

Check Valve Selection and Reference



Table of Contents

I.	Scope	1
II.	Introduction	1
III.	Check Valves	3
	Bolted Bonnet Flanged Swing Check	
	Wafer or Lug Wafer Body Single-Flapper Swing Check	
	Wafer or Lug Wafer Body Dual-Flapper Swing Check	
	Ball Check	
	Tilting Disc	
	Piston Check	
	Combined Function Check	
	Y-Pattern Stop Check	
	Centre-Guided Spring Check	
	Slurry Check	
IV.	Summary.....	7
V.	Appendix.....	8
	Biogas	
	Chemical	
	Food and Beverage	
	Industrial Gases	
	Mining	
	Oil & Gas	
	Power	
	Pulp and Paper	
	Water and Wastewater	

Scope

This guide identifies the various types of check valves (non-return valves) and makes recommendations for their application in fluid and gas piping systems to increase process reliability and lower their cost of ownership. A list of references of Hy-Grade Valves API 594 check valves by industry is included.

Introduction

Check valves are generally selected for use as insurance against the damaging effects of flow reversal due to both planned and unplanned events. The basic purpose of every check valve or non-return valve is to allow fluid flow in one preferred direction and prevent backflow or flow in the opposite direction using entirely self-contained or internal mechanisms.

As pressure drops in a pipe and fluid momentum slows, a check valve should begin to close. As the flow reverses or preferably before, the check valve closes completely, and flow is stopped. This rather simple requirement appears to indicate that a single check valve design would be sufficient to use for any application, however, as has been pointed out repeatedly in other CGIS Tech papers, there is no “perfect valve” and selecting the right check valve involves careful consideration of many factors.

Often, the check valve type is not considered in terms of its inherent closing speed, Cv, isolation quality or cycle ability. This lack of consideration in turn leads to poor valve performance and even catastrophic piping system pressure surges resulting in valve or other piping element failure. In addition, there are no specifications that govern the internal designs (shaft diameters) of check valves so performance between manufacturers can vary greatly.

Examination of these failures within check valves or check valve induced piping system problems often reveals that the wrong type or oversized check valve was installed in the line. Easily, Swing Check valves number the largest problem types, with dual-flapper and ball checks contributing their significant share of failures.

Careful consideration of the check valve design and size should be considered when compressible flow, (air, steam, gases) are involved. Check valves require a minimum flow velocity to keep the disc fully open, therefore the manufacturer or supplier should be consulted to aid in the selection of the proper size and design.

Flanged Swing Checks regularly demonstrate poor performance due to their method of construction and standard selection without any determination of the correct valve size; they are typically selected to match the pipe size they are installed within. It's a common belief that Swing Checks offer higher Cv than other styles of check valves, and while this is sometimes true, the installed valve does not normally operate with the disc fully open, therefore installed Cv is significantly less, and the hoped-for limited

pressure losses are lost. Oversizing not only leads to shortened valve life and higher pressure drops, it costs significantly more to acquire the valve.



This 24" Class 300 Super Duplex Swing Check had a significantly shortened operational life because it was greatly oversized; calculations determined a 16" would have been the best valve size; saving over 70% of the CAPEX cost and lasting many times longer due to the flapper being fully open and stable. See [Why You Should Size Check Valves](#) for details to learn why check valves and control valves require a similar sizing consideration.

Optimal valve and system performance will only be realized when check valves are selected by their features and every possible piece of information regarding the process is considered. This information includes: flow velocity, pump type; pump curves, operating temperature and pressure, proposed or actual piping arrangement, single or multiple pump piping system, liquid or gas media, normal operating frequency, upset conditions, pipe size, type and schedule and connection method.

Well sized and selected check valves are an important asset for a properly designed and operating process pipeline. They are the first line of defence upon flow reversals and provide the necessary time

for final containment of any process upset by the piping system's isolation valves which complete the system shutdown.

Check Valves

Check valve types include the following styles:

- Bolted Bonnet Flanged Swing Check
- Wafer or Lug Wafer Body Single-Flapper Swing Check
- Wafer or Lug Wafer Body Dual-Flapper Swing Check
- Ball Check
- Tilting Disc Check
- Piston Check
- Combined Function Check
- Y-Pattern Stop Check
- Centre-Guided Spring Check
- Slurry Check

Bolted Bonnet Flanged Swing Check

The “Swing Check” is the traditional choice for most process piping systems larger than 2 inches. It features a full laying length face to face in accordance with ASME B16.10, which allows maximum flow at a minimum pressure drop when the flapper is fully open. A bolted bonnet allows access to the single flapper element. A hinge riding on an unsealed and bearingless shaft typically connects the flapper to the valve body. The flapper is relatively heavy and reacts to slowing fluid flow by closing by gravity alone and later by reversed flow. Generally, these valves are metal seated. The fully opened flapper is entirely contained within the valve body, so no consideration must be made for interference with mating pipe.

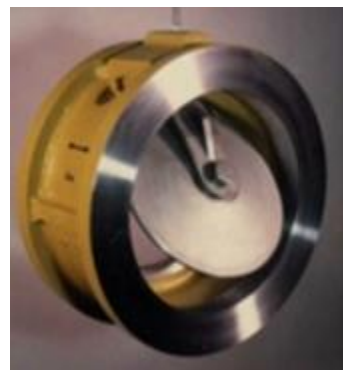


The majority of documented ⁽¹⁾ failures of flanged swing check valves include: 1) improper seating, 2) sticking open, 3) restricted motion of flow, and 4) loose or damaged parts.

This valve should be relegated to the back of the list when looking for a check valve. Its lack of isolation performance coupled by its large size and weight and high potential for contributory water hammer problems makes it a poor choice. The ironic fact that it is the largest selling style of check valve globally is a testament to its historical selection rather than any correct, careful, and calculated one.

Wafer or Lug Wafer Body Single-Flapper Swing Check

The “Wafer Check” is a compact face-to-face valve conforming either to API Std.594 or API Spec. 6D short pattern (ASME B16.10 Table B refers to the two API standards). They usually feature a single or double wound spring attached to the single flapper. The flapper is typically attached to the body by a bolted hinge that rides on a shaft. Better quality manufacturers incorporate an integral shaft and hinge design without the use of bearings and packing and “size” the valve orifice to allow the disc to be fully open when fluid velocities are operating at the piping system’s normal velocities. This predetermined valve sizing often covers the common mistake of using line size check valves for every application.



Wafer Checks can be selected with elastomer, polymer or metal seats and typically provide better isolation than any other style of check valve. The API Spec. short pattern wafer check allows the flapper to protrude past the body when partially open so attention must be paid to the mating pipe especially if its lined. The spring-assisted flapper and sized orifice make the wafer check the best choice when considering check valve types. Better quality manufacturers produce check valves that not only close on upset, but also close soon enough to lessen or even eliminate the potential for the devastating effects of water hammer. In addition, single flapper check valves are available in retainerless designs that have no external body penetrations for zero external emissions.

Wafer or Lug Wafer Body Dual-Flapper Swing Check

The “Dual Disc” check valve is a compact face-to-face valve conforming to API Std. 594. They usually feature a single wound spring attached to the dual flappers and a central shaft. The flappers are typically attached to the central shaft by an integral cast hinge that rides on washers or bearings on the shaft. Another integrally cast bar upstream of the flappers and shaft provides protection for the shaft from the flowing medium.



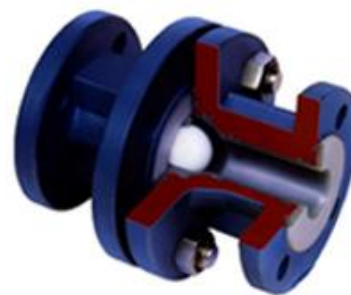
The lower mass of the twin flappers over single flapper designs is used in systems that have very low pressure and velocities. These valves feature elastomer, polymer and metal seats and can be reasonably effective in isolation as well as reducing slamming due to reverse pressures. These check valves can be very cost effective to purchase but do tend to have a higher cost of ownership and pressure loss than single flapper wafer checks.

Pay careful attention to improper sizing, two-phase flows or suspended solids when installing Dual Disc check valves because these items can lead to premature wear and/or catastrophic failure. ⁽¹⁾

Ball Check

The Ball Check is generally used for small sizes less than 2 inches and uses threaded or socket weld connections. A free-floating ball is held away from the seat by the flowing media and floats back upon flow reversal. There are specialized designs especially in slurries where very large ball checks up to 36 inch are used, as well as Teflon lined ball checks for chemical services up to 10 inches.

The ball check has a low Cv and is not normally considered for general check valve duty.



Tilting Disc

The Tilting Disc check valve uses an angled seat and a single flapper with the shaft or hinge at some intermediate position so that the mass of the flapper is divided into two parts. Typically, these valves are fabricated from carbon and stainless steel and are selected when large non-critical applications are required, such as pulp stock, although they can be used in severe services like boiler feedwater. The Tilting Disc design features a shorter travel arc and therefore will reach the seat in a shorter time and will less energy than with a full travel swing check.



Piston Check

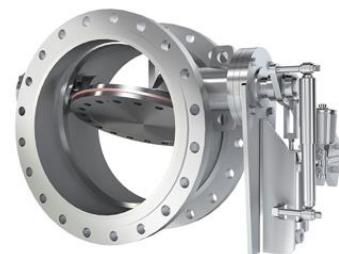
The Piston Check is generally used in small sizes up to 2 inches and is normally supplied with threaded or welded connections. A free floating or spring-loaded piston is lifted by fluid flow and closes by gravity or spring tension. This valve is usually suitable for horizontal installation only and provides adequate isolation with its normally supplied metal seats.

Documented failures ⁽¹⁾ indicate that periodic inspection of piston checks need to be performed to ensure the valves are not stuck in the open or closed position.



Combined Function Check

This unique check valve combines two or three valve types into one: a free acting check, an isolation valve and control valve. This is accomplished by using a lost motion coupling and extending the shaft outside the valve body where manual or automated actuators can be applied for control. These critical service valves usually start at 8 inches and are typically 16 inch to 54 inch for use on pump discharge isolation to a common header.



These valves commonly include dampening devices that can be engineered to control the speed of which the closure member contacts the seat. Designs are available with stepped speed control, with up to three separate and field adjustable rates. The primary area these critical service isolation valves are used is large diameter water systems where multiple pumps may be brought on and offline, forcing the offline pump discharge checks closed. The correct selection of these combined function valves will eliminate water hammer problems.

Another important ability of these valves is on some filter applications where the valve's ability to be fitted with an actuator, allows for the "locking" open while backwash occurs.

Y-Pattern Stop Check

The Y-Pattern Stop Check is designed to freely close and then be manually locked in place for safety. Traditionally this check valve is used on steam boilers and features Stellite hardfacing on the plug and seating areas. It is an old-fashioned design still prevalent in the very traditional Power Industry.



Centre-Guided Spring Check

Centre-Guided Spring Checks, Nozzle or Silent Checks as they have become known are spring assisted diaphragm or plug seating checks in narrow face to face wafer bodies or full globe style bodies. These valves were designed for use where there is pulsing flow or rapid volumetric variation between minimum and maximum flow rates.



Careful attention to improper sizing, two-phase flows or suspended solids needs to be taken when installing Centre-Guided Spring Checks because these items can lead to a "stuck-open" condition. ⁽¹⁾

Slurry Check

Specifically designed for high solids applications like mineral concentrate pipelines, a carbide (chrome or tungsten) coated flapper style of swing check with a polyurethane seat has been used successfully for over 30 years on iron, bauxite and copper concentrate pipelines.

Summary

As with many types of valves, the variation of check valve styles, features, and functions, can make their selection complicated and difficult. A full understanding of the inherent design of each check valve type will assist in the proper selection of the check valve that best suits the application.

And as with other valve selections, it is imperative to have the complete application details before selecting the valve type. Each check valve has features that make it more or less suitable for use in the particular case.

While there is no perfect valve, CGIS has applied Hy-Grade Valve single and dual flapper check valves into some of the world's most demanding applications with a great deal of success. Hy-Grade's method of manufacture provides an almost infinite variety of inlet sizes as the valve bodies and seat inserts are made from solid bars or forgings. When process flows are provided, Hy-Grade's sizing program will identify what sized orifice will be the most effective and this "venturi" inlet provides the flapper stability that then provides a longevity in service several orders of magnitude longer than unsized or commodity check valves.

In our opinion, the single most effective style of check valve for most applications is the single flapper swing check. When it is properly sized to the flow, it greatly enhances its OPEX. They should not be used in severe cyclic and pulsating flow, or in heavy slurries. These applications are where centre-guided nozzle checks (severe cyclic or pulsating) or slurry checks (high solids slurries) are best.

Author:

Ross Waters, Chairman, CGIS

ross@cgis.ca

1.604.263.1671 (office)

1.604.813.9557 (mobile)

Footnote:

(1) K.L. McElhaney, "An Analysis of Nuclear Check Valve Performance by Valve Type", Valve Magazine, 1997, Volume 9, No. 3

Appendix

Biogas

Company	Facility/Location	Primary Process
Aircom Technologies	Quebec, Canada	Biogas Rotary Compressor
Greenlane Biogas	Arizona	Biogas Rotary Compressor
Greenlane Biogas	Brazil	Biogas Rotary Compressor
Greenlane Biogas	Canadian Operations	Biogas Rotary Compressor
Greenlane Biogas	CR&R Perris California	Biogas Rotary Compressor
Greenlane Biogas	Quebec	Biogas Rotary Compressor
Greenlane Biogas	Tekova BV	Biogas Rotary Compressor
Greenlane Biogas UK Limited	Greenlane UK	Biogas Rotary Compressor

Chemical

Company	Facility/Location	Primary Process
Carbon Engineering Ltd	Squamish, Canada	CO2 Production
Chemetics Inc. (a Worley Company)	Sumatra, Indonesia	Sodium Chlorate
Indorama Ventures	Quebec, Canada	Polyethelene Terephthalate (PET)
PeroxyChem Canada	Peroxygen Chemicals Division	Hydrogen Peroxide
Shin-Etsu Silicones Thailand	Thailand Plant	Silane
Sulphur Corporation of Canada Ltd	BC, Canada	Molten Sulphur
Suncor Energy Inc.	St. Clair Ethanol Plant	Ethanol

Food and Beverage

Company	Facility/Location	Primary Process
Gambrinus Malting Corporation	BC, Canada	Grain Malt
Lantic Inc.	Rogers Sugar, Canada	Sugar Beet

Industrial Gases

Company	Facility/Location	Primary Process
Air Liquide (China) Holding Co.Ltd.	Shanghai, China	High Pressure Oxygen
Air Liquide India Holding Pvt. Ltd	New Delhi, India	High Pressure Oxygen
CryoPeak LNG Solutions Corp.	Richmond, Canada	LNG

Mining

Company	Facility/Location	Primary Process
Antofagasta Minerals	Los Pelambres	Molybdenum Purification
Barrick Gold Corporation	Zaldivar	Weak Acid Heap Leaching
BHP Billiton	Nickel West Kwinana Nickel Refinery	Sulphuric Acid
BHP Billiton	Olympic Dam	Sulphuric Acid
Canadian Natural Resources Limited	Horizon Oil Sands	Process Water
Capstone Mining Corporation	Minto Mine Site	Tailings Water
Centerra Gold	Kemess Mine	Air Blow
CODELCO	Chuquicamata Cobre & Smelter	Process Water
Dominion Diamond Ekati Corporation	Ekati Minesite	Process Water
Dynatec Madagascar S.A.	Ambatovy Plant	HPAL Autoclave
EcoMetales Limited	Calama Operations	Acid Bio-Leaching
Freeport-McMoRan Copper & Gold	Tenke Fungurume Mining	Copper Concentrate
Glencore Xstrata	Murrin Murrin Mine	HPAL Autoclave
Hanwa Co. Ltd	QMB New Energy Materials	HPAL Autoclave
Hudbay Minerals	Triple 7	Underground Mine Dewatering
Imperial Metals Corporation	Red Chris Mine	Underground Mine Dewatering
Jordan Bromine Company Limited		Bromine Leaching
Kinross Gold	Fort Knox Mine	Thickener Underflow
Ma'Aden Gold	Bulghah Mine	Acid Leaching
Mantos Copper	Mantos Blancos	Weak Acid Heap Leaching
Mantos Copper	Mantoverde	Weak Acid Heap Leaching
Minera Chinalco Peru SA	Toromocho	POx Autoclave
Molibdenos y Metales S.A.	Molymet	POx Autoclave
Newcrest Mining Ltd	Lihir Gold Mine	POx Autoclave
Ningbo Lygend	Obi Nickel & Cobalt	HPAL Autoclave
Quiyang Zijin Mining Co. Ltd	Quiyang Zijin Gold	HPAL Autoclave
Quzhou Huayou Cobalt New Material	Huayou Cobalt	HPAL Autoclave
Ramu NiCo Managment (MCC)	Ramu Process Plant	HPAL Autoclave
Rio Tinto	Diavik Diamond Mine	Process Water
Rio Tinto Alcan	Alcan Kitimat Works	Process Water
Sheritt Technologies	Dynatec Metallurgical Technologies	POx Autoclave
Teck Metals Ltd.	Trail Smelter	POx Autoclave
Thompson Creek Metals Company	Endako Mines Division	Process Water
Zhejiang Huayou Cobalt Co. Ltd.	Pt Huayue Nickel Cobalt	HPAL Autoclave

Oil & Gas

Company	Facility/Location	Primary Process
APA Group	Australia	Natural Gas Production Well
Beach Energy	Middleton P106 Station	Natural Gas Compressor

Brittania Industries Inc	Alberta, Canada	Natural Gas Compressor
Canadian Natural Resources Limited	Horizon Oil Sands, Canada	Bitumen
Canadian Natural Resources Limited	Wolf Lake TEOR Facility	Water Disposal Well
Canadian Natural Resources Limited	Horizon Oil Sands	Produced Water
Canadian Natural Upgrading Limited	Muskeg River Oil Sands	Tailings Water
Cenovus Energy	Christina Lake SAGD	SAGD Steam
Cenovus Energy	Foster Creek SAGD	Heavy Oil Emulsion
Cenovus Energy	Weyburn CO2 EOR Oilfield	CO2 Enhanced Oil Recovery
Certarus Ltd.	Alberta CNG Facility	CNG
Chevron Australia Pty Limited	Wheatstone LNG Production Plant	LNG
EnCana Corporation	Christina Lake SAGD	Heavy Oil Emulsion
EnCana Corporation	South Central Liquids Hub	Natural Gas Liquids (NGLs)
ExxonMobil	Nigeria	Offshore Oil Platform
ExxonMobil	Sakhalin	Oil Production
ExxonMobil Canada Ltd.	Hibernia Operations	Offshore Oil Platform
Fluxys SA	Netherlands	LNG Gasification
Husky Energy Inc	Bi-Provincial Upgrader	Heavy Oil Upgrading
Husky Energy Inc	Rainbow Gas Plant	Acid Gas
Husky Energy Inc	Tucker Thermal	Steam
Imperial Oil Resources Ltd.	Strathcona Refinery	Refinery
Imperial Oil Resources Ltd.	Edmonton Refinery	Refinery
Imperial Oil Resources Ltd.	Kearl Oil Sands	Tailings Water
International Petroleum Corp.	Alberson Compressor Station	Natural Gas Compressor
Irving Oil Limited	Saint John Refinery	HF Acid
Japan Canada Oil Sands Limited	Hangingstone, Canada	Steam
MRC Global Australia Pty Ltd	Melbourne Valves, Australia	Coal Gas Extraction
NorthRiver Midstream Inc.	McMahon Gas Plant, Canada	Natural Gas Cleaning
NuVista Energy Ltd.	Wembley Gas Plant, Canada	Natural Gas Cleaning
Oil & Gas Midstream	ATCO Gas Australia	Natural Gas Distribution
Pacific Northern Gas Ltd.	BC, Canada	Natural Gas Distribution
Pembina NGL Corporation	Redwater Fractionation Facility	Natural Gas Liquids (NGLs)
QGC	Surat Basin, Australia	Coal Seam Gas Production
Santos	GLNG, Australia	LNG
Santos	GLNG Surat Basin, Australia	Coal Seam Gas Production
Santos	Moomba Gas Plant, Australia	Potassium Carbonate
Santos	Roma Gas, Australia	Coal Seam Gas Production
Santos	Scotia, Australia	Coal Seam Gas Production
Shell Canada Energy	Caroline Gas Complex, Canada	Sour Gas
South East Australia Gas Pty Ltd	Australia	Natural Gas
Sukunka Natural Resources Inc.	Kwoon Gas Treating Plant, Canada	Natural Gas Cleaning
Suncor Energy Inc.	Edmonton Refinery, Canada	Refinery
Suncor Energy Inc.	Sarnia Refinery, Canada	Refinery
Suncor Energy Inc.	Tar Island, Canada	Tailings Water

Tidewater Midstream	Prince George Refinery	Refinery
Westport Innovations Inc.	Vancouver, Canada	LPG
Whitecap Resources Inc.	Weyburn CO2 EOR Oilfield	CO2 Enhanced Oil Recovery
Wolf Carbon Solutions	AG - CO2 Compressor Station	Natural Gas Compressor
Woodside	Goodwyn Alpha Platform	Offshore Oil Platform

Power

Company	Facility/Location	Primary Process
Atlantic Power Corporation	Williams Lake Power Plant	Steam
B.C. Hydro	Masset, BC, Canada	Diesel
B.C. Hydro	Telegraph Creek Generating Stn	Diesel
EPCOR Generation	Alberta, Canada	Steam
Thermogenics Inc	Ontario, Canada	Steam

Pulp and Paper

Company	Facility/Location	Primary Process
A.H. Lundberg Systems Ltd.	BC, Canada	Pulp Cleaner
Canadian Kraft Paper	Manitoba Kraft Ltd., Canada	Batch Digester Steam
Canfor Pulp Ltd.	Intercontinental Pulp Mill	Steam
Canfor Pulp Ltd.	Northwood Pulp Mill	Steam
Catalyst Paper	Alberni Specialties, Canada	Steam
Catalyst Paper	Elk Falls Division, Canada	Batch Digester Steam
Catalyst Paper	Powell River Division, Canada	Steam
Eurocan S.R.L	BC, Canada	Steam
J.D. Irving Limited	Lake Utopia Paper, Canada	Batch Digester Steam
Mercer Celgar Limited Partnership	Celgar Pulp, Canada	Effluent Sludge
Millar Western Ltd.	Whitecourt Forest Products	Sulphuric Acid
Neucel Specialty Cellulose	Port Alice Pulp, Canada	Cellulose Red Stock Washer
PT Oki Pulp & Paper Mills	Sumatra, Indonesia	Sulphuric Acid
Tolko Industries Ltd.	Manitoba Kraft Ltd., Canada	Batch Digester
West Fraser Mills Ltd.	Hinton Pulp, Canada	Black Liquor

Water and Wastewater

Company	Facility/Location	Primary Process
City Of Kamloops	BC, Canada	Wastewater
Metro Vancouver	Annacis Island Treatment Plant	Secondary Waste
Sheng-Li Desalination	China	Desalination
Smith Cameron Process Solutions	BC, Canada	Water