection and wastewater treatment.

Specific Applications for Non-metallic Pumps

Abrasive solutions	Industrial odor control
Absorber feed	Laboratory drains
Acid injection	Lagoons
Acidic rinse water	Landfill leachate
Acid sludge	Lift stations
Acidic waste	Lubricants
Acetic acid	Metal precipitation unit
Ammonia solutions	Metering
Bilge water	Mixed acids
Bleaching agents	Municipal odor control
Blending tanks	Nitric acid
Boiler treatment chemicals	Nitric/hydrofluoric mixture
Brine	Odor control
Bulk chemicals	Oil containment systems
Caustic soda	Oil field drilling fluids
Chemical feed	Oil spill pick up
Chemical sewers	Oil water mix
Chemical spills	Oily water sewers
Chlorides	pH adjustment/control
Chlorine scrubbers	Phosphoric acid
Chromium plating wastes	Pickle liquor
Citric acid	Pits
Collection pits	Plating agitation
Coolant water	Polymer feed/injection
Condensate	Portable pump/tank units
Core blower scrubbers	Rain water collection
Deionized water	Reactor vent scrubber
Deodorizing systems	Recirculation
Detergents	Retention ponds
Dilute acids	Salt water
Evaporator pumps	Scrubbers
Ferric chloride	Sludge
Ferric sulfate	Sodium bisulfate
Filtering systems	Sodium hypochlorite
Flocculants	Spill pick up
Fluoride transfer	Sulfuric acid
Fluosilicic acid	Sulfur dioxide scrubbing
Fume scrubbers	Sumps
Groundwater remediation	Tank cleaning
Hazardous waste	Tank draining
Hydrochloric acid	Transfer of chemicals
Hydrofluoric acid	Tank vent scrubbers
Hydrogen peroxide	Wastewater
Incinerator ash slurry	Ultrapure water

Table 4

Bad experiences with non-metallic pumps

The majority of respondents said they had not had a bad experience with non-metallic pumps. Of those who had, most offered their own carelessness, negligence or lack of knowledge as the primary cause. The bad experiences of respondents fell into four basic categories:

- Buying low quality because of low price.
- Improper applications, selecting the wrong materials, the wrong pump or improper design.
- Poor installation, often due to carelessness
- Improper maintenance, often due to unfamiliarity with recommended maintenance procedures for plastic pumps.

The most common material-related selection problem appears to be improper use of thermosetting FRP/GRP pumps in severe corrosive/abrasive applications. Switching from thermoset to thermoplastic pumps helped solve the problem in many cases. In some abrasive applications where polypropylene pumps were originally selected, impeller wear was overcome by switching from polypropylene impellers to PVDF.

A number of respondents referred to difficulties under cold or freezing temperatures, particularly when PVC was the basic material. One solution is to specify PVDF instead of PVC because it maintains its strength at temperatures as low as -40°F. Other solutions involve heat tracing, proper insulation and special handling techniques.

Operating problems due to seal and bearing failure are the result of poor maintenance practices. Analysis of the bad experience mentioned in the responses points out the importance of working closely with the pump manufacturers before specifying materials or design for difficult applications.

Pump headaches

The final question asked for information on pumping applications that still cause the biggest headaches. The answers fit into two basic groups: difficult-to-pump products and demanding operating conditions (Table 5). Responses cut across all pump materials —metals and plastics.

Pump Application Headaches

Products rated difficult to pump
Wide and varying pH range
Products that tend to crystallize
Abrasive slurries
Liquids with solid particulates
Sludges
Chemicals such as chlorine, chromic acid, bromine, hydrogen peroxide, ferrous sulfate
Viscous liquids
Mixed slurries, salt water, waste crude, sand drilling muds
Waste acids with iron scale
Polymers

Difficult operating conditions
Low temperature operation, freezing
Low flow, high head
Skimming a thin petroleum product layer off the groundwater surface
Variable flow rates and head conditions
Transferring small quantities of recycled chemicals between tanks.

Table 5

The biggest headaches are associated with pumping sludges, heavy slurries and high head, low flow conditions —things that have nothing to do with the basic material selection and can cause problems for metal as well as plastic pumps. With the exception of thick sludges and sand/oil slurries, all of the difficult products listed by respondents can be pumped with properly engineered non-metallic pumps. None of the difficult operating conditions are beyond the scope of non-metallic pumping systems.

It also is obvious from the responses that satisfactory service life is a relative term. Downtime is expensive. Extending it by days or even hours is frequently of significant value. The larger the operation the greater the significance in most cases. But in the environmental industry, where equipment often operates in remote locations, continuous operation is unrelated to the size of the operation.

This again highlights the importance of discussing pump problems with the manufacturer and seeking out manufacturers who will modify existing designs when off-the-shelf products can lead to expensive problems.

Engineered plastic pumps have made strong inroads in water and wastewater treatment, pollution control and related environmental services. For maximum performance and efficient service life, the emphasis should be on quality products engineered for the specific corrosive or abrasive applications.

In addition to selecting the right materials of construction, the right pump type and the necessary design features, it is imperative that care be taken during installation and that sound maintenance programs be followed.