

FOCUS

Selecting a Material Handling Gate

To most engineers the selection of a material handling gate is a fairly simple process. The complications arise when a gate fails. The question is: "If it's so simple, why doesn't it work?" Engineers, though exceptionally careful and methodical in other areas of process design, will overlook the gate selection, and make a quick, often wrong decision. Later, they find that the gate fails to open or close or seal properly. Other complications can arise from selecting the wrong type of gate for the application, or the wrong gate size for the material flow. This article is designed to outline the criteria for selection, simplify the selection process, and improve the workability of gates.

Types of Valves

Confusion exists in industry over the proper nomenclature. This article defines a gate as a device that controls the flow of bulk material solids and a valve as a device that controls the flow of liquids or slurries. In most operations, there are two kinds of bulk material gates: those that control the flow of material that moves by gravity, and those that control the flow of material in a dilute-, medium-, or dense-phase pneumatic system. This article deals primarily with gravity flow gates.

Gate Configurations

There are a variety of gate configurations available, including:

- Slide gates
 - Double-blade slide gates
 - Diverter gates (Fig. 1)
 - Rolling-Blade gates (Fig. 1)
 - Belt feeder gates (Fig. 1)
 - Clamshell gates
 - Coal valve gates (Fig. 1)
- Slide gates, whether single- or double-bladed,

are best suited for the complete shut-off of material flow. The double-blade slide gate provides faster shutoff by actuating both blades; each blade travels only half the distance.

There are a variety of diverter gates to divert the flow of material from one direction to another. These units are also available in a number of other configurations, including triverter and quadverter combinations.

Rolling-Blade gates meter or control material flow. They are best suited for partially-open positions. The repeatability of flow at intermediate rates is said to be good. These units can also be used as diverter gates in the diverter, triverter, and quadverter configurations.

The belt feeder gate utilizes the Rolling-Blade gate to meter material flow onto a conveyor belt. It is used where the flow varies or in blending various materials onto a conveyor.

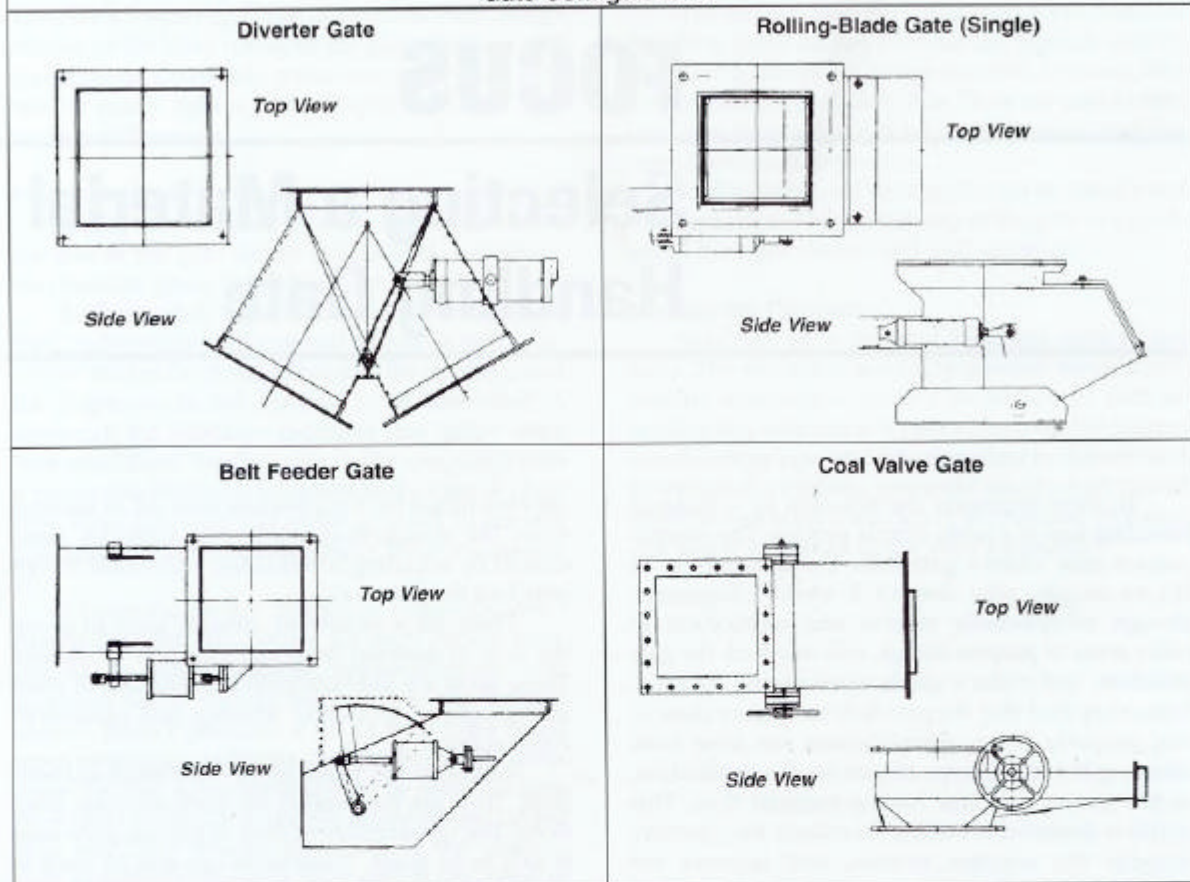
The single or duplex clamshell gate is an old standard for cutting off material flow when loading hoppers, bins, and other containers.

Finally, there are coal valves, which are an anomaly. They should be referred to as coal gates. The term *coal valve* comes from specific use in the utility industry. The unit is heavy-duty slide gate with self-cleaning internals and an exceptionally long life. The design features lend themselves to coal-fired utility plant applications.

Type of Actuation

Four types of actuation are described below. Each is used in various applications, and each has specific advantages and disadvantages. Actuation selection is governed by the service the gate will perform and the type of material it will control. Oftentimes, the selection is not based on scientific or objective appraisal, but on the personal preference of

Fig. 1
Gate Configurations



the engineer or operator. In a lot of ways, this isn't bad. If the operating people don't like a piece of equipment, then it doesn't matter how well it's designed - it will produce complaints. There is prejudice, for instance, against both hydraulic and pneumatic actuation. However, here are some selection guidelines:

If the gate will not be used a great deal, the most economical choice is a manual rack-and-pinion actuator or a jackscrew. These are recommended on opening sizes up to 24 inches. Above 24 inches, a gear reducer is generally needed. Though it is possible to use these reducers on gates as large as 84 inches, the size of the reducer and the large mechanical advantage required are impractical. No more than 50 pounds should be exerted to turn the wheel of the reducer, but this criterion (on a large gate) results in extremely slow opening or closing times.

Electrically-driven, mechanically-actuated gates are popular in a number of applications because they develop high thrust. They are reliable, fairly simple to install, and do not require a lot of maintenance. These units tend to be fairly expensive,

though, and they are slow. Unlike hydraulic or pneumatic actuators that attain opening/closing rates of 36 inches per second, most electromechanical actuators operate at a speed of less than one inch per second.

In plants where air is available, pneumatics is an obvious choice. Pneumatic cylinders are readily available; they are proven and economical. The pneumatic cylinder must be designed for the air pressure available at the gate. Air is compressible, however, and if repeatability is important, pneumatic actuation may not be a good choice. Also, the cost of using pneumatic cylinders with very large gates may be prohibitive.

Hydraulic systems are economical to operate, offering the greatest force in the smallest package. They also allow repeatability. Many operators are biased against hydraulics because of oil leaks which hinder good housekeeping. Over the years, though, the quality of hydraulic components has improved considerably. It's now possible to design and install a leak-proof hydraulic actuation system that's economical and powerful.

An interesting combination occurs by mounting a self-contained power unit on a hydraulic cylinder that requires little or no piping. This combination is suited for applications where high thrust is required to open or close the gate, and in situations where the gate is isolated from the rest of the plant or is used intermittently.

Unlike manual or electrical gates, hydraulic and pneumatic systems can be provided with accumulators that allow the gate to open or shut automatically in case of electrical power failure.

Electromechanical Gate Control

Control of the gate requires actuation and positioning. To modulate a gate, position indication is required. Control is simplest with an electromechanical device because it uses a basic potentiometer for position indication. This electromechanical device and potentiometer combination provides analog signals and infinite positioning. The analog feedback allows precise manual or automatic control, relays and reversing contractors are used to drive the gate motor in the desired direction.

Solenoid Valve Gate Control

With hydraulic and pneumatic gate actuation, solenoid valves are used. The electrical enclosures of solenoid valves are offered in a variety of NEMA ratings. The most popular are NEMA 4 watertight and NEMA 7 and 9 for hazardous areas. Three types of solenoid valves are generally selected:

The 4-way, 2-position, single-coil valve is used in applications where full extension or full retraction of the actuator is required. Intermediate positioning of the actuator is not possible with this valve. In order to maintain the valve in its shifted position, the voltage must be maintained on the coil. Whenever the electrical power is interrupted, the valve shifts to its normal or spring-offset condition. If an air receiver or hydraulic accumulator is used for energy storage, the valve directs the actuator to its normal, or power-off, position.

The 4-way, 2-position, double-coil, detented valve is also used in applications where full extension or full retraction of the actuator is required. Intermediate positioning of the actuator is not possible. A momentary electrical signal to the coil allows the valve to shift and remain in that last-shifted position. In the event of an electric power failure, the valve remains in its last position. Automatic movement of the actuator to another position is not possible, since electrical power is required to shift the valve.

The 4-way, 3-position, double-coil, spring-centered valve allows for full extension, full retraction, and intermediate positioning of the actuator.

Automatic movement of the actuator due to an electric power failure is not possible. This valve does allow the position of the actuator to vary, thereby controlling the rate of material flow through the gate.

Other Gate Controls

Other means of actuator-directional control are also available. Such devices as manual hand valves, air or hydraulic piloted valves, air or hydraulic proportional valves, and bi-directional power units are common.

With pneumatic systems, a filter, regulator, and lubricant unit should be provided for the air. These trio-units consist of polycarbonate bowls and bowl guards, manual drains with a mist-type lubricator, and a low-micron filtration unit. Desiccant filters, high-temperature, and high-pressure devices are also available.

Table 1
Flow Rates Based Upon Optimum Conditions
for Straight Gravity Drop

Valve Size (square)	Material Flow Rate	
	Inches	CFM
6	16	24
8	34	57
10	75	110
12	125	185
14	190	285
16	280	420
18	390	580
24	840	1260
30	1500	2200
36	2400	3600
48	5500	8200
60	9000	13500

Gate Selection

For material flow control or metering, a Rolling-Blade gate is a good choice. The design of the curved blade enhances flow, providing an almost direct ratio of position to flow rate. For example, if the gate is closed halfway, material flow will be about 50 percent less. If the gate is closed three-quarters of the way, material flow will be about 75 percent less. Also, the flow is fairly repeatable.

For material flow shutoff applications, an economical clamshell gate or slide is generally used. The gate's frequency of use determines such design criteria as the duty rating of the gate structure and components. Obviously, a less-frequently used gate can be made lighter and cheaper than one that cycles continuously.

Sizing the Gate

Sizing is a frequent concern. However, before the size of the gate can be determined, consideration must be given to the flow rate.

Unfortunately flow rate calculations are complex, and involve such external factors as the geometry of the bin or chute, the size of the opening, and the properties of the material to be controlled. A review of the literature indicates that under mass flow conditions, the flow rate can be computed with a reasonable degree of accuracy. In the case of plug-flow bins, however, the outlet is sized to prevent plugging, piping, or rat-holing of the stored material¹.

Obviously, project deadlines frequently don't permit detailed calculations for each system component. In such instances, approximations with generous safety factors built in are the rational choice. Table 1 provides a list of flow rates based upon optimum conditions for straight gravity drop. Some caveats: Allowances should be made for less-than-ideal bin designs, and for materials that do not flow well. For diverter gates, where the material flow direction changes, a flow rate of one-third of that shown in the table should be used. And finally, in order to prevent the gate from plugging, the size of the gate should be at least ten times the average material size or four times the largest lump size.

Characteristics of the Controlled Material

The material to be controlled is another determining factor of gate selection. The following material characteristic should be taken into account when selecting the type and size of gate to be used:

- Average Size
- Bulk Density
- Temperature
- Abrasiveness
- Corrosiveness
- Surface Moisture
- Particle Uniformity

Areas of Concern

Two problems predominate in the selection of the proper gate for bulk material handling applications: closing and sealing. In order for a gate to close, it must have a protected area or a displace-

ment space (also called a displacement pocket) for dislodged material to be displaced into.

The second area concerns seals. Most material handling gates do not provide 100 percent sealing. There are a number of design features, however, that can be incorporated to do this. There are also a number of materials that can be used for seals, ranging from elastomers to plastics.

Both closing and sealing should be considered during design. The workability of the gate is a product of the right closure and seal selection.

Making the Decision

Selection of a material handling gate is not hard. The process is relatively painless when a systematic approach is used. Crucial factors such as application, frequency of operation, material characteristics, flow rate, and function must be determined beforehand. Problems generally result when one of these factors is not considered. Remember, "It's simple, and it will work (if it's done properly)."



P.O. BOX 7506 • PADUCAH, KY 42002-7506
(270) 442-1996
FAX NO: (270) 442-5214
WEB ADDRESS: www.pebco.com **P/BS**

Footnote

1. A further source on this subject is *Storage and Flow of Solids* by A.W. Jenike (University of Utah, Engineering Experimental Station, Bulletins One, Two, Three). Also, H. Colijn (Monroeville, Pennsylvania) is a well-known and frequently called-upon consultant.