Quick Reference Guide – An Overview of Pharmaceutical Pump Types, Capabilities and Differentiators

By Craig Hill, pharmOvate-Triangle Process Equipment General Manager

	Positive Displacement — Rotary				Positive Displacement — Reciprocating			Dynamic
	Lobe	Progressive Cavity Pump	Double Screw Pump	Peristaltic	Air Operated Double Diaphragm	Quaternary Diaphragm	Piston	Centrifugal
Key Performance/Technical Characteristics								
Single Use Options Widely Available?	No	No	No	Yes	No	Yes	No	No
Scale Up with Same Equipment?	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Typical Flow Range	Low - High	Low - Medium	Low - High	Low	Low - High	Low - High	Low - Medium	Low - High
Viscosity	Medium - High	Medium - High	Low - High	Low - Medium	Low - High	Low - Medium	Low - Medium	Low
Includes Mechanical Seals?	Yes	Yes	Yes	No	No	No	Yes	Yes
Dry-run Capable?	Yes (Double Seal)	No	Yes (Double Seal)	Yes	Yes	Yes	Yes	Yes (Double Seal)
Self-Priming?	No	No	Yes	Yes	Yes	Yes	Yes	No
CIP Capable?	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes
Product and CIP Flow Duties with Same Pump?	Yes	No	Yes	N/A	Yes	Yes	Yes	Yes
SIP Capable?	Yes	Yes	Yes	N/A	Yes	Yes	No	Yes
Streamlined Validation?	Yes	No	Yes	Yes	No	Yes	No	Yes
Other Performance Strengths – N/A, Good (★), Better (★★), Best (★★★)								
Flow Control	★★★	★★/★★★	★★★	★★★	★★	★★★	★★★	★
Suction-lift Capabilities	★★	★★	★★★	★★	★★★	★★★	★★★	★
Dosing Accuracy	★★	★★	★★★	★/★★	★	★★★	★★	★
Performance/Technical Weaknesses – Never Happens (0), Rarely Happens (X), Sometimes Happens (XX), Frequently Happens (XXX)								
Pulsation	X	X	0	XXX	XXX	X	XX	0
Particle Generation	0	XXX	0	XXX	X	0	X	0
Shear	X	X	XX	X	XXX	X	XXX	XXX
Slippage	X	XX	XX	XXX	X	X	0	XX
Operation Raises Product Temperature	X	XXX	X	X	X	X	X	XXX
Metal-to-Metal Contact	X	0	0	0	0	0	XX	0

Highlights of This Quick Reference Guide:

Includes a comparison chart of pumps' technical characteristics, performance strengths and weaknesses

Explains the common types of pumps used in pharmaceutical and biotech applications

Outlines the main differentiators among pump types

Discusses important after-purchase considerations

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Triangle Process Equipment | P.O. Box 1116 Wilson, NC 27893-1061
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With people living longer and the global population increasing, the pharmaceutical market is growing. It is projected that the United States will record the largest growth.[1] However, several issues unique to the industry are challenging pharmaceutical manufacturing companies to capitalize on this growth. These challenges include, but are not limited to:

- Meeting rigorous regulatory requirements and high-purity obligations
- Changing production models that address:
  - The demands of today require that we consolidate the timeline of bringing products to market
  - Pressure to control costs/ to meet the demands of managing prices to the consumer pricing
  - The introduction of more "next-generation" treatments that offer curative results in a single dose and the demand for personalized medicine

One way pharmaceutical manufacturers can help protect their bottom line is to ensure their processing equipment is contributing to efficient production that is free of contamination issues. Medicine and drug manufacturers, as well as biotech, biopharmaceutical and life sciences operations that make prudent equipment choices optimize their processing capabilities, which in turn, improves their ability to overcome common production challenges in a repeatable process.

Optimized processing begins with careful pump selection. However, numerous styles of pumps serve the pharmaceutical industry, which can make the selection and acquisition process difficult to navigate.

The purpose of this report is to help engineers and operations managers obtain a better understanding of the nuances of pumps in pharmaceutical manufacturing by:

- Explaining the common types of pumps utilized in pharmaceutical and biotech applications
- Outlining the main differentiators among pump types
- Discussing important after-purchase considerations

Pumps – It's A Big World

Most people who work in the processing equipment industry agree: establishing a strong "pump IQ" can be challenging. This is because there is a wide diversity of pump styles available that feature highly technical performance capabilities to serve an immeasurable variety of application needs.

In the pharmaceutical and biopharmaceutical industries, 8 types of pumps are commonly utilized, each with a number of variations available from a lengthy list of pump manufacturers. Among those 8 pumps however, pharmaceutical and biopharmaceutical processing is the primary application for only about half of them. Some pumps are better known for their applications in waste water, pulp and paper and chemical processing, which makes this subset of pumps' value in pharmaceutical manufacturing more obscure.

Further, dense technical data that summarizes equipment specifications and capabilities dominates the reference materials that are available for most pumps. All of these factors can make self-guided research for new pump purchases both time-consuming and frustrating.

Reference: 1. https://www.contractpharma.com/issues/2018-01-01/view_features/pharma-industry-outlook

Overview of the Most Common Pumps

In many ways, pumps are like cars. Not each type of vehicle on the market is the right fit for specific transportation goals. For example, if you put a Ferrari on a racetrack, it will be a top performer. However, if you put a Ferrari in a quarry setting where the primary job is to move heavy loads, it will fail at the core mission. A parallel observation can be applied to pumps, which are characterized by a high level of nuance.

To help people working in biopharmaceutical and pharmaceutical applications develop a foundation of pump knowledge, the charts featured on this page and the next page reference pumps **in general terms**. The information is meant to serve as a high-level overview of pharmaceutical and biopharmaceutical pumps, with the goal of helping operators build up their "pump IQ." It is not meant to be used as a definitive, comprehensive equipment selection tool. Please consult with a trusted equipment representative for more detailed information about individual product offerings and their specific capabilities to help ensure correct product selection for your unique application, which may vary slightly from what is presented here.

Additionally, some common data points – energy consumption and equipment footprint, for instance – have purposefully been omitted from the chart to prevent operators from fixating on points that aren't genuine representations of value. Pump size and energy consumption are largely pre-determined by the pump's performance capabilities. A pump's performance capabilities should be the key driver in equipment selection. Pump size and energy consumption are derivative and should be secondary considerations.

	Positive Displacement — Rotary				Positive Displacement — Reciprocating			Dynamic
	Lobe	**Progressive Cavity Pump**	**Double Screw Pump**	**Peristaltic**	**Air Operated Double Diaphragm**	**Quaternary Diaphragm**	**Piston**	**Centrifugal**
Also Known As:				Hose Pumps	AODD			
Operating Principle:	Fluid flows into a cavity that is created between two rotating lobes and it travels in the pockets between the lobes and casing. It is forced through the outlet under pressure created by the meshing of the lobes.	A single helical rotor moves eccentrically within a double helical stator.	Axcille transportation of product through meshing screws.	Fluid is contained in a single-use tube that is compressed and decompressed by a moving rotor, which moves the fluid in the tube.	Compressed air is shifted from one chamber to the other by a linked shaft that allows the chambers to move simultaneously. This back-and-forth motion forces liquid out of one chamber while the other chamber is filled with liquid.	Four-piston (quaternary) diaphragm technology enables a gentle pumping through soft "heartbeats". Each stroke of the four diaphragms is generated by an eccentric shaft, which is connected to the electric motor.	Pump cycles through a suction phase and a pressure phase to move fluid.	The fluid enters the pump impeller along or near the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits.
Most Common Applications:	Pulp and Paper, Chemical, Food, Beverage, Pharmaceutical	Viscous and Shear-Sensitive Materials	Cosmetics, Food, Beverage, Pharmaceutical and Biotech	Cosmetics, Food, Beverage, Pharmaceutical and Biotech	Waste Water, Pulp and Paper, Beverage, Chemcial, Petrochemical, Biofuel, Dairy, Food	Cosmetic, Food, Beverage, Pharmaceutical and BioTech	Beverage, Food	Waste Water, Pulp and Paper, Beverage, Chemcial, Dairy, Food

Chart Continues on Next Page

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Dosing Accuracy	★★	★★	★★★	★/★★	★	★★★	★★	★
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Particle Generation	0	XXX	0	XXX	X	0	X	0
Shear	X	X	XX	X	XXX	X	XXX	XXX
Slippage	X	XX	XX	XXX	X	X	0	XX
Operation Raises Product Temperature	X	XXX	X	X	X	X	X	XXX
Metal-to-Metal Contact	X	0	0	0	0	0	XX	0

Additional Considerations

Two important considerations should be at the forefront of pump research and selection for the owner:

1. Assessing the value a single-use pump could bring to your operation
2. Estimating the cost of ownership

Single-use technologies are helping pharmaceutical and biotech operations improve process optimization. Disposable pump chambers significantly reduce cleaning, sterilization and validation procedures to enable quick batch changeovers (a single-use pump chamber can be changed in as little as one minute). As scrutiny about drug prices grows and speed-to-market becomes an increasingly important consideration, single-use pumps help drug manufacturers streamline production and get more product to the market quicker while eliminating losses resulting from cross-batch or cross-product contamination.

All pumps require some maintenance. But the frequency and complexity of maintenance requirements will have a lasting impact on cost of ownership. There are three primary drivers of increased maintenance costs, product losses and production downtime:

- The pump includes mechanical seals that need to be changed.
- The pump is not dry-run capable. Some pumps are marketed as dry-run capable, but they require double seals, which themselves can be cost-prohibitive.
- There is metal-to-metal contact within the pump that causes rotating parts to wear and shed particles.

Pumps designed to minimize these maintenance issues will yield higher production uptime with lower expenses.

Conclusion

The traditional pharmaceutical and biopharmaceutical production models are evolving as drug manufacturers are challenged to deliver the right drugs at the right time at cost-effective price-points. At the same time, processing technologies continue to advance. Decision-makers who advance their pump IQ will have more productive discussions with their equipment supplier about equipment offerings, and ultimately, will be in the best position to acquire the best pump for their application's unique needs. Reputable supplier partners collaborate with biotech and pharmaceutical manufacturing stakeholders to provide the following benefits:

- Extensive technical expertise
- Years of practical experience on production floors
- A consultative approach to fully understand the needs and challenges unique to individual operations
- After-purchase support
- Equipment solutions that:
  - Provide a low cost of ownership
  - Create efficiencies
  - Increase production output
  - Improve operational profitability

Process engineers and plant managers who expand their knowledge of pumps and then leverage the experience of trusted equipment suppliers during the pump acquisition process will prepare their pharmaceutical or biopharmaceutical operation for a competitive future.

Craig Hill is General Manager of pharmOvate-Triangle Process Equipment. He has over 20 years of experience in the processing equipment space, with particular expertise in pharmaceutical and biopharmaceutical applications. Contact him at chill@pharmovate.com.