Tech Brief

A NATIONAL DRINKING WATER CLEARINGHOUSE FACT SHEET

Valves

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Summary

Valves direct, start, stop, mix, or regulate the flow, pressure, or temperature of a fluid. Valves range from simple water faucets to control valves equipped with microprocessors. Many different valve types exist; however, the most common types include gate, plug, ball, butterfly, check, pressure relief, and globe valves.

What are the valve functions?

Valve functions vary based on the position of the closure element in the valve. The closure position can be adjusted manually or automatically. Valves usually fall into one of three classes:

1. shut-off valves block the flow or allow it to pass;
2. anti-reversal valves allow flow to travel in one direction; and
3. throttling valves regulate flow at a point between fully open to fully closed.

However, specific valve-body designs may fit into one, two, or all three classifications.

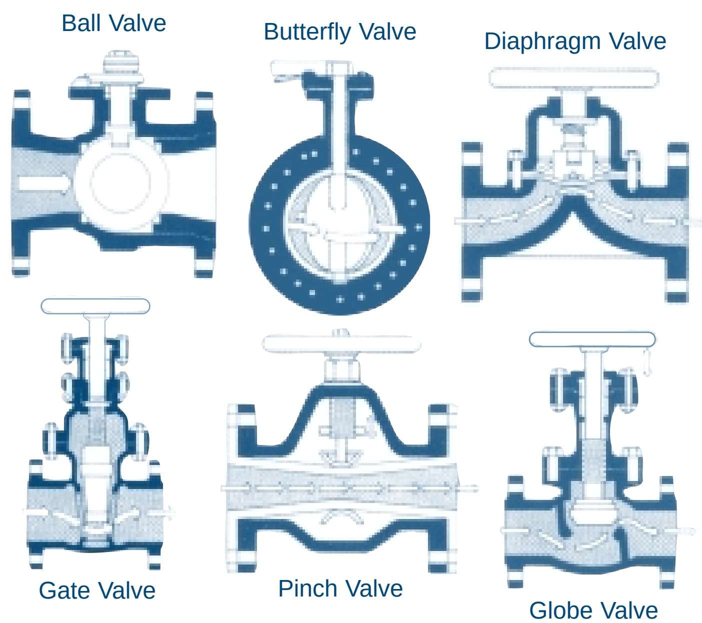
What are the basic valves?

Manual Valves *(See Figure 1)*

Manual valves require manual operation, such as a hand wheel or lever, which are primarily used to stop and start flow (shut-off valves), although some designs can be used for basic throttling. A manual valve operator is any device that requires the presence of a human being to operate the valve, as well as to determine the proper action (open, closed, or a throttling position). Manual valves are also used to divert or combine flow through a three- or four-way design configuration. Four types of manual valves exist:

1. rotating valves, such as plug, ball, and butterfly valves;
2. stopper valves, such as globe and piston valves;
3. sliding valves, such as gate and piston valves; and
4. flexible valves, such as pinch and diaphragm valves.

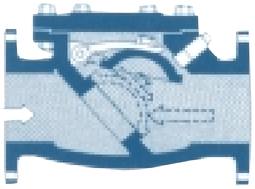
Figure 1 - Manual Valves



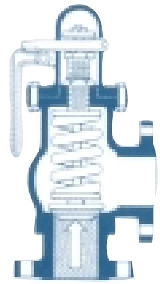
Check Valves *(See Figure 2)*

Check valves are automatic valves that open with forward flow and close against reverse flow. Check valves, also known as non-return valves, prevent return or reverse flow and maintain pressure. Check valves do not require an outside power supply or a signal to operate. In fact, a check valve's operation depends upon the direction in which the water is flowing. A pump or a pressure drop may determine water flow. If the flow stops or if pressure conditions change so that flow begins to move backward, the check valve's closure element moves with the reverse flow until it is seated, preventing any backward flow. There are different types of check valves, but they all have the same

Figure 2 - Check Valves



Check Valve



Relief Valve

operating principle. Check valves include lift-check valves, swing-check valves, tilting-disk valves, split-disk valves, and diaphragm-check valves.

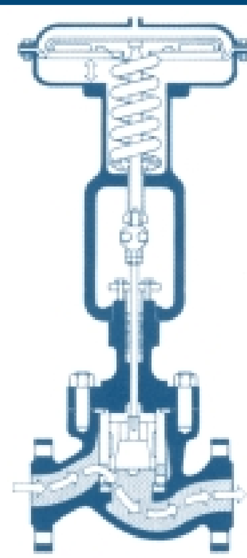
Pressure Relief Valves

A pressure-relief valve is used to protect against over-pressurization of the system. When excess line pressure is detected, the pressure-relief valve automatically opens and relieves the excess pressure. A pressure-relief valve is installed where excess pressure constitutes safety concerns, such as pipes or equipment bursting. Following the depressurization of the water line to safe or normal limits, the pressure-relief valve automatically closes again to allow for normal system operation.

Control Valves *(See Figure 3)*

Control valves, also known as automatic control valves, are used to regulate flow anywhere from fully open to fully closed. Control valves are a fast growing segment of the valve industry because of the quickening pace of water-industry automation. Control valves are almost always equipped with some sort of actuator or actuation system (See definition under Manual Operators and Actuators below.) Manually operated valves and pressure regulators can stand alone in a throttling application, while a control valve cannot. Hence the difference: a control valve is a throttling valve, but not all throttling valves are control valves.

Figure 3 - Control Valves



Control Valve

Manual Operators and Actuators

With most valves, some mechanical device or external system must be devised to open or close the valve or to change the position of the valve. Manual operators, actuators, and actuation systems are those mechanisms that are installed on valves to allow this action to take place. Automatic valve control requires an actuator, which is defined as any device mounted on a valve that, in a response to a signal, automatically moves the valve to the required position using an outside power source.

What are common valve problems?

Pressure drop or pressure differential, which is the difference between the upstream and downstream pressures, makes water flow move through a valve. If the piping size is identical both upstream and downstream from the valve and the velocity is consistent, the valve will use frictional losses to reduce the fluid pressure and create flow. Because the pressure drop that a valve generates absorbs energy through frictional losses, an ideal pressure drop allows the full flow to pass through the valve's body without excessive velocity, absorbing less energy.

However, some systems may need to take a larger pressure drop through the valve. A high-pressure drop through a valve creates a number of problems, such as cavitation, flashing, choked flow, high noise levels, and vibration. Such problems present a number of immediate consequences: erosion or cavitation damage to the body and trim, malfunction or poor performance of the valve itself, attached instruments will not remain calibrated, piping fatigue, or hearing damage to nearby workers. In these instances, valves in high-pressure-drop applications require expensive trims, more frequent maintenance, large spare-part inventories, and piping supports. Such measures drive up maintenance and engineering costs.

Although users typically concentrate on the immediate consequences of high-pressure drops, the greatest threat a high-pressure drop presents is lost system efficiency. Usually, a pump adds pressure and, thus, energy to the system. As the system absorbs more energy, including the energy that valves with high-pressure drops lose, it must use larger pumps. Consequently, if the system is designed with few valves with high-pressure drops, the system is more efficient and able to use smaller pumps.

Cavitation

Cavitation happens when low-pressure bubbles suddenly form and then collapse within a small area of the valve within microseconds. Minor cavitation damage may be considered normal for some applications, which can be dealt with during routine maintenance. If unnoticed or unattended, severe cavitation damage can limit the life expectancy of the valve. It can also create excessive leakage, distort flow characteristics, or cause the eventual failure of the valve body and piping. In some severe high-pressure drop applications, cavitation can destroy valve parts within minutes.

One of three basic actions can control or eliminate cavitation. Operators can:

- modify the system;
- make certain internal body parts out of hard or hardened materials; or
- install special devices in the valve that are designed to keep cavitation away from valve surfaces or prevent the formation of the cavitation itself.

Flashing

When the downstream pressure is equal to or less than the vapor pressure, the vapor bubbles generated stay intact and do not collapse. This phenomenon is known as flashing. When flashing occurs, the fluid downstream is a mixture of vapor and liquid moving at a very high velocity, which results in erosion in the valve and in the downstream piping.

Unfortunately, eliminating flashing completely involves modifying the system itself, in particular the downstream pressure or the vapor pressure. However, not all systems are easily modified and this may not be an option. When flashing occurs, no solution can be designed into the valve, except possibly using hardened trim materials.

Choked Flow

The presence of vapor bubbles that cavitation or flashing cause significantly increase the specific volume of the fluid. This increase rises at a faster rate than the increase that the pressure differential generates. If upstream pressure remains constant, decreasing the downstream pressure will not increase the flow rate. Choked flow must be considered when sizing a valve.

High Velocities

Large pressure differentials create high velocities through a valve and in downstream piping. This in return creates turbulence and vibration if the velocities are not lowered. Lower velocities will reduce problems associated with flashing and erosion.

Water Hammer Effects

A valve that is opened too quickly or slammed shut when the closure element is suddenly sucked into the seat (“bathtub stopper effect”) as the valve nears shutoff may cause water-hammer effect. Although water hammer generates considerable noise, the real damage occurs through mechanical failure. Water hammer can burst or damage piping supports and connections. In valves, water hammer can create severe shock through trim, gasket, or packing failure.

With valves, the best defense against water hammer is to prevent any sudden pressure changes to the system. For example, one solution may involve slowing the closure of the valve itself. Adding some type of surge protection to the piping system can also reduce water hammer.

What are the operation and maintenance requirements?

To avoid mechanical failure, design a practical valve maintenance program, which can result in cost savings for the water system. A job that appears to be mammoth becomes less daunting if the operator implements a systematic maintenance schedule. Operation and maintenance procedures for various types of valves are included in the manufacturer’s operation manuals and in the appropriate product standards. Valve records are essential for planning, operating, and verifying the system’s integrity. The valve record should contain information about valve condition, testing, and maintenance required.

What about safety/terrorism?

Recent events have understandably heightened concern that water supplies may be vulnerable to terrorist attacks—biological, chemical, and structural. Relief from this concern can come via knowledge, planning, and preparedness. It is crucial now to regularly inspect the location, accessibility, and operation of all the valves in the distribution system. This inspection will reveal the condition of the valve box and chamber.

It also is imperative to update the location of the valves on the map. E. H. Wachs Companies for example, offer "Valvecard" software that allows water utilities to manage their valve distribution system from a desktop computer. The software can be used to create valve inventory databases that require a secure user-friendly system to input, store, and analyze valve data or to collect valve information directly from each valve in a system. The software also can be used to operate and exercise valves in the system and record this information or monitor the system and keep it operational at all times. It can perform queries regarding valve properties, location, activities, and conditions as well as interface with Geographic Information Systems and map files.

After having complete and accurate information about all the valves in the system, the utility manager can run through a large number of "what if" scenarios to determine where a contaminant is likely to move and how valves or other utility operations can control its movement. To do this, the utility needs a calibrated, extended-period simulation model. There are a few types of software on the market for water distribution modeling and engineering that allow system managers to view scenarios graphically. Some of this software, such as WaterCad by Haestad Methods, can give a clear picture of what is occurring or will occur in the system in response to any operational measures that management proposes.

U.S. Environmental Protection Agency and the American Water Works Association in collaboration with Sandia National Laboratories continue to develop a risk- and consequence-based vulnerability assessment technique to improve the safety and security of water supply and distribution systems against emerging physical, chemical, and biological threats.

Where can I find more information?

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