

# BUTTERFLY VALVE SELECTION: KEY STYLES AND APPLICATION FACTORS

Butterfly valves serve as critical flow control components across a broad spectrum of applications and industries, offering a compact footprint, low torque operation, and reliable shutoff capabilities. Their streamlined construction and operational efficiency make them well-suited for isolation, throttling and control duties in systems where space, weight, and cost are significant considerations.

As process requirements evolve across industries such as water & wastewater treatment, pulp & paper, chemical processing, oil & gas, HVAC, power generation, and mining, the need for application specific valve configurations has become increasingly important. Butterfly valves are uniquely adaptable to meet these challenges due to their wide range of designs, body configurations, seat materials, and performance capabilities.

This white paper provides a comprehensive overview of butterfly valve technologies, including design types, style classifications, and performance characteristics, with the goal of guiding engineers, specifiers, and plant operators toward optimal valve selection. Emphasis is placed on matching valve configuration to service conditions such as pressure, temperature, flow characteristics, and media compatibility to ensure long-term reliability and regulatory compliance.

## End Connection Styles

**Wafer:** The wafer-style butterfly valve is engineered to fit between two pipeline flanges, secured using bolts that pass through the flanges on either side. This streamlined construction eliminates the need for separate flange connections, reducing overall weight and material usage. Although the design promotes cost-efficiency by minimizing the number of components required and simplifying installation and maintenance, disc alignment issues can occur.

### Butterfly End Connection Styles



Wafer



Lugged



Fully Flanged

Typically employed in low to medium pressure systems, wafer valves are well-suited for applications that do not require valve removal under pressure. Their bi-directional sealing capability helps prevent backflow, although they are not recommended for dead-end service without proper downstream support.

The term “wafer butterfly valve” can be used to describe either the end connection or the body style, which are two separate aspects of valve design. A wafer end connection refers to the method of installation, where the valve is clamped between two pipe flanges using through-bolts. In contrast, a wafer body refers to the valve’s physical form, typically a flat, compact body without integral flange faces or threaded bolt holes. Properly distinguishing between these terms ensures accurate valve selection and compatibility with the piping system.

**Lugged:** The lug-style butterfly valve incorporates threaded lugs on both sides of the valve body, allowing it to be bolted directly to the mating flanges without requiring through-bolts and is easier to align in the pipeline than wafer-style valves. This configuration enables one end of the piping system to be disconnected without affecting the other, making lugged valves particularly advantageous for systems requiring frequent maintenance, sectional isolation, or dead-end service. Their ability to remain securely mounted on one flange while the other side is removed simplifies both upstream and downstream service operations.

Lugged butterfly valves are suitable for medium pressure systems and are commonly utilized in industries where process integrity and system uptime are critical. The robust body construction and rigid mounting provide additional stability in pipeline systems subjected to moderate vibration or mechanical stress.

**Fully Flanged:** Fully flanged butterfly valves are designed with a continuous pattern of threaded inserts, or lugs, uniformly spaced around the valve body. This construction allows for the valve to be bolted independently to each flange, providing superior mechanical integrity and system isolation. Unlike partially lugged designs, the fully flanged body can serve as a terminal valve for dead-end service, as it can support the required structural load without downstream support.

This configuration is highly advantageous in systems requiring high reliability and operational safety, especially where frequent maintenance or valve replacement is anticipated. The design enables the valve to be isolated and removed without disturbing adjacent pipeline components, minimizing downtime and mitigating process disruption. Fully flanged butterfly valves are ideally suited for hazardous, toxic, or high-risk applications where system containment is critical.



A 168" AWWA butterfly valve, the largest ever manufactured in North America, has fully flanged double flanges for exceptional strength.

Fully flanged valves are commonly deployed in high-pressure and high-temperature systems, such as industrial gas pipelines, chemical handling facilities, and refineries, where operational reliability is paramount. They also meet the rigorous demands of regulated industries, including those governed by ANSI, ASME, and API standards. Their rugged construction allows for integration into both onshore and offshore environments and is often specified in fire-safe or SIL-rated systems and easily accommodate international drill patterns.

## Design Types

**Resilient Seated:** Resilient seated butterfly valves utilize a flexible, elastomeric seat—typically composed of materials such as EPDM, NBR, or FKM—molded or bonded to the valve body or liner. The disc interfaces with this soft seat to achieve zero leakage when closed which corresponds to Class VI shutoff under ANSI/FCI 70-2 (Control Valve Seat Leakage) and bubble tight performance under API 598 (Valve Inspection and Testing). The design incorporates an on-center disc alignment, which allows bidirectional sealing while simplifying actuation requirements. These valves are ideal for low to moderate pressure services where leak-tight performance, cost-efficiency, and simplicity are prioritized.

Resilient seated valves are particularly common in potable water systems, wastewater treatment, irrigation networks, and HVAC circuits due to their resistance to scaling, ease of installation, and suitability for frequent cycling. Their seats provide good resilience to wear and accommodate minor pipeline misalignments or thermal expansion. While these valves are not intended for high-temperature or abrasive services, proper material selection enables them to handle a variety of clean and lightly contaminated fluids.

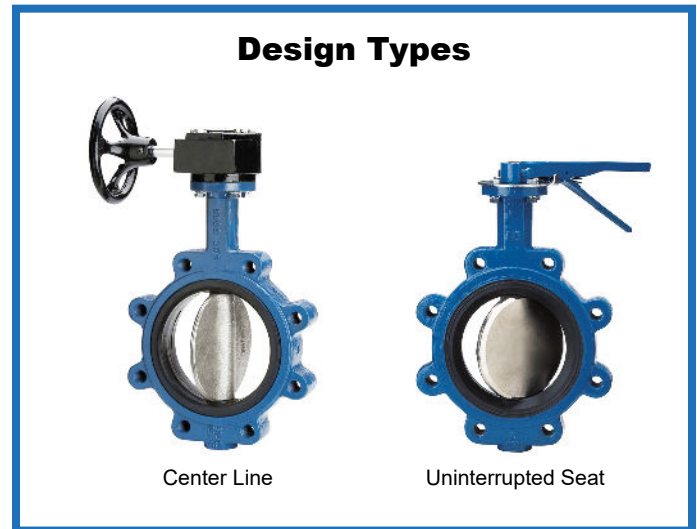
**Metal Seated:** Metal-seated butterfly valves are engineered for demanding applications where soft-seated designs are unsuitable due to elevated temperatures, abrasive media, or high-pressure conditions. Unlike resilient-seated valves that rely on elastomeric or polymeric materials for sealing, metal-seated butterfly valves employ precision-machined metal-to-metal contact between the disc and seat to achieve shutoff. These valves typically achieve Class IV or Class V shutoff per ANSI/FCI 70-2. Class IV allows a limited leakage rate based on valve size and differential pressure, while Class V represents a higher standard with more stringent leakage limits.

Metal-seated butterfly valves are typically constructed with an eccentric disc configuration to minimize friction between the disc and seat during operation. These valves offer long-term reliability and performance where resilient-seated valves would otherwise fail.

**Centerline:** Centerline butterfly valves, also known as concentric valves, are engineered with the disc and stem aligned along the central axis of the valve body. This alignment allows the disc to rotate within the seat with uniform pressure distribution, resulting in consistent sealing performance and minimal wear overtime. The design is inherently simple, cost-effective, and reliable, offering bidirectional shutoff capabilities in moderate-pressure applications. Centerline valves are particularly effective in systems where corrosion resistance, sealing integrity, and maintenance accessibility are critical factors. Typical applications include chemical and petrochemical processing, industrial steam distribution, and utility water systems within power generation facilities. The concentric configuration facilitates stable flow regulation and ensures reliable operation even under varying thermal and hydraulic conditions.

**Uninterrupted Seat:** An uninterrupted seat in butterfly valve design refers to a sealing configuration in which the seat extends as a continuous surface around the entire 360 degrees of the valve body, without being penetrated or interrupted by the shaft or other internal components. This feature is independent of the seat material and can apply to both soft-seated and metal-seated valves, though it is more commonly associated with concentric configurations.

An uninterrupted seat in a butterfly valve enhances sealing performance by maintaining a continuous sealing surface free from shaft intrusion. This design principle improves reliability, simplifies sealing dynamics, and is advantageous in critical service applications across various industries.

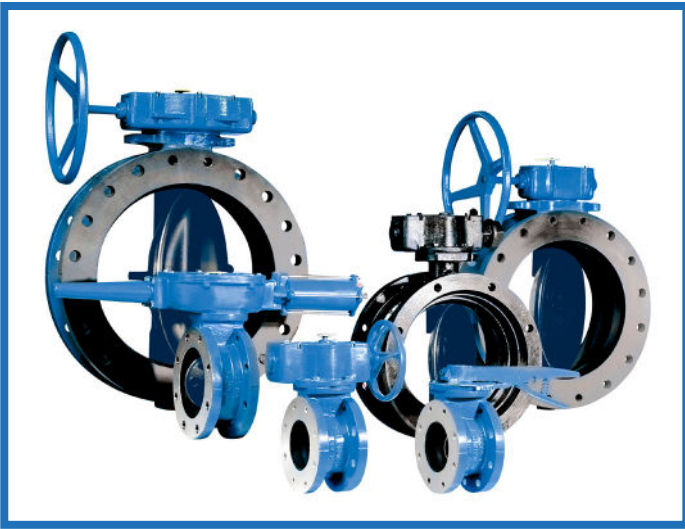


**High Performance:** High-performance butterfly valves are engineered to operate under more demanding service conditions, including elevated pressures, high temperatures, and aggressive media. They feature an offset disc configuration, where the shaft and sealing axis are displaced from the valve body centerline. This geometry reduces seat contact during opening and closing, minimizing wear and extending seat life.

High Performance Butterfly Valves utilize elliptical sealing motion, suitable for moderate to high pressure systems in chemical processing, power generation, steam distribution, and hydrocarbon transportation. Dual combination seats are utilized to ensure reliable sealing performance under both standard operating conditions and in the event of a fire. These seats typically consist of a primary soft seat, such as PTFE or elastomer, for bubble-tight shutoff during normal service, and a secondary metal seat designed to maintain sealing integrity when the soft material is compromised due to elevated temperatures.

**AWWA:** Butterfly valves designed to AWWA (American Water Works Association) standards, specifically C504 and C516, are optimized for use in municipal water, wastewater, and industrial utility applications. These valves are manufactured to meet stringent dimensional, material, and performance criteria, ensuring consistent operation across large infrastructure networks. They are available in sizes ranging from 3" to 168", making them suitable for large-diameter distribution mains, pump stations, and water treatment facilities.





AWWA Butterfly Valves are built to be more robust and heavy-duty than standard designs, delivering longer service life in demanding water and wastewater applications.

AWWA butterfly valves emphasize robust construction, ease of operation, and longevity in buried service or above-ground installations. These valves are frequently specified for isolation, throttling, and control functions in drinking water systems, stormwater handling, flood mitigation, and other municipal services.

AWWA-compliant valves are valued for their ease of maintenance, dependable sealing, and adaptability to various joint types and connection standards.

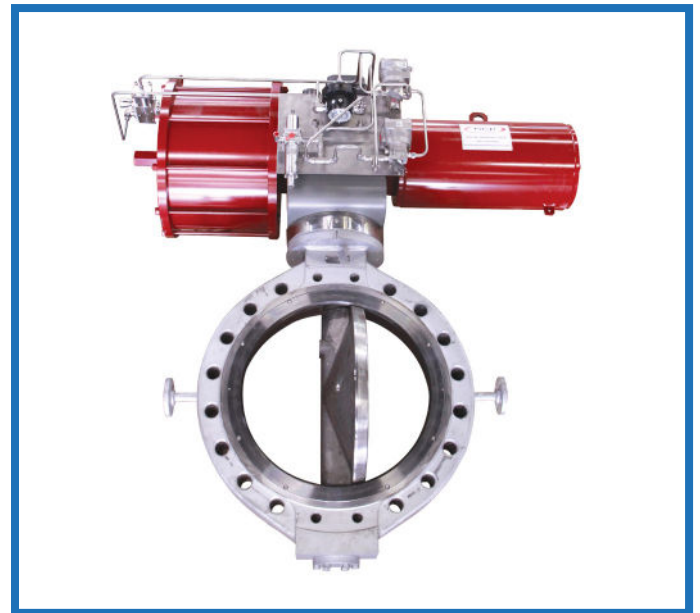
## Applications/Industries

**Polymerizing Media:** A tail gas butterfly valve is an engineered valve specifically designed for use in sulfur recovery units within refineries and gas processing facilities. These valves are constructed to withstand the severe operating conditions associated with the tail gas stream, which may include elevated temperatures, corrosive components, and the potential for fluid solidification or polymerization. Tail gas butterfly valves are typically fabricated from high alloy or corrosion resistant materials and may include features such as purge ports or steam jackets to maintain flow integrity and prevent valve fouling or blocking during operation.

**Water and Wastewater Treatment:** Butterfly valves are a preferred solution in municipal and industrial water and wastewater treatment applications due to their fast-acting shutoff, low torque requirements, and space-saving profile. These valves are used extensively for flow isolation, throttling, and in relatively clean systems. Their robust construction and corrosion-resistant materials ensure long service life in environments with varying fluid characteristics, including abrasive slurries, corrosive chemicals, and biological contaminants.

NSF certification on butterfly valves confirms they meet strict health and safety standards for potable water applications. Certification to NSF/ANSI/CAN 61 ensures that the valve materials do not leach harmful contaminants into drinking water under specified conditions, while NSF/ANSI 371 verifies that the valve complies with lead content requirements. These certifications are critical for valves used in municipal water treatment, storage, and distribution systems, helping ensure regulatory compliance and safeguarding public health. Manufacturers must undergo rigorous testing and periodic audits to maintain NSF certification.

**Chemical:** Butterfly valves serve a critical role in the chemical processing industry, where the safe handling of aggressive fluids, corrosive vapors, and variable temperatures is essential. High-performance butterfly valves, featuring offset disc configurations and chemically resistant materials such as PTFE, Hastelloy, and Inconel, are selected to meet the stringent demands of these environments. These valves provide dependable shutoff and flow regulation while minimizing the risk of leakage and seat degradation. Their compatibility with a broad range of chemicals, from strong acids and bases to volatile organic compounds, makes them integral to reaction processes, storage transfer lines, and effluent control systems.



Tail Gas Butterfly Valves are equipped with steam jackets to prevent media from solidifying.

**HVAC:** Heating, ventilation, and air conditioning systems rely on butterfly valves to regulate chilled and hot water flow throughout complex networks of piping. Resilient seated butterfly valves are the most common style used in HVAC due to their economical design, bubble-tight shutoff capabilities, and ability to withstand frequent cycling. Their compact form is particularly advantageous in commercial and institutional buildings where space is constrained. The simplicity of operation and minimal maintenance requirements make them suitable for zone control, pump bypass, and coil isolation applications.

**Power:** In power generation facilities, butterfly valves are utilized in high-pressure, high-temperature applications including steam lines, cooling circuits, seawater and brackish water. High-performance designs are particularly well-suited for these conditions, offering exceptional durability and tight sealing under thermal cycling and elevated differential pressures. Their ability to throttle and control flow accurately and maintain performance over extended service intervals reduces downtime and maintenance costs. Applications include isolation of turbine bypasses, ammonia skid isolation valves, compressor bleed valves, control of condenser water flow, and regulation of auxiliary services in both fossil-fuel and nuclear power plants.

**Pulp & Paper:** Butterfly valves are commonly used in the pulp and paper industry for their compact design, fast actuation, and ability to handle high flow rates with moderate pressure drops. Typical applications include pulp slurry flow control in stock preparation, process and wastewater systems, chemical feed lines, low pressure steam, wet end vacuum control, liquor isolation, and tank or chest isolation. Depending on service conditions, rubber lined or high performance butterfly valves are selected to manage corrosive, abrasive, or fibrous media. Their durability, low maintenance, and adaptability make them well suited for both on/off and throttling duties across various stages of pulp and paper processing.

## Operating Conditions

**Pressure and Temperature:** Operating pressure and temperature are primary considerations when specifying a butterfly valve. Each valve style and construction material has defined limits that must align with the application's requirements. Standard resilient seated valves are suitable for low-pressure and moderate temperature environments, whereas high-performance butterfly valves are designed for elevated pressure and temperature ranges. These high-performance variants incorporate metal or reinforced composite seating and robust disc and stem assemblies to maintain sealing integrity under extreme conditions. Understanding the full range of normal and transient operating parameters, including pressure spikes and thermal expansion, is essential for preventing premature valve failure and ensuring system safety.

**Media Compatibility:** The nature of the process media, whether it is clean, abrasive, corrosive, or contains suspended solids, significantly influences material selection for valve components. Valve seats, discs, stems, and body materials must be chemically and physically compatible with the media to avoid corrosion, erosion, swelling, or degradation. For example, elastomer seats such as EPDM or FKM are selected based on chemical resistance profiles, while metal alloys like stainless steel, Duplex, or Hastelloy may be required for aggressive or high-temperature fluids. Media composition also affects seat selection in high-performance valves, especially in applications involving steam, hydrocarbons, or oxidizing agents. It is also important to evaluate the system's cleaning procedures to ensure that the selected elastomer is chemically compatible with the cleaning agents used.



48" AWWA butterfly valves equipped with electric actuators are installed at a water treatment disinfection facility for precise flow control.

**Flow Characteristics:** Butterfly valves are well suited for control applications due to their near linear flow characteristics in the midrange of operation, typically between 20° and 70° of disc rotation. In this range, the flow rate is approximately proportional to the disc position, allowing for stable and predictable modulation, making them effective for throttling applications. For precise control, particularly in modulating services, high-performance valves offer improved flow coefficients and reduced seat wear due to minimized disc-seat contact. Additionally, consideration must be given to the valve's ability to handle flow-induced vibration, cavitation, and pressure drops. Accurate flow characterization ensures that the selected valve will maintain stability, minimize energy losses, and extend operational life.

## Summary

Effective butterfly valve selection requires a systematic evaluation of process parameters and operational demands to ensure reliable, long-term performance. Key selection criteria include media composition, pressure and temperature conditions, required sealing performance, and system-specific design constraints. A thorough understanding of these variables is essential to specifying a valve configuration that aligns with the service environment and application requirements.

Engineers and system designers must carefully consider factors such as the chemical compatibility of wetted materials and expected cycle frequency. In addition, industry standards such as API, ASME, ISO, or AWWA must be factored into the specification process to ensure compliance and performance consistency.

By aligning application requirements with the appropriate valve design, operators can ensure mechanical integrity, enhance flow control, reduce downtime, and support broader objectives such as energy efficiency, environmental compliance, and total lifecycle cost reduction. As a result, when properly matched to system demands, butterfly valves provide robust, efficient flow control across a wide range of industrial applications.

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