YOUR COMPANY'S GUIDE TO PUMPS AND VALVES

Helping your organization understand the fundamentals of pumps and valves, and their selection for optimal system performance.



ASME L&D LEARNING & DEVELOPMENT

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PUMPS AND VALVES

Pumps and valves are crucial in a wide range of engineering applications, from large scale industrial processes to everyday applications.

While pumps are used to move fluids from one place to another, valves are used to control their flow through pipes, tubes and other channels. For example, pumps are used in power plants to circulate water through the cooling system — crucial for keeping the facilities running safely. Valves control the flow of fuel in engines.

Both are critical components in many industrial applications, including piping systems within manufacturing, transportation and power generation.

There are a wide variety of different pumps and valves which can be used within the industry, and for a range of purposes. It's crucial to thoroughly understand the needs of the project when selecting a component for use.

This guide will explore the fundamentals of pumps and valves, along with challenges engineers face when selecting pumps and valves for industrial applications. Learn some of the key benefits of taking ASME training to get up to speed. As well as some of the most frequently asked questions answered by ASME's industry expert.



TYPES OF PUMPS

Centrifugal pump

A centrifugal pump consists of two main components: the impeller and the volute (diffuser).

The impeller is the rotating part, which converts the energy from the motor or an engine into kinetic energy.

The volute is the stationary part, which converts kinetic energy into pressure energy.

There are two types of centrifugal pumps:

- **Single stage pumps** have one impeller located within the volute and most of the pumps in operation are single stage, where the required head is about 40 to 50 meters.
- **Multistage pumps** contain two or more impellers, used where higher heads are required, such as the feedwater pump of a boiler. For example, for a boiler operating pressure of 10.5 kilograms per square centimeter, the required pump would be multistage and deliver heads greater than 105 meters.

Positive displacement pumps

Positive displacement pumps cause a liquid to move by trapping a fixed amount of it, and then forcing (displacing) that trapped volume into a discharge pipe.

Positive displacement pumps include:

- **Reciprocating pumps**
- **Gear pumps**
- **Lobe pumps**
- **Screw pumps**

THE FUNDAMENTALS OF **PUMP SELECTION**



When selecting a centrifugal pump:

- Identify the system (for example fresh water, chilled water, hot water, hot liquid)
- Draw piping configuration with respect to the site
- Calculate the total system head, considering the length of the pipe, number of bends, reducers, and valves
- Select the appropriate materials of choice for the pump
- Select the pump from the family of curves provided by the manufacturer, and superimpose the system curve on the performance curve of the pump. Most manufacturers now have selection software that can be used for this step
- Specify the testing standard
- Ask for the performance test certificate

The selection of a positive displacement pump is based on the following criteria:

- The material to be pumped
- The nature of the material
- The viscosity of the fluid
- The number of particles in the fluid (if any)
- The quantity of fluid to be pumped
- The height to which the fluid is to be pumped, or the head required at the delivery of the pump
- The temperature of the fluid
- The available suction head
- The amount of leakage allowed
- The application

TYPES OF VALVES

There are many different types of valves used for a range of different applications.

Valves used in industry

- **Gate valves**
- **Globe valves**
- **Ball valves**
- **Butterfly valves**
- **Plug valves**

Gate valves are the most common

There are also what's known as Check and Squeeze valves. Check valves have a unidirectional flow, and prevent the reverse flow of the line medium. They are self-actuated and open and close due to line pressure.

Check valves are used for the protection of any item of equipment that can be affected by reverse flow, such as flow meters, strainers, and control valves.

The most commonly used are:

- **Swing Type**
- **Tilting**
- **Lift Type**
- **Ball Type**
- **Axial flow**
- **Dual plate**
- **Diaphragm valves**
- **Pinch valves**

THE FUNDAMENTALS OF **VALVE SELECTION**

The selection of any valve is based on the following criteria:

- Application requirements
- Valve type suitable to application
- Valve size required
- Valve material based on the medium being handled
- Valve actuation (manual, electric, hydraulic)
- Ensuring they meet the industry requirements

The Selection of Pipe Size for Installation

Understanding pipe sizing is a significant part of the selection process, and engineers can encounter optimization problems if the incorrect sizing is chosen.

An example selection process might look like this:

A piping system that moves water from one tank to another is needed

↓

Engineer must select pipe size, and then calculate a system curve

↓

The pump can now be selected — with components of the system (such as valves) added

↓

Performance is then evaluated and reviewed

Complications can arise at the selection stage for several reasons. For instance, the larger the pipe diameter, the greater the initial cost, which suggests that a small diameter should be selected. However, fluid flowing through a small diameter pipe requires a larger pump — which in turn increases the initial and operating costs.

Engineers must be fully aware of the implications that pipe size will have on the installation, and ongoing maintenance of the project. Therefore, having a working knowledge of the codes and standards used to determine pump and valve selection is absolutely essential.

PROCEDURES FOR **PUMP AND VALVE SELECTION**

There are several codes and standards that are typically associated with pumps and valves. These include:

- Valves — **ASME B16.34**
- Gate Valves — **API 600 — BS 1414**
- Globe Valves — **BS 1873**
- Check Valves — **BS 1868**
- Plug Valves — **API 6D**: Pipeline Valves, **API 599**: Metal Plug valves
- Pipeline Valves — **API 6D**: Gate; Ball; Plug; Check Valve
- Ball Valves — **ISO 17292, BS 5351, BS 5319**
- Butterfly Valves — **AWWA C504, BS 5155, API 609, MSS SP 67, ISO 5752**



CHALLENGES FOR ENGINEERS

Engineers face a number of challenges when it comes to pump and valve selection. Including:

Understanding the application:

choosing the right pump/valve requires a clear understanding of the application requirements, including flow rate, pressure, temperature, fluid type etc. Engineers need to be able to accurately identify and analyze the application to ensure the chosen components will operate safely.

Complexity:

Pumps/valves can be complex, with many different types and configurations available. Understanding the difference between different types of pumps and valves can be challenging for inexperienced engineers.

Compatibility:

The pump and valve must be compatible with the fluid being handled, as well as any other equipment in the system. This can be a challenge when dealing with corrosive or abrasive fluid that require special materials.

Maintenance:

Maintenance and repair of pumps can be challenging in hazardous environments, so engineers should consider the ease of maintenance when selecting equipment to ensure that downtime is minimized and safety upheld.

FREQUENTLY **ASKED QUESTIONS**

We asked our expert Dr. William S. Janna some of our most frequently asked questions about pumps and valves selection

1. How important is it to graph the system curve during the pump selection process?

“Very important! The objective is to plot the system curve onto the pump performance graph to locate the approximate operating point of the installation. This is necessary to be sure that the pump is operating at or near its maximum efficiency point.”

2. What is cavitation in a centrifugal pumps?

“The rotating component of a centrifugal pump is it’s impeller, and as it rotates, the pressure at the pump inlet is very low. If the pressure is lower than the vapor pressure of the liquid, the liquid will begin to boil. The vapor bubbles will eventually leave the pump and will collapse downstream where the pressure is higher. At this point, the metal will begin to wear away, and the pump will fail.”

3. Can valves cause cavitation?

“Yes. As liquid moves through a valve, the liquid will lose pressure due to frictional effects. Again, if the pressure is less than the vapor pressure of the liquid, bubbles form and when they collapse, they wear away the metal.”

4. What are things to consider when selecting a flow control valve?

“The best valve generally for flow control is the globe valve. A gate valve should be used only its fully open or fully closed positions. Otherwise, the closure element will vibrate and become worn. A ball valve also should be fully open or full closed, or the ball seals will become worn and the valve will leak.”

5. What effect does the pipe size have on the pump power required in an installation?

“A smaller than necessary pipe size will have a liquid velocity that is comparatively high. The frictional effect and power required vary with square of the velocity, and the pump will be larger than necessary. On the other hand, too large a diameter (and associated fittings) will be costly. Somewhere between too small and too large is the “optimum” pipe size.”



Dr. William S. Janna is a retired professor of Mechanical Engineering at the University of Memphis. He earned his BS, MS, and Ph.D. degrees from the University of Toledo. He has taught at the University of Memphis for 32 years, serving as Department Chair and as Associate Dean for Research and Graduate Studies. Previously, Dr. Janna worked at the University of New Orleans for 11 years; serving four years as Chair of the Mechanical Engineering Department. Dr. Janna has written three textbooks: *Introduction to Fluid Mechanics, 6th Edition, Engineering Heat Transfer 3rd Edition, and Design of Fluid Thermal Systems, 4th Edition.*

Find out more about our courses here**.**

FUNDAMENTALS OF PUMPS AND VALVES AND THEIR SELECTION FOR OPTIMUM SYSTEM PERFORMANCE (VIRTUAL CLASSROOM)

Topics covered:

1. Centrifugal Pumps

- Net Positive Suction Head
- Suction lift and suction head configurations
- Avoiding cavitation
- Example problems to demonstrate pump selection procedure
- Series and parallel pump configurations
- Evaluating system performance
- Derivation of Euler's equation for turbomachines
- Application of Euler's equation to predict pumping power
- Designing a centrifugal pump impeller
- Designing a centrifugal pump volute
- Extension to positive displacement pumps

2. Positive Displacement Pumps

- Reciprocating diaphragm pumps
- Reciprocating piston pumps
- Gear pumps
- Lobe pumps
- Screw pumps
- Testing procedures
- When to use a PD pump

3. Valves

- Introduction to Valves
- Types of Valves
- Materials Used in Valve Construction
- Selection of Valves
- Flow Characteristics of Valves
- Valve Operation
- Best Practices
- Avoiding cavitation in Valves

ASME FUNDAMENTALS OF PUMPS AND VALVES (VIRTUAL CLASSROOM)

You will learn to:



- Calculate the pressure loss in a pipeline due to friction in circular and noncircular ducts
- Determine the pipe diameter that minimizes first plus operating costs of a piping system
- Generate a system curve for a pipeline
- Discover the testing methods used by a manufacturer to obtain a performance map for a centrifugal pump
- Employ the system curve to select an efficient centrifugal pump
- Explain how to predict when cavitation will occur and identify the necessary steps to avoid it
- Explain how to use dimensional analysis to correlate experimental data for a pump
- Explain how the specific speed is determined
- Apply affinity laws to predict off-design behavior for a pump
- Identify types of positive displacement pumps
- Describe the different types of valves that are commercially available
- Explain how to select the correct valve for a piping system
- Identify and avoid problems by selecting the correct valve
- Explain how to install, operate and maintain valves
- Describe the process of diagnosing and troubleshooting valve problems

OUR COURSES

ASME Learning & Development provides technical and management courses to teach standards and best practices to individual learners and teams across a range of engineering disciplines.

Courses are designed for engineers of all levels from early career engineers to experienced engineers. They are essential resources for mechanical engineers, and design engineers; process engineers, and chemical engineers; reliability engineers, and maintenance engineers; inspectors, and testing engineers; as well as plant supervisors, managers, Quality Assurance staff and procurement personnel.

All of our courses are delivered either virtually or in-person, with the ability to tailor content to include specific use cases and pain points for corporate customers.



LET'S TALK ABOUT IT

ASME is the go-to expert in both fundamentals and applications of the relevant procedures for pump and valve selection. Our courses are designed to help engineering professionals remain consistent in their practice throughout the engineering process.

All ASME courses include real-world examples so that learnings can be applied to projects that your company is working on. With ASME Corporate Training, your team can address your unique challenges with an expert in a private and confidential setting.

Get in touch today to learn more about ASME Corporate Training

- corporatetraining.asme.org
- learningsolutions@asme.org

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