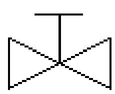
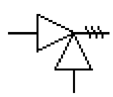
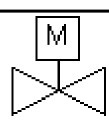
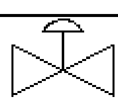
Issues in Valve Selection

Valves are used extensively for affecting the process; we often say that values are the “handles” by which we operate a process. We have many goals in influencing the process; therefore, we use the flow and valve principles in many applications. There are many types of valves. The four most prominent types of valves are summarized below.

Table 3.1.1. Most common applications of valves in the process industries.

Name	Symbol	Power	Typical process application
Block		Manual (by person)	These valves are usually fully opened or closed, although they can be used to regulate flow over short periods with a person adjusting the valve opening.
Safety Relief		Self-actuated (the difference between process and external pressures results in opening when appropriate)	These are located where a high (low) pressure in a closed process vessel or pipe could lead to an explosion (implosion).
On-off		Electric motor	These valves are normally used for isolating process equipment by ensuring that flows are not possible. They can be operated by a person in a centralized control room, who can respond quickly regardless of the distance to the valve.
Throttling control		Usually pneumatic pressure	These valves are typically used for process control, where the desired flow rate is attained by changing the opening of the valve.

Properly operating valves are essential for safe and profitable plant operation. Valve selection can be guided by the analysis of a set of issues, which are presented in this section. Each issue is introduced here with process examples, and details on the issues are provided in the remainder of this site for the most common valves in the process industries.

Exercise 3.1.1 You have just started your first job as an engineer. You supervisor presents you with the process drawing in Figure 3.1.1. She asks you to select valves for this process, specifically the four identified in the figure. "Please have your proposal ready tomorrow for the design review meeting."

Note that the regenerator is a fluidized bed for catalyst, and the riser reactor transports the catalyst with the reacting vapors.

Guidance on selecting valves is provided in this site, with an introduction to the key issues in this section.

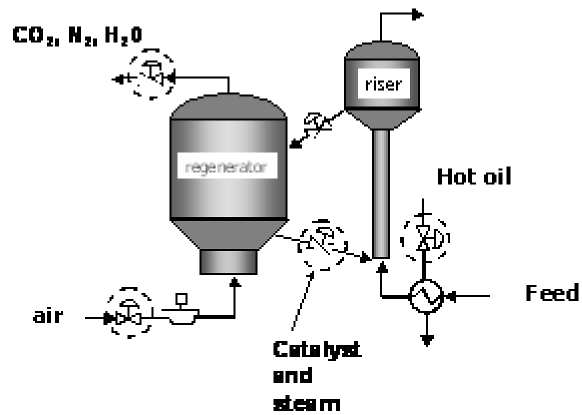


Figure 3.1.1 Fluid catalytic cracking unit in a petroleum refinery.

When defining valve requirements and principles, the engineer should use terminology that has a unique meaning, which is not easily achieved. Therefore, the engineer should refer to accepted standards and use the terminology provided in the standards. For instrumentation, standards published by the ISA (formerly, Instrument Society of America) are the most relevant. This section uses terms from the ISA wherever possible.

3.1.1 Major issues for selecting valves

The major issues in valve selection are summarized in the following. The relative importance of each issue depends upon the specific application; for example, one application might require a low pressure drop, while another might require a large range. Generally, we find that the greater the requirements for good performance, the higher the cost for purchase and maintenance. Therefore, we must find the proper balance of performance and cost, rather than always specify the best performing valve.

ISSUE		COMMENTS
· Capacity - The maximum flow rate through the flow system (pipes, valves, and process equipment) must meet operating requirements. Guidelines are available for calculating the pipe diameter for a desired flow rate, and guidelines are given here for the percentage of the system pressure drop contributed by the valve.		The driving force for flow, i.e., the pressure, must be provided by a centrifugal pump or static pressure difference between vessels.
· Range - The range indicates the extent of flow values that the valve can reliably regulate; very small and large flows cannot be maintained at desired values.		This is often reported as a ratio of the largest to the smallest flows that can be controlled acceptably and is usually in the range of 35 to 50.
· Failure position - Each valve has a power supply that is used to move the valve to its desired opening. The most common power source is air pressure, but hydraulic pressure or an electric motor can be used. The power can be lost for one of two reasons (1) failure in the power source (e.g., air compressor) or (2) a control action that requires the valve to rapidly attain a position that gives a safe process condition. The engineer must define whether the safest condition for each valve is fully open or fully closed. This will be the failure position, and the combination of the actuator and valve body must achieve this position upon loss of power.		We must analyze the entire process, including integrated units to identify the safest conditions. In a few cases, the failure condition is “unchanged”. If the air power is lost, air leakage will result in a slow drift to either open or closed.

· Gain - The gain is $K_p = \frac{\Delta \text{measured variable}}{\Delta \text{valve opening}}$ In the equation, the measured variable refers to the variable being controlled by the valve adjustments. The gain should not be too small (or the variable cannot be influenced strongly enough to compensate for distrubances) or too large (which would require very small, precise changes to the valve).		Usually, the measured variable is expressed as a percentage of the normal range (or sensor range). If a sensor had a range of 0-200 °C, a five degree change would be 2.5%. A typical range for the gain is 0.5 to 3 (dimensionless).
· Pressure drop - The purpose of the valve is to create a variable pressure drop in the flow system. However, a large pressure drop wastes energy. In some systems, the energy costs for pumping or compressing can be very high, and the pressure drop introduced by the valve should be as small a practically possible.		Here, the key factor is the non-recoverable pressure drop.
· Precision - Ideally, the valve would move to exactly the position indicated by the signal to the valve, which is usually a controller output. However, the valve is a real physical device that does not perform ideally. The following factors prevent ideal performance. · Deadband - Upon reversal of direction, the greatest amount that the signal to the valve can be changed without a change to the valve opening (stem position). · Resolution - The smallest amount that the signal to the valve can be changed without a change to the valve opening (stem position). This change is after a change that has overcome deadband and is in the same direction.		Two major causes of non-ideal valve behavior are backlash and stiction. Backlash - A relative movement between interacting parts, resulting from looseness, when motion is reversed. Stiction - Resistance to the start of motion,usually required to overcome static friction. The valve precision can be improved by the addition of a valve positioner. See Section 3.5.

· Linearity - The relationship between the signal to the valve (or stem position) and the flow can be linear or non-linear. Either may be desired, since a linear relationship is sought between the signal to the valve and the measured variable (which is not necessarily theflow, it could be a pressure, temperature or other process measurement).		See the discussion on valve characteristic in Section 3.3 and in Marlin (2000), Chapter 16.
· Dynamics - The valve is part of the feedback system, and any delay due to the valve slows the feedback correction and degrades control performance. Therefore, the valve should achieve the desired opening rapidly.		The actuator must provide sufficient force and the speed of response that can be improved by a booster. See Section 3.5.
· Consistency with process environment - Each valve body will function for specified fluid properties. Conditions requiring special consideration include slurries, very viscous fluids, flashing and cavitation. In addition, some applications require a tight shutoff. Naturally, the parts of the valve that contact the process must be selected appropriately to resist corrosion or other deleterious effects.		Flashing - The pressure drop across the valve can result is partial vaporization of a liquid; this situation is termed flashing when the fluid after the valve remains at least partially vaporized. Cavitation - While the fluid at the entrance and exit of a control valve may be liquid, two phases may exist where the flow area is narrowest and the pressure is at its minimum. This temporary vaporization is termed cavitation and can cause severe damage to the valve.

· Cost - Engineers must always consider cost when making design and operations decisions. Valves involve costs and when selected properly, provide benefits. These must be quantified and a profitability analysis performed. In some cases, a valve can affect the operating costs of the process, where the pumping (or compression) costs can be high, and the pressure drop occurring because of the valve can significantly increase the pumping costs. In such situations, a valve with a low (non-recoverable) pressure drop is selected.		Remember that the total cost includes costs of transmission (wiring around the plant), installation, documentation, plant operations, and maintenance over the life of the valve. See a reference on engineering economics to learn how to consider costs over time, using principles of the time value of money and profitability measures.

The "Smart valve" revolution

Currently, valve technology is experiencing a dramatic change. While the basic physics of valves is not changing, valves are being enhanced by the addition of microprocessors at the location of the actuator and valve body. This change makes the following features possible that were not available with older technologies. The following assumes a digital valve positioner.

· Digital conversion and transmission - The "signal" from the controller is no longer an analog signal (typically 4-20 mA). The signal can be digital, with many controller outputs transmitted by a single digital transmission. This substantially reduces the cable costs. The signal is converted to an analog pneumatic value for the valve actuator at the control valve.

· Diagnostics - The valve can provide sophisticated diagnostics of its performance. For example, excessive backlash or stiction can be identified and reported to the centralized control room. Then, maintenance can be performed before the valve performance degrades to the point of reducing process performance.

Source: http://pc-education.mcmaster.ca/Instrumentation/go_inst.htm