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Derek B. Scott is marketing and technical manager and John R. Helf is product engineer with AMERICAN Flow Control (www.american-usa.com), Birmingham, Ala.

Research Sheds New Light on Gate Valve Bypasses

Features used to operate newer resilient-seated gate valves have eliminated the need for traditional valve bypasses. Recent research suggests bypasses may not be required. **BY DEREK B. SCOTT AND JOHN R. HELF**

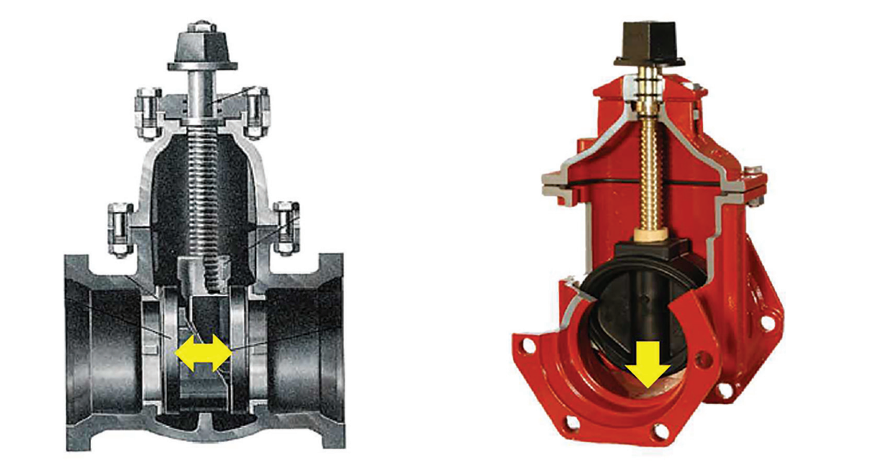
FOR CENTURIES, valves have been an integral part of water and wastewater systems. Over time, improvements in materials, workmanship, and technology have led to increasingly more durable and reliable valve solutions.

The advent of the Industrial Revolution brought to prominence iron-bodied and bronze-mounted (IBBM) gate valves that evolved into the double-disc gate valves of the 20th century. These early double-disc gate valve designs were covered under the first American valve standard, published in 1913. That standard would later become the ANSI/AWWA C500 Standard, *Metal-Seated Gate Valves for Water Supply Service*. Double-disc gate valves were an important step forward for the waterworks industry, particularly in larger size ranges, as they offered features such as rollers, tracks, and scrapers for debris clearance; integral bypass valves for pressure differential reduction; and gearing for input torque reduction. These features assisted in operating double-disc gate valves.

Later in the 20th century, the resilient-seated gate valve grew in popularity due to its simplicity, ease of operation, and reliability. The first resilient-seated gate valve standard, ANSI/AWWA C509, *Resilient-Seated Gate Valves for Water Supply Service*, was published in 1980. ANSI/AWWA C515, the standard for *Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service*, would be published 20 years later, leveraging the strength of ductile iron. Most present-day designs use features, such as acetal polymer wedge guides and a durable fusion bond epoxy coating, that have eliminated the need for rollers, tracks, and scrapers. The use of a monolithic, rubber-encapsulated wedge common in today's gate valves has virtually eliminated the use of bypasses on larger valve designs. Clearly, gate valves and best practices related to their use have changed dramatically in the past few decades.

Figure 1. Gate Valve Seating

Metal-to-metal seating (left) requires exponentially more torque to seal and unseat than resilient-seated gate valves (right).



TAKING A DEEP DIVE INTO VALVE BYPASSES

The use of valve bypasses, once considered a requirement with metal-seated gate valves, has received more scrutiny in the past few years. Although bypasses are available for resilient-seated gate valves in various sizes, they're typically installed only at the end user's request. Some manufacturers may see some benefit in their use; others may not. To the end user, a bypass is an added component in the system that must be maintained. There are countless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PHOTOGRAPH: AMERICAN FLOW CONTROL

stories in which an operator, seeing two adjacent valve box lids, mistakenly operates the bypass valve as if it were the much larger mainline valve, damaging the bypass valve in the process. At the end of the day, most resilient-seated gate valve manufacturers supply only a handful of bypasses in any given year. Still, enough industry confusion exists to suggest the need for a deeper dive.

Bypasses Aren't Necessary on All Large-Diameter Gate Valves. Gate-valve bypasses originated as an option for valves with metal seats. Metal-to-metal seating requires exponentially more torque to seal and unseat than resilient-seated gate valves. Many metal-seated designs are configured with parallel seats. For these valves to seal at higher pressures, fluid must leak past the first seat until the internal cavity of the valve is stabilized with the higher upstream pressure, forcing closed the second, downstream seat.

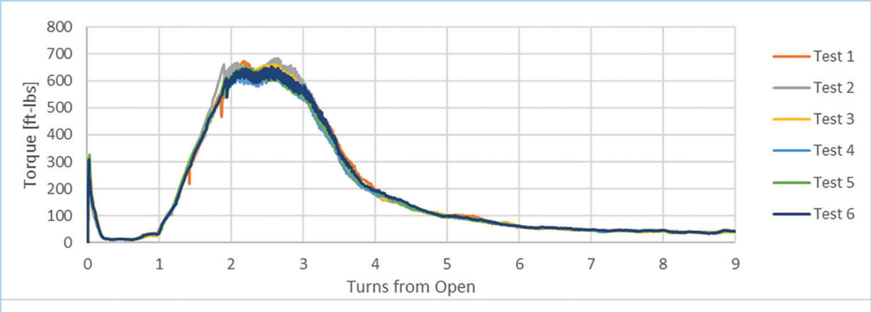
As illustrated in Figure 1, this concept is effective for metal-seat designs, as it results in a trapping of the high-pressure fluid inside the valve body. However, this elevated pressure must be relieved when opening the valve. With these older-style metal-seated designs, the bypass aids in valve operation by relieving the lateral "pressure lock" present across a smaller seating area. This pressure lock exists because of the forces distributed across the seating areas. These forces serve to significantly increase the friction between the seats on the valve disc and in the valve body.

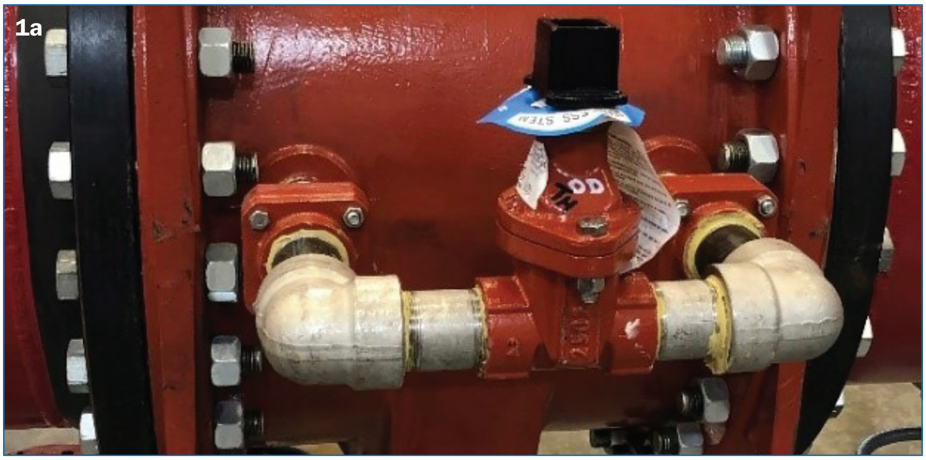
A resilient-seated gate valve design doesn't have this problem. Although pressure can assist in achieving a valve seal, the softer, more forgiving sealing surface of the rubber-encapsulated wedge allows for significantly lower operating torques for closing and opening the valve.

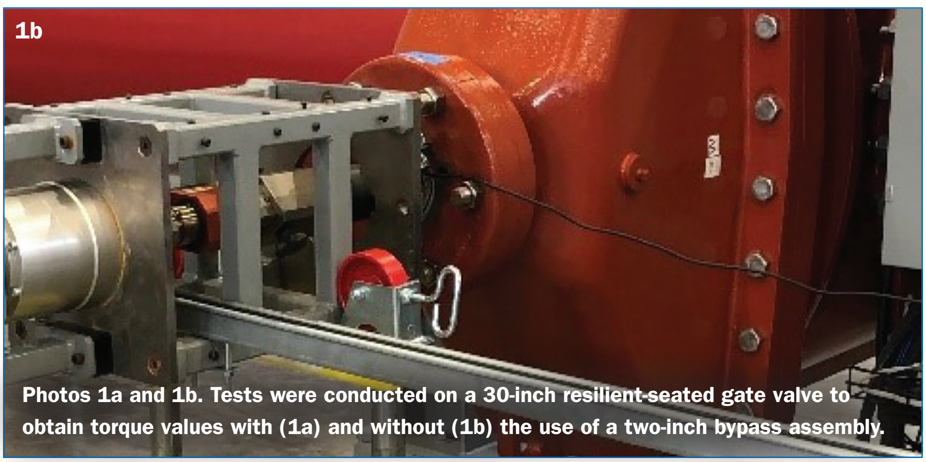
Just as important as the differences in the function of the resilient-seated gate valve is its history. Considering resilient-seated gate valves have been in

Figure 2. Torque vs. Turns for Nine Operating Turns

The input torque data were collected directly at the valve stem three times with the bypass closed and three times with the bypass open while opening the 30-inch valve.







Photos 1a and 1b. Tests were conducted on a 30-inch resilient-seated gate valve to obtain torque values with (1a) and without (1b) the use of a two-inch bypass assembly.

existence for more than 40 years, and the use of bypasses to aid in their operation has been almost nonexistent, most manufacturers have concluded their need is virtually nonexistent, if at all.

Bypasses May Not Lower the Operating Torque of Resilient-Seated Gate Valves. The traditional use for integral bypass valves has been to aid operation of metal-seated gate valves by reducing operating torque. As mentioned previously, resilient-seated gate valves inherently have much lower operating torques than metal-seated valves. But for some the question remains, is an integral bypass helpful to resilient-seated gate valves by reducing operating torque? The answer may depend on valve design, system conditions, and other factors. However, recent testing performed by AMERICAN Flow Control showed the effects of a bypass, relative to operating torques, are negligible.

To determine the effects a bypass might have on large-diameter resilient-seated gate valve operation, a series of tests was conducted on a 30-inch resilient-seated gate valve equipped with a 2-inch bypass assembly. The tests were conducted using the setup illustrated in Photos 1a and 1b employing a line pressure greater than 80 psig, which is a common working pressure in waterworks applications.

The 30-inch gate valve was cycled from fully open to closed to achieve a leak-tight seal, then back to fully open while measuring input torque. The input torque data were collected directly at the valve stem in six different cycles—three with the bypass closed and three with the bypass open while opening the 30-inch valve. Figure 2 exhibits the input torque recorded over the first nine turns to open the valve. For testing purposes and to record operational torque more accurately, a manual gear operator wasn't used.

The peak torque recorded on the 30-inch valve during all six tests, regardless of the use of the bypass, occurred within the first two to three turns open from fully closed. Torques immediately leveled out at a much lower value for the duration of the open cycle. This peak value, sometimes referred to as the "cracking torque," is where the leak-tight seal of the rubber-encapsulated wedge against the epoxy-coated body is broken. A closer analysis of the data revealed the average peak torque to operate the valve with the bypass open (662 ft-lb) was within 1% of the average peak torque of the values obtained with the bypass closed (660 ft-lb). The testing verified years of experience showing that bypasses may not be required when operating resilient-seated gate valves.

Bypass Sizing Depends on System Application. As mentioned previously, reducing metal-seated gate valve operating torque was historically the primary reason for using a bypass. However, in rare cases, some systems may use bypasses for other reasons, such as slowly filling a downstream line or keeping water moving during main valve closure. Most of the time, such needs are handled using system or network bypass piping that isn't integral to the gate valve.

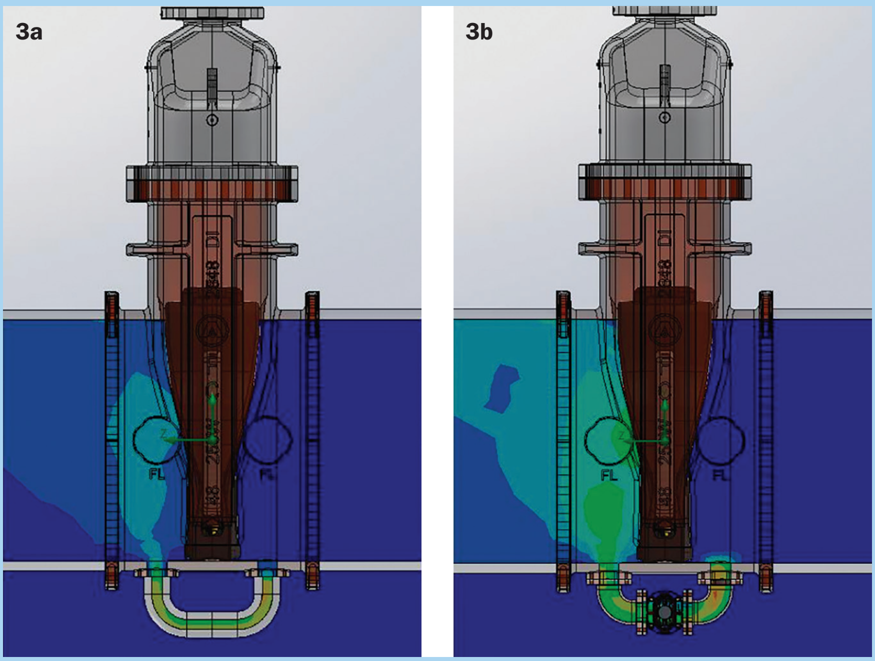
More commonly, utilities may elect to partially open an inline valve. The inherent advantage to using a system bypass is the end user can customize the size and shape of the bypass needed without constraints. Integral gate valve bypass sizes will vary from manufacturer to manufacturer, as configurations will be limited by the larger valve body geometry. Additionally, system bypasses can help eliminate operator error should operation of the two valves inadvertently get switched. Regardless, it's useful to understand the general principles of flow through a bypass, if one is used,

PHOTOGRAPHS: AMERICAN FLOW CONTROL

Today's resilient-seated gate valve employs better materials and a more durable, efficient design.

Figures 3a and 3b. Bypass Velocities

The impacts of the 2-inch (3a) and 4-inch (3b) bypass valves themselves were negligible because of the minimal resistance coefficient unique to gate valves.



and the impact of its size. Sometimes end users make potentially misguided assumptions that smaller bypasses will have higher fluid velocities, leading to potential problems.

To examine the relationship between flow, velocity, and bypass size, water professionals can use Crane Co.'s guide *Flow of Fluids Through Valves, Fittings, and Pipe* (Technical Paper No. 410). An assumption can be made that differential pressure is the independent variable, as is the case in most system and valve applications.

To determine the discharge of fluid through valves, fittings, and pipe, we use Henry Darcy's formula:

$$Q = 19.64d^2\sqrt{\frac{h_L}{K}}$$

Where:

Q = Flow rate through bypass (gpm)

d = Inside diameter of bypass assembly (inches)

h_L = Differential pressure head across the valve (feet of water)

K = Sum of the resistance coefficients for components in the bypass assembly

Calculating flow through bypasses at various pressure differentials, it becomes clear that minor losses associated with the bypass pipe, fittings, and valve (K values found in the Crane guide) have little effect on the results. The flow through the bypass is driven by the pressure differential across the valve and the bypass diameter. To that point, larger bypasses can fill a downstream line a little faster, but they'll encounter virtually the same velocities with different bypass sizes. In other words, the flow rate increases linearly with the bypass cross-sectional area, while the velocity remains virtually the same.

To verify these results, as shown in Figures 3a and 3b, an analysis was conducted using flow-simulation software on a hypothetical 48-inch resilient-seated gate valve equipped with 2-inch bypass piping. The analysis was repeated using 4-inch bypass piping. The impacts of the 2- and 4-inch bypass valves themselves were negligible because of the minimal resistance coefficient unique to gate valves. The analysis was performed using the same upstream and downstream conditions. This resulted in velocities and flow rates that were closely similar to those calculated using Darcy's formula, reinforcing the concept that velocity will remain relatively constant while flow rate changes with bypass cross section.

TECHNOLOGY ADVANCES

Not all valves are the same. Some are more efficient in design and concept than others. The French novelist Jean-Baptiste Alphonse Karr is credited with saying, "The more things change, the more they stay the same." It's doubtful he was talking about gate valves.

On your next large-diameter gate valve project, if a gate valve manufacturer tells you its valve requires a bypass to function properly, by all means, consider the message. However, if the message is that *all* gate valves require bypasses, don't be misled. Science and history aren't on the side of that argument. A focus on valve selection, life cycle, and flow analysis, as well as the use of air-release valves, will yield much greater benefit to the pipeline's operation.

Technology has allowed gate valve designs to improve dramatically in the past 50 years. Today's resilient-seated gate valve employs better materials and a more durable, efficient design. Rather than applying antiquated concepts, end users and engineers alike should consult with a gate valve manufacturer, experienced in the design of various gate valves and the use of bypasses, to ensure an understanding of today's innovative features and benefits.