BEFORE THE TENNESSEE PUBLIC UTILITY COMMISSION
NASHVILLE, TENNESSEE

IN RE: **PETITION OF TENNESSEE-AMERICAN WATER TO MODIFY TARRIFF, CHANGE AND INCREASE CHARGES, FEES, AND RATES, AND FOR APPROVAL OF GENERAL RATE INCREASE**	)))))))	**DOCKET NO. 24-00032** **FILED: October 21, 2024**

REVISED DIRECT TESTIMONY OF WITNESS SHAWN GARVEY
PROFFERED BY INTERVENORS UWUA AND UWUA, LOCAL 121

The Utility Workers Union of America, AFL-CIO ("UWUA"), and UWUA Local 121 (hereinafter collectively "UWUA"), intervenor parties in this action, hereby present the revised direct testimony of Shawn Garvey.

Mr. Garvey's testimony sponsors the following exhibits:

EXHIBIT UWUA-1:
American Water Valve Operation, Inspection and Maintenance Practice Manual
This Exhibit was included as Attachment 3 to Tennessee-American Water Company's Response to UWUA DR 2-1, docketed on August 27, 2024, and is attached hereto for ease of reference.

EXHIBIT UWUA-2:
Distribution Valves: Selection, Installation, Field Testing, and Maintenance
Published by the American Water Works Association (3rd Ed. 2016).

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Shawn Garvey. My business address is 1300 L Street, N.W., Suite 1200, Washington, DC 20005.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by the Utility Workers Union of America, AFL-CIO ("UWUA"). I was hired as a UWUA National Representative in April 2010, and I became a Senior National Representative in 2014. UWUA is a national labor organization representing approximately 45,000 workers primarily in water, electric, and gas utility companies across the United States, including the unionized hourly workers at Tennessee-American Water Company ("TAWC" or the "Company").

Q. FOR WHOM ARE YOU APPEARING IN THIS PROCEEDING?

A. I am testifying on behalf of UWUA and UWUA Local 121 (referred to collectively as "UWUA"). Local 121 is the UWUA local union that represents TAWC's hourly workers.

Q. PLEASE DESCRIBE YOUR EMPLOYMENT EXPERIENCE.

A. Prior to becoming a Senior National Representative with UWUA in 2010, I worked as a utility mechanic for New York American Water, a subsidiary of TAWC's parent corporation American Water Works Company ("American Water") in Hewlett, New York for 11 years. Before then I worked for Long Island Water Corp. ("LIWC") at the same location for ten years starting in 1989 until American Water bought LIWC in 1999, and then continued working for New York American Water until I began work with UWUA in 2010. (American Water has since sold New York American Water to another company.)

Q. PLEASE DESCRIBE YOUR RESPONSIBILITIES AS A UWUA SENIOR NATIONAL REPRESENTATIVE, INCLUDING SPECIFICALLY WITH REGARD TO TAWC'S PARENT COMPANY AMERICAN WATER.

A. My primary job responsibilities include processing grievances for UWUA local unions assigned to me, handling grievance arbitrations, and negotiating collective bargaining agreements with companies. Specifically concerning American Water, I am assigned to represent UWUA local unions at seven American Water locations – three in Pennsylvania, three in New Jersey, and one in Maryland. I was lead negotiator for UWUA in 2018 and 2023 with American Water for the National Benefits Agreement, which provides for retirement and healthcare benefits for numerous American Water locations across the U.S. I have also represented UWUA on the American Water Joint Healthcare Cost Committee since 2014.

Q. IN YOUR ROLE AS SENIOR NATIONAL REPRESENTATIVE, HAVE YOU HAD ANY DEALINGS WITH TAWC OR UWUA LOCAL 121?

A. Yes. I have worked with UWUA Local 121 many times over the years since I joined the UWUA staff in 2010, and also in connection with negotiations for the National Benefits Agreement. I also conducted UWUA safety training for Local 121 in Chattanooga during about 2006 or 2007.

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. UWUA supports TAWC's request for approval to recover in rates expenses for its forecasted 117 full-time employees. However, UWUA requests that any increase in rates should be conditioned on a requirement for the Company to maintain its full-time workforce at least at the 117-person level. Our position is based on the following:

- TAWC witness Grady Stout has testified that the current staffing level of 101 full-time employees as of December 31, 2023 "didn't, and doesn't, support completion of all necessary day-to-day work. . . ." (Testimony of Grady Stout, at 38: 4-6, docketed on May 1, 2024.) Mr. Stout has also testified that the forecasted staffing level of 117 full-time employees is necessary "to maintain the company's current level of operations while also managing increased organic customer growth" and to support "increasing state and federal regulations [that are] also adding to the company's workload." (Stout Testimony, at 38: 11-14 & 39: 3-5, docketed on May 1, 2024.)
- Mr. Stout has also confirmed that "the growth of our customer base and system growth, new and evolving regulatory requirements, and natural workforce attrition, among other things, have impacted our ability to support completion of all necessary day-to-day work at December 31, 2023, staffing levels." (*See* TAWC Response to UWUA DR 1-19, docketed on July 30, 2024.) Indeed, in recent years TAWC has allowed its hourly workforce to significantly decline to such an extent that the Company is unable to deliver essential services to customers, as I summarize in more detail below.
- Moreover, while TAWC lists nine hourly union positions as "vacant or currently being recruited" in its supplementary response to UWUA DR 1-21, UWUA witness Danny Seebeck notes in his direct testimony that all nine of these vacancies resulted from TAWC's failure to replace employees who have left the Company in recent years due to retirements, resignations, or for other reasons. (*See* TAWC Supplemental Response to UWUA DR 1-21, docketed on August 14, 2024.)
- Notwithstanding the clear need for additional staffing, UWUA is concerned that even if the Commission approves the 117 full-time employee level proposed by the Company,

TAWC may not fully staff its operations at that level. Our concern is based on TAWC's documented history of requesting and receiving authority to recover from customers funding for certain employee levels in previous rate cases, only to fail to hire and maintain the authorized workforce.

- UWUA is also concerned that TAWC is already falling behind in delivering safe and adequate services to customers at current employment levels – especially in the areas of distribution valve maintenance, fire hydrant maintenance, water main and other infrastructure leaks, and new customer service installations – and that the adequacy of customer service will continue to deteriorate if the Company is not required to maintain at least the number of full-time employees authorized by the Commission in TAWC's rates.
- UWUA is especially concerned about evidence that Tennessee-American Water Company has instructed hourly employees not to operate its distribution valves during routine valve inspections since early 2024 – contrary to existing American Water valve inspection procedures and best industry practices – and moreover that TAWC management has informed employees this is necessary to boost the Company's numbers this year for valve inspections. As I explain in more detail below, failure by TAWC to physically operate its valves during inspections means there is no way to know whether the valves TAWC claims to have "inspected" are in fact operable. As a result, the Company's reported data for valve inspections this year are clearly unreliable.
- Chronic understaffing by a water utility such as TAWC can result not only in service delivery deficiencies for customers, but also in serious safety risks for hourly workers, including the stresses and worker fatigue associated with excessive overtime and

onerous workload demands. In particular, the failure of companies to properly inspect and maintain distribution valves and other water infrastructure can impose additional workload demands on employees and lead to unsafe working conditions, such as employees being required to conduct water main repairs under full water pressure whenever improperly maintained distribution valves fail to work.

- To ensure the Company is adequately staffed, UWUA urges that TAWC should be required to include in quarterly reports to the Commission data showing the Company's authorized and actual employment levels. In the event the Company fails to maintain a workforce level consistent with the level authorized in this case – absent a showing of emergencies or unforeseen circumstances – TAWC should be subject to a penalty. For example, this penalty could take the form of a reduction in the equity component of the Company's rates.
- Alternatively, at the very least TAWC should be required to submit semi-annual staffing level reports to the Commission, showing "(1) the actual number of full-time equivalent employees for the previous period, by month, (2) an explanation concerning any differences between the authorized and actual full-time equivalent employees, and (3) a date by which Tennessee American Water Company expects to fill any vacant positions," as the Tennessee Regulatory Authority ordered in the TAWC rate case in Docket No. 10-00189. (TRA Order, April 27, 2012, pages 134-35.)
- TAWC should also be required to properly operate its distribution valves during routine inspections to ensure operability, as well as to periodically report to the Commission on its progress for valve inspections and maintenance of fire hydrants currently out of service.

II. STAFFING LEVELS

Q. PLEASE SUMMARIZE TAWC DATA THAT ARE RELEVANT TO UWUA'S CONCERNS ABOUT COMPANY STAFFING LEVELS.

A. The following chart should assist in reviewing my testimony. This summarizes several key staffing points, based on data provided by TAWC's Response to UWUA DR 1-18:

Full-Time Employee Staffing Level Approved in TRA Docket 10-00189, April 27, 2012	110
TAWC Full-Time Employee Staffing Level, Year End 2012	95
TAWC Full-Time Employee Staffing Level, Year End 2013	101
TAWC Full-Time Employee Staffing Level, Year End 2014	101
TAWC Full-Time Employee Staffing Level, Year End 2015	103
TAWC Full-Time Employee Staffing Level, Year End 2016	104
TAWC Full-Time Employee Staffing Level, Year End 2017	103
TAWC Full-Time Employee Staffing Level, Year End 2018	113
TAWC Full-Time Employee Staffing Level, Year End 2019	107
TAWC Full-Time Employee Staffing Level, Year End 2020	111
TAWC Full-Time Employee Staffing Level, Year End 2021	106
TAWC Full-Time Employee Staffing Level, Year End 2022	102
TAWC Full-Time Employee Staffing Level, Year End 2023	101

(*See* TAWC Response to UWUA DR 1-18, docketed on July 30, 2024.)

As shown by this data, TAWC barely maintained the full complement of employees authorized by the TRA in the 2010 rate case only twice during the past twelve years – despite the authorized level having been financed by customer rates. On average, TAWC maintained only 104 full-time employees a year over this time period – an average of six fewer employees than the 110 employees TAWC asserted it needed in the 2010 rate case to deliver safe and adequate utility services to customers.

I am amending the data set forth in the foregoing paragraph and chart as a result of corrected data presented by Tennessee-American in its "Supplemental Response No. 1-18 to First Set of Discovery Requests of Utility Workers Union of America, AFL-CIO, and UWUA Local 121," which Tennessee-American produced on October 16, 2024.

Q. HAS THE COMPANY'S CUSTOMER WORKLOAD DECREASED DURING THAT TIME PERIOD?

A. No, just the opposite. Mr. Stout has testified that "since 2012 the company has added 11,449 customers organically (meaning new customers connecting to the company's existing footprint)," and that the rate of new customer growth has increased over these years. Mr. Stout also explains that "an increasing customer base brings more infrastructure improvement projects, customer inquiries, meter readings, and water quality testing. Increased state and federal regulations are also adding to the Company's workload." Mr. Stout then concludes that "recognizing the foregoing, a failure to appropriately plan for sufficient staffing needs will impact Company operations." (*See* TAWC Response to UWUA DR 1-20, docketed on July 30, 2024.)

Q. HOW MANY TAWC EMPLOYEES ARE REPRESENTED BY UWUA?

A. According to the Company, UWUA represents 63 hourly employees as of August 14, 2024. This is ten fewer than the 73 hourly union employees the Company reported as recently as of the end of 2020. (Compare TAWC Supplemental Response to UWUA DR 1-21, docketed on August 14, 2024, to TAWC Response to the Consumer Advocate DR 1-20, docketed on June 25, 2024.)

Q. HOW ARE UWUA MEMBERS INVOLVED IN THE OPERATIONS OF THE COMPANY?

A. UWUA members engage in all critical aspects of TAWC's operations, including the production of clean water, ensuring water quality and proper filtration, operating and maintaining distribution facilities, reading meters, replacing customer meters, and performing new service installations. The job classifications UWUA represents at TAWC include process technician (covering water plant operations and water sampling), field service representative, truck driver/utility, heavy equipment operator, laboratory worker, laborer/laborer relief, and master maintenance mechanic.

III. DISTRIBUTION VALVE MAINTENANCE

Q. DOES UWUA HAVE CONCERNS ABOUT TAWC'S PERFORMANCE WITH RESPECT TO INSPECTION AND MAINTENANCE OF DISTRIBUTION VALVES?

A. Yes, very much so.

Q. PLEASE EXPLAIN THE IMPORTANCE OF DISTRIBUTION VALVES IN A WATER UTILITY SYSTEM.

A. Any water utility has to maintain a network of properly functioning distribution valves to control the flow of water throughout the system. Valves are used to isolate parts of the system for maintenance purposes and during emergencies. A proper valve maintenance program helps to ensure easy valve location and proper functioning. If a company fails to maintain its distribution valves through proper inspection and maintenance, problems that should have been quickly contained can spiral out of control, causing more damage and property loss, unnecessarily wasting resources, and inconveniencing more customers through wider service disruptions.

Q. PLEASE ELABORATE.

A. For example, if a water main breaks or needs other maintenance and the closest, relevant valve doesn't operate, then water will continue to flow through the main, potentially causing significant property loss or damage. When this happens, utility workers have to search for other functioning valves that might shut off that water main. If workers can't locate functioning valves, the only other alternative is to try to repair the main while water is still flowing under full pressure. In the first example, more customers will have their water service disrupted because water would be shut off for a larger area while the main is repaired. There are also public safety concerns since more fire hydrants in the area could become inoperable while water main repairs are underway. In the second example, attempting to repair a water main under full pressure is more difficult and far more dangerous for the workers involved. In both cases, the repair will take longer, and customers will have their water service shut off for a longer time period.

Q. WHAT ARE THE POTENTIAL DANGERS FOR UTILITY WORKERS ATTEMPTING TO REPAIR A WATER MAIN UNDER PRESSURE?

A. The primary dangers are that the water main or valve can burst, causing flooding of the excavation pit or a cave-in of the ground surrounding the pit. The pipe burst alone can cause serious injuries or worse for employees working in the excavation, and of course the flooding or a cave-in can kill employees through drowning or suffocation. Danny Seebeck's testimony in this case provides additional information concerning these types of dangers.

Q. HOW IMPORTANT IS THE PROPER INSPECTION OF VALVES TO THE SYSTEM?

A. It's critical. Unless a water utility regularly inspects its valves, there is no way to know whether valves are functioning properly, and which valves may need repair. American Water emphasizes this in its Valve Operation, Inspection and Maintenance Practice document, which provides that "improper or insufficient maintenance may result in valve failure causing extensive damage to infrastructure and/or property loss, extended service interruptions to American Water customers, loss of fire protection, and can lead to costly repairs or replacement activities." (*See* American Water *Valve Operation, Inspection and Maintenance Practice*, page 1, included as Attachment 3 to TAWC's Response to UWUA DR 2-1, docketed on August 27, 2024, and attached for ease of reference hereto as Exhibit UWUA-1 (hereinafter "American Water Valve Operation Manual")).

Q. IS THE PHYSICAL OPERATION OF DISTRIBUTION VALVES AN IMPORTANT PART OF PROPER VALVE INSPECTION?

A. Absolutely, for two reasons. First, regular operation of valves – meaning to close and open them during inspections to make certain they work – is essential to verify that a valve is functioning properly. Second, regular operation is important for proper valve maintenance. As the leading water utility trade group American Water Works Association ("AWWA") emphasizes, "if not consistently operated, the probability of effectively opening and closing an older valve decreases over time." (*Distribution Valves: Selection, Installation, Field Testing, and Maintenance*, page 51, American Water Works Association (3rd Ed. 2016) (attached as Exhibit UWUA-2) (hereinafter "AWWA Distribution Valve Manual").

Q. ARE THERE RECOGNIZED INDUSTRY BEST PRACTICES FOR AN EFFECTIVE VALVE INSPECTION PROGRAM?

Q. Yes. According to AWWA guidelines, there are three key components of proper inspection to make certain a valve is usable. First, the valve must be "locatable," meaning for example that workers are able to locate the correct valve in a reasonable period of time. Second, the valve must be "accessible," meaning employees must be able to access the operating "nut" on the valve. For example, the inspection needs to make certain the valve hasn't been paved over in the street, that the valve box isn't cluttered with debris or concrete, or that the valve hasn't become inaccessible for some other reason. Third – and critically – the valve must be "operable," meaning that it will properly open and close. As the AWWA has emphasized, "once the correct valve is found and the operating nut is accessible, you must be able to close and open the valve. . . . If any one (or more) of these [three] critical physical attributes is not achieved, the valve cannot be used to turn on or turn off water. Any failure (locatability, accessibility, and operability of an individual valve) will prevent the valve from fulfilling its purpose." (AWWA Distribution Valve Manual, page 52, attached as Exhibit UWUA-2.)

Q. DOES UWUA HAVE CONCERNS ABOUT TAWC'S VALVE INSPECTION PROGRAM?

A. Yes. According to Grady Stout's testimony, TAWC's current valve operation and inspection goal "is to inspect all valves 16 inches and larger annually and to inspect all valves smaller than 16 inches every 6 years." (TAWC Response to UWUA DR 1-1(b), docketed on July 30, 2024.) This compares unfavorably to AWWA guidelines for smaller valve inspections, which recommend a three to five-year inspection cycle. (AWWA Distribution Valve Manual, page 55, attached as Exhibit UWUA-2.)

Q. DOES UWUA HAVE OTHER CONCERNS?

A. Yes. We are especially concerned that TAWC is failing to comply with American Water's own policy for routine valve inspections, primarily because of a lack of adequate staff. Most concerning, we believe the Company is currently failing to inspect many if not most of its valves properly at all because management recently instructed hourly employees not to physically operate valves during inspections.

Q. PLEASE EXPLAIN.

A. According to Danny Seebeck's direct testimony, earlier this year TAWC management informed hourly workers in the Distribution Department that during routine valve inspections, employees should verify only that the valve can be located and that the employee can get a "key" on the valve nut. (A key is a specialized tool used to operate the valve.) If employees are able to get a key on the valve and the valve isn't obviously broken, they should mark the valve as having passed inspection without necessarily operating it. TAWC has also instructed employees this is necessary in order to get the numbers up for completed valve inspections.

Q. WOULD FAILURE TO OPERATE VALVES DURING INSPECTIONS BE CONSISTENT WITH AMERICAN WATER COMPANY'S POLICIES?

A. No. American Water's Valve Operation Manual – provided by TAWC in response to UWUA DR 2-1 – clearly instructs valve operators to "operate valves through a full cycle, counting turns," and that this should be done during "every inspection." (Exhibit UWUA-1, American Water Valve Operation Manual, page 1.)

Q. WOULD TAWC'S PRACTICE OF NOT OPERATING VALVES DURING INSPECTIONS BE CONSISTENT WITH YOUR EXPERIENCE AT OTHER AMERICAN WATER SUBSIDIARIES?

A. Unfortunately, yes. After American Water purchased the New York American Water location in 1999, management instructed me and other hourly workers to no longer operate valves 12 inches and larger for the full number of turns necessary to cycle the valves off and on. Instead, we were instructed that for these valves, we were just to make certain we could get a key on the valve nut, turn the valve a couple of times, and then move on to the next valve. Management informed us this was necessary because it took too long to fully close and open the valves. American Water followed this practice for the entire time I worked at New York American Water until I left in 2010. Under the previous owner, the standard operating procedure was that workers were to fully close and open every valve inspected for one full cycle. Typically, it takes 39 turns to fully operate a 12-inch valve, and up to 215 or more for larger valves.

Q. HAVE YOU BECOME AWARE OF AMERICAN WATER NOT FULLY OPERATING VALVES DURING VALVE INSPECTIONS AT OTHER LOCATIONS?

A. Yes. I have been informed by other UWUA local unions assigned to me over the years that American Water has regularly instructed hourly workers not to fully operate valves in order to increase the company's numbers for completing valve inspections.

Q. DOES OTHER EVIDENCE SHOW THAT TENNESSEE AMERICAN WATER HAS IN FACT MADE THIS CHANGE IN INSTRUCTIONS FOR VALVE INSPECTIONS DURING 2024?

A. Yes. In response to UWUA DR 1-2, TAWC provided an Excel spreadsheet labeled TAW_R_UWUADR1_002_0703024, docketed on July 30, 2024. The worksheet labeled

"Inspections" on this spreadsheet shows a substantial increase in the numbers of "turns" recorded as zero or in low single digits on "inspected" valves.

Q. PLEASE EXPLAIN.

A. Starting during January and especially after February 1, 2024, the number of "turns" recorded between zero and eight by TAWC for valve inspections substantially increased. Depending on the size and type of valve, it typically takes a minimum of eight and up to 215 or more turns to operate one complete cycle on a valve. According to American Water policy, for example, the typical number of turns required to cycle off the smallest 2-inch valve is eight. For 48-inch valves and larger, one cycle typically requires between 149 and 215 turns. Valves between those sizes typically require 11 turns (for 2.5-inch valves) to 136 turns (for 42-inch valves). (*See* TAWC Response to UWUA DR 2-1, 37th page of the Response, titled "Typical Valve Number of Turn(s)," docketed on August 27, 2024.)

Q. WHAT DOES THE DATA TAWC PROVIDED IN RESPONSE TO UWUA DR 1-2 SHOW?

A. The information provided by TAWC shows that the number of turns exercised by employees on valves has substantially decreased during 2024 inspections, including numerous turns at zero or otherwise recorded in single digits. As American Water's practice manual shows, eight turns would be the minimum expected to operate a small 2-inch valve, and larger valves progressively require 11 turns for two-and-a-half-inch valves and up to 215 turns for the largest valves. (*See* TAWC Response to UWUA DR 2-1, 37th page of the Response, titled "Typical Valve Number of Turn(s)," docketed on August 27, 2024.) Almost none of the valve inspections that TAWC has recorded as fewer than 11 turns for 2024 can be considered a proper valve inspection. (*See* TAWC Response to UWUA DR

1-2, spreadsheet labeled TAW_R_UWUADR1_002_0703024, docketed on July 30, 2024.) Even for "inspections" indicating the technician made eight turns on a valve, most of these were for valves larger than two inches. This clearly supports Danny Seebeck's testimony that hourly employees in the Distribution Department were instructed earlier this year not to physically operate valves during routine inspections in order to boost the numbers of recorded inspections.

Q. DOES OTHER INFORMATION IN TAWC'S DISCLOSURES CONFIRM THIS?

A. Yes. Reviewing the notes in column O in that spreadsheet, you can see that employees have routinely reported for example, "Did not operate, just made sure valve was open and accessible." (*See, e.g.,* TAW_R_UWUADR1_002_0703024, docketed on July 30, 2024, worksheet labeled "Inspections," column O, line 567, and numerous similar entries.) Just by way of example, that particular entry shows only one turn for a 16-inch valve, which normally would need to be turned 49 times to ensure operability – and yet TAWC has recorded this as a completed inspection.

Q. DO YOU HAVE ANY OTHER OBSERVATIONS CONCERNING THIS DATA?

A. Yes. In other cases during 2024 when employees have in fact completed a more typical number of turns on valves, the employee gave a reason, such as "operated for a main break." (*See* TAW_R_UWUADR1_002_0703024, docketed on July 30, 2024, "Inspections" worksheet, column O, line 41.) This suggests that employees have been instructed not to operate valves during inspections unless they need to close the valve for some other reason such as a main break.

Q. IS THIS PRACTICE OF NOT OPERATING VALVES DURING ROUTINE INSPECTIONS CONSISTENT WITH BEST INDUSTRY PRACTICE OR AMERICAN WATER'S POLICIES?

A. Clearly not. As I have testified, AWWA guidelines emphasize that proper inspection of any valve must include operation of the valve to make certain it is working. The AWWA Distribution Valve Manual clearly states that valve "condition assessment includes locating, accessing, *and operating the valve*. . . ." (AWWA Distribution Valve Manual, page 54 (emphasis supplied); attached as Exhibit UWUA-2.) And as I have also testified, failure to operate valves during inspections is also contrary to American Water's policy, which instructs employees to operate valves one full cycle during every inspection.

Q. GIVEN THESE CONSIDERATIONS, DO YOU BELIEVE TAWC DATA REPORTING THAT VALVES HAVE BEEN INSPECTED DURING 2024 ARE RELIABLE?

A. Clearly not. As I have testified, the Company's own data establish that TAWC has not properly inspected numerous valves during 2024 that it claims it has inspected. By my estimate – and giving the Company the benefit of the doubt in close cases – at least 55% of inspections conducted since February 2024 have not inspected these valves for operability. When TAWC fails to physically operate distribution valves during inspections, there is no way to know whether valves the Company claims to have inspected will in fact close and open.

Q. DOES UWUA HAVE OTHER CONCERNS ABOUT TAWC'S VALVE MAINTENANCE PROGRAM?

A. Yes. Even assuming TAWC is conducting proper inspections of its valves at this time, the Company's data show that it is falling behind its own inspection targets.

Q. PLEASE EXPLAIN.

A. TAWC's supplemental and original responses to UWUA DR 1-1 provide data on total valves in the TAWC system, the Company's target goals for valve inspections from 2020 through 2024, and inspections completed during those years. According to the spreadsheet labeled TAW_R_UWUADR1_001_073024, docketed on July 30, 2024, the Company currently has 12,455 valves in its system: 312 large valves (16 inches and greater) and 12,143 smaller valves (smaller than sixteen inches). According to the "Response B" worksheet on this same spreadsheet:

- For 2020, TAWC reports that it had a target goal of inspecting 4,536 valves (for the Chattanooga service area only), and that it completed 2,241 inspections that year. This works out to a completion rate of less than 50%.
- For 2021, TAWC reports that it planned to inspect 4,079 valves (again, for the Chattanooga service area only), and that it completed 1,049 for a completion rate of only 26%.
- For 2022, TAWC claims that it had no target number of valve inspections, but that it completed 1,368 inspections that year (for the Chattanooga service area only). Assuming the Company expected to conduct a similar number of valve inspections as in 2021, that works out to a completion rate of only 34%.
- For 2023, TAWC reports that it planned to inspect 2,614 valves for the entire TAWC system, and that it completed only 39% – or about 1,019 valve inspections completed.

(*See, also,* TAWC Supplemental Response to UWUA DR 1-1, docketed on August 14, 2024.)

- Relying solely on 2023 data – the most recent full-year data available – it would take more than twelve years for TAWC to inspect all valves in its system at its 2023 inspection rate. This is more than twice the time TAWC says it hopes to inspect all valves in its system.

Q. WHAT ABOUT VALVE INSPECTIONS FOR 2024?

A. The Company claims it has targeted 2,535 valves in the entire TAWC system for inspection during 2024 and that it completed 76% of these as of June 30, 2024. (*See* TAWC Supplemental Response to UWUA DR 1-1, docketed on August 14, 2024; TAW_R_UWUADR1_001_073024, docketed on July 30, 2024, sheet labeled "Response B.") On the surface this might seem like an improvement, but this fails to take into account the evidence that TAWC has substantially degraded its "inspections" during 2024 – as shown by its own data – and that the Company has done so to inflate its numbers for valve inspections. Considering the stark difference between TAWC's claimed completion rate so far during 2024 and its remarkably low completion rates during each of the previous four years, it seems likely the increase in TAWC's purported 2024 completion rate is a result of the Company having substantially degraded its inspections this year by failing to operate valves during routine inspections.

Q. DOES UWUA HAVE CONCERNS REGARDING TAWC'S VALVE REPAIRS?

A. Yes. In the two spreadsheets attached to TAWC's responses to UWUA DR 1-1 and 1-2, the Company reports it has opened 745 work orders between January 1, 2020 and June 30, 2024 for valves that are broken, leaking, or otherwise in need of repair or investigation.

Over those four-and-a-half years, TAWC reports completing only 99 of these work orders, and that 646 remain uncompleted. This represents a completion rate for valve repairs or investigations of only 13%. This is an exceptionally low percentage in my experience and is most likely a result of TAWC under-staffing hourly employees. (*See* TAW_R_UWUADR1_002_073024 (worksheet labeled “Open WO Maint_Repair”) and TAW_R_UWUADR1_003_073024 (all work orders for which there is no “date completed” in Column E), both docketed on July 30, 2024.)

Q. DOES UWUA HAVE OTHER CONCERNS ABOUT TAWC’S VALVE MAINTENANCE?

A. Yes. If you carefully review TAW_R_UWUADR1_003_073024, docketed on July 30, 2024, some of these open work orders for valve maintenance date back as far as January 2020. In fact, there were 208 open work orders created during 2020, 124 during 2021, 128 during 2022, and 86 during 2023. In addition, if you review the notes in column M, you can see numerous open work orders for broken or inaccessible valves in which TAWC employees have noted “valve spins free,” “valve stuck,” “valve is missing operating nut,” “cannot locate valve, been missing for years,” “valve box is full of concrete,” and similar issues making these valves inoperable or inaccessible.

IV. FIRE HYDRANT MAINTENANCE

Q. DOES UWUA HAVE CONCERNS REGARDING TAWC’S PERFORMANCE FOR FIRE HYDRANT MAINTENANCE?

A. Yes. In TAWC’s response to UWUA DR 1-6 and the attached spreadsheet, the Company reported 200 fire hydrants out of service at some time since the beginning of 2020, including 125 active or otherwise non-retired hydrants and 75 that have since been retired.

The Company reported that 31 of these non-retired hydrants were still out of service as of June 30, 2024. Of the 94 remaining non-retired hydrants that were out of service for some period of time starting in 2020, 20 of these were out of service for more than three months – including two for more than a year. The Company also reports an additional 25 hydrants that are currently listed as retired but were out of service for more than three months at some time since January 1, 2020. (*See* TAWC Response to UWUA DR 1-6, TAW_R_UWUADR1_006_073024, worksheet entitled "OOS" (sorted by status, dates out of service, and dates back in service), docketed on July 30, 2024.)

Q. HAS TAWC SUPPLEMENTED ITS DISCLOSURES CONCERNING OUT-OF-SERVICE FIRE HYDRANTS?

A. Yes, but only in part. In its response to UWUA DR 2-8, the Company reports that 11 of the 31 hydrants it had previously reported as out of service were listed as such "due to incomplete finalization of the out of service note," and that these hydrants are now back in service or retired. However, TAWC has provided no updated information for how long these 11 hydrants were out of service. (*See* TAWC Response to UWUA DR 2-8, docketed on August 27, 2024.)

Q. WHAT IS UWUA'S CONCERN FOR HYDRANTS OUT OF SERVICE FOR ANY EXTENDED PERIOD OF TIME?

A. Obviously, any hydrant that is out of service is not available during a fire emergency. In our view, water utility companies should consider the repair of out-of-service fire hydrants one of its highest priorities so that no active hydrant is disabled for any extended period of time. Even though TAWC argues in response to UWUA DR 2-8 that public safety has not been impacted by these out-of-service hydrants because "nearby hydrants are available and the fire department knows which hydrants to use in case of emergency," the fact remains that any hydrant that is out of service means the closest hydrant for some number of TAWC customers is not available for fire emergencies.

Q. DOES TAWC HAVE A BACKLOG OF OPEN WORK ORDERS FOR FIRE HYDRANTS?

A. Yes. According to the Company's response to UWUA DR 1-7 and the attached spreadsheet (TAW_R_UWUADR1_007_073024), docketed on July 30, 2024, TAWC has 144 open work orders for hydrant repairs, hydrants leaking, or hydrant investigation. Eighty-six of these work orders have been open since 2023 and earlier, with the oldest dating back to March 27, 2018.

V. WATER MAINS AND OTHER INFRASTRUCTURE LEAK REPAIRS

Q. DOES UWUA HAVE CONCERNS REGARDING TAWC PERFORMANCE FOR WATER MAINS AND OTHER INFRASTRUCTURE LEAKS?

A. Yes. According to the spreadsheet the Company provided in response to UWUA DR 1-15, docketed on July 30, 2024, TAWC reported 395 open work orders for water infrastructure leaks – other than in valves, hydrants, or meters – which were opened between January 7, 2020, and June 28, 2024. More than 280 of these open work orders were created before March 2024. In addition, the Company's spreadsheet categorizes 258 of all open work orders as either emergencies or high priority, and the job descriptions include 18 water main break repairs or main investigations and 124 service line repairs or service investigations. While it is normal for a water utility to have some backlog of open work orders for water infrastructure leaks, in our view having any sizable number of open work orders older than four months indicates a lack of available staff to promptly address these issues. (*See* TAW_R_UWUADR1_015_073024_Response, docketed on July 30, 2024.)

Q. HAS TAWC SUPPLEMENTED ITS DISCLOSURES CONCERNING WATER INFRASTRUCTURE LEAK REPAIRS?

A. Yes, but again only in part. In its response to UWUA DR 2-10, docketed on August 27, 2024, the Company identified 11 of these open work orders as having been duplicates or otherwise recently closed, but TAWC has not updated or identified any other duplicates or closed work orders in its spreadsheet.

VI. NEW CUSTOMER SERVICE INSTALLATIONS

Q. DOES UWUA HAVE CONCERNS REGARDING TAWC'S PERFORMANCE FOR NEW CUSTOMER INSTALLATIONS?

A. Yes. According to the spreadsheet attached to TAWC's response to UWUA DR 1-17, the Company reported 158 new service request work orders that are incomplete as of June 30, 2024. As the Company also explained in its response to UWUA DR 2-11, docketed on August 27, 2024, a new service work order is opened only *after* the developer or other new customer has informed TAWC the property is ready for the service installation. The Company's data show that 106 of these 158 incomplete work orders were opened prior to 2024, or fully 67%. The oldest of these incomplete work orders dates back to February 25, 2020. This backlog of incomplete work orders for new services for extended periods of time suggests the Company lacks sufficient staff to meet new customer growth in a timely manner. (*See* TAW_R_UWUADR1_017, worksheet entitled "All Incomplete NSI WO" (sorted by date), docketed on July 30, 2024.)

Q. DOES OTHER INFORMATION DISCLOSED BY TAWC SUGGEST UNDERSTAFFING IN THIS AREA?

A. Yes. According to TAWC's response to UWUA DR 2-11, docketed on August 27, 2024, during 2023 and 2024 the average customer wait time for new service installations – meaning the average number of days between the opening of a new service work order and work order completion – was as follows:

Year	Meter Size						
	5/8"	1"	1-1/2"	2"	4"	6"	No Size
2023	16	10	17	13	22	4	35
2024	20	1	27	51	36	172	19

(TAWC Response to UWUA DR 2-11, docketed on August 27, 2024.)

In other words, so far during 2024 it took TAWC an average of nearly four weeks to complete customer requests for new service installations for one-and-one-half inch meters, and even longer for larger meters. This includes an average of 51 days to install two-inch meters, 36 days to install four-inch meters, and a remarkable 172 days to install six-inch meters. In our view, these customer wait times also suggest that inadequate staffing has impeded the Company's ability to meet new customer growth.

VII. UWUA RECOMMENDATIONS

Q. WHAT DOES UWUA RECOMMEND WITH RESPECT TO TAWC STAFFING LEVELS?

A. UWUA agrees that TAWC needs at least 117 full-time employees to deliver essential services to TAWC customers. Based on the Company's chronic understaffing over recent years, however, we are concerned that TAWC may never fully staff its operations at that level – even if the Commission grants the Company's request to fund 117 full-time employees in rates. We therefore recommend that the Commission should condition any rate increase granted to TAWC by requiring the Company to in fact staff its operations at least for 117 full-time employees and then to maintain that authorized staff level. We believe this is necessary to at least begin to meet TAWC's minimum staffing needs and to make certain customers will receive the safe and adequate utility services they are paying for in their increased water rates.

Q. HOW MIGHT THIS CONDITION BE ENFORCED?

A. UWUA recommends that TAWC be required to submit quarterly reports to the Commission stating its authorized and actual employment levels. In the event the Company fails to maintain the workforce consistent with the authorized level – absent a showing of emergencies or other unforeseen circumstances – TAWC should be subject to a penalty. This could include, for example, a reduction in the return on equity component in its rates. This penalty could continue until the staffing shortage is corrected.

Q. DOES UWUA HAVE ANY ALTERNATIVE SUGGESTIONS FOR STAFFING LEVELS?

A. Yes. At the very least, we urge the Commission to impose on TAWC the same requirement adopted by the Tennessee Regulatory Authority in Docket No. 10-00189. In that case, TRA ordered the Company to file staffing level reports twice each year, showing "(1) the actual number of full-time equivalent employees for the previous period, by month, (2) an explanation concerning any differences between the authorized and actual full-time equivalent employees, and (3) a date by which Tennessee American Water Company expects to fill any vacant positions."

Q. DOES UWUA HAVE ANY OTHER RECOMMENDATIONS TO HELP ENSURE TAWC MEETS SERVICE OBLIGATIONS TO CUSTOMERS?

A. Yes. We recommend that TAWC should be required to properly operate its distribution valves during routine inspections to ensure operability, and also to report on its progress for valve inspections, maintenance, and repair of faulty valves on a quarterly basis. This should not pose any significant burden on the Company since the full operation of distribution valves during inspections is already standard operating procedure under American Water's long-standing policies. Moreover, TAWC is already collecting the information it would need to prepare these quarterly reports for the Commission. Similarly, we also recommend that TAWC should be required to submit quarterly reports showing the number of fire hydrants currently out of service and the Company's progress in repairing any faulty hydrants. In our view, TAWC customers should have a right to know which fire hydrants are disabled in their neighborhoods.

Q. DOES THIS COMPLETE YOUR TESTIMONY?

A. Yes, it does.

BEFORE THE TENNESSEE PUBLIC UTILITY COMMISSION
NASHVILLE, TENNESSEE

IN RE:	)	
PETITION OF TENNESSEE-AMERICAN WATER TO MODIFY TARRIFF, CHANGE AND INCREASE CHARGES, FEES, AND RATES, AND FOR APPROVAL OF GENERAL RATE INCREASE	)	**DOCKET NO. 24-00032** **FILED: September 17, 2024**

VERIFICATION

STATE OF New York }
}
COUNTY OF Nassau }

I, SHAWN GARVEY, being duly sworn, state that I am authorized to testify on behalf of the Utility Workers Union of America, AFL-CIO ("UWUA"), and UWUA Local 121 in the above-referenced docket, that if present before the Commission and duly sworn, my testimony would be as set forth in my pre-filed testimony in this matter, and that my testimony herein is true and correct to the best of my knowledge, information, and belief.

SHAWN GARVEY

Sworn to and subscribed before me
this 18th day of October, 2024.

Tanaiah McPhail
Notary Public

My Commission Expires: May 1, 2028

Tanaiah McPhail
Notary Public State of New York
01MC6024165
Qualified in Queens County
Commission Expires May 1, 2028

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing *Revised Direct Testimony of Shawn Garvey Proffered by Intervenors UWUA and UWUA, Local 121* was served via electronic mail, upon:

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EXHIBIT UWUA-1

American Water Valve Operation, Inspection and Maintenance Practice Manual

AMERICAN WATER

Valve Operation, Inspection and Maintenance Practice

Practice Number: PRA-OPS09

Applicability: American Water Works Company, Inc., and its controlled subsidiaries as described below (together "American Water" or the "Company")

Effective Date: August 25, 2020

Document Owner: Operations Excellence

Document Approver: Operations Excellence - Director

Executive Sponsor: Operations Excellence - SVP

I. PURPOSE

The Valve Operation, Inspection and Maintenance Practice establishes a consistent program to effectively inspect and maintain valves within Company Transmission and Distribution (T&D) systems in order to ensure the operational integrity of these assets and to optimize the utilization of personnel resources.

II. SUMMARY

Effective valve maintenance is important to local operations as a pro-active program to increase valve reliability, reduce valve failure and extend valve life. Improper or insufficient maintenance may result in valve failure causing extensive damage to infrastructure and/or property loss, extended service interruptions to American Water customers, loss of fire protection, and can lead to costly repairs or replacement activities.

III. KEY ACTIVITIES

Area/ Function	Key Activities (S=Follow Safety Requirements)	Responsibility	Frequency/ Trigger	System	Links
T&D	Locate Valve Requiring Inspection	Valve Operator	Per Schedule	MapCall	Search
T&D	Physically Locate Valve (S)	Valve Operator	Every Inspection		
T&D	Ensure valve operation will not cause damage to the distribution system	Valve Operator	Every Inspection	MapCall	
T&D	Clean out the valve box if necessary (S)	Valve Operator	Every Inspection		
T&D	Insert valve key onto valve nut, wheel, or tee head (S)	Valve Operator	Every Inspection		
T&D	Operate valves through a full cycle, counting turns, and leave in normal operating position (S)	Valve Operator	Every Inspection		
T&D	Record Date and Time of Inspection	Valve Operator	Every Inspection	MapCall	
T&D	Record Operated Y/N	Valve Operator	Every Inspection	MapCall	

T&D	Record Position Found	Valve Operator	Every Inspection	MapCall	
T&D	Record Position Left	Valve Operator	Every Inspection	MapCall	
T&D	Record Number of Turns	Valve Operator	Every Inspection	MapCall	
T&D	Update valve attribute data to make corrections or additions	Valve Operator	As Needed	MapCall	
T&D	Create Repair Orders if needed	Valve Operator	As Needed	MapCall	
T&D	Monitor Progress	Supervisor	Monthly	MapCall	Report
T&D	Frequency Guidelines	Supervisor	Reference		

Valve Operator – Is not an official AW position but refers to the individual performing the activity. The individual can be referred to as a Field Worker as well. This activity can be performed by internal or contracted resources.

IV. WAIVERS

Any deviation, waiver or exception from this practice requires the prior written approval of the Document Approver of this practice. If the deviation, waiver or exception conflicts with any policy, approval from the Executive Sponsor of that policy is required. The Document Owner, or her or his designee, is responsible for tracking all requests for waivers, decisions with respect to those requests, and maintaining documentation related to each waiver request. Each individual receiving a waiver is responsible for retaining documentation of the waiver that was granted.

V. DEFINITIONS

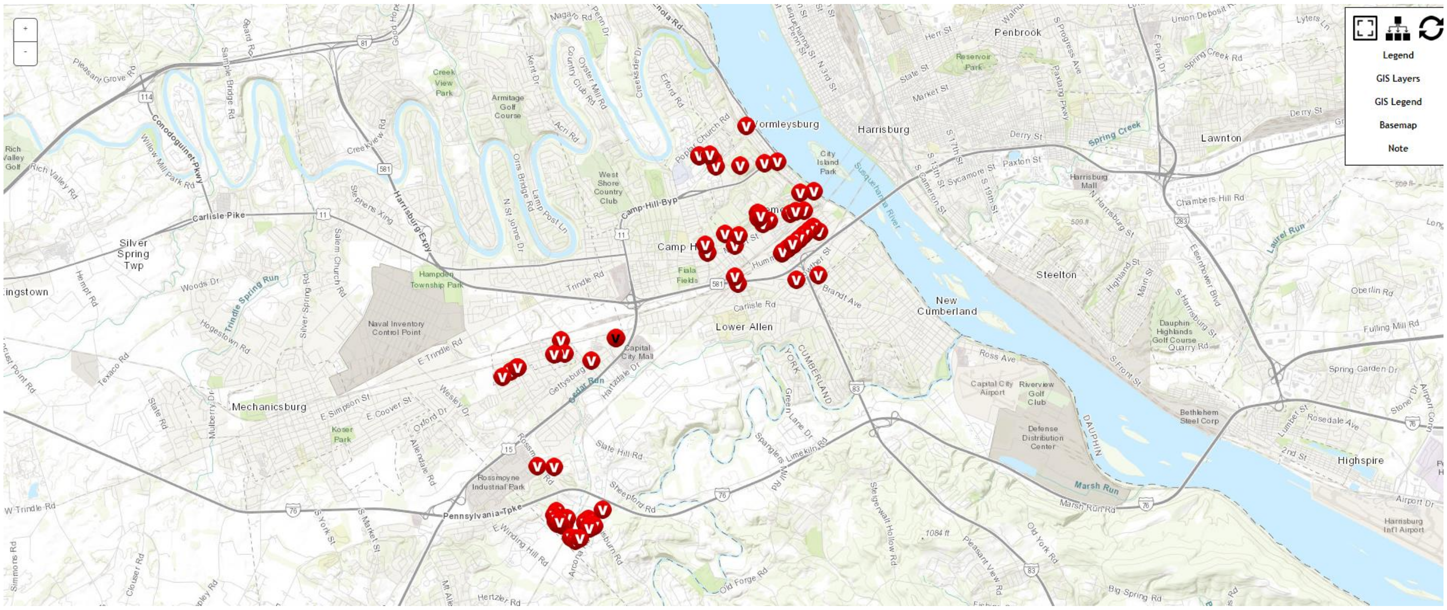
VI. NON-COMPLIANCE

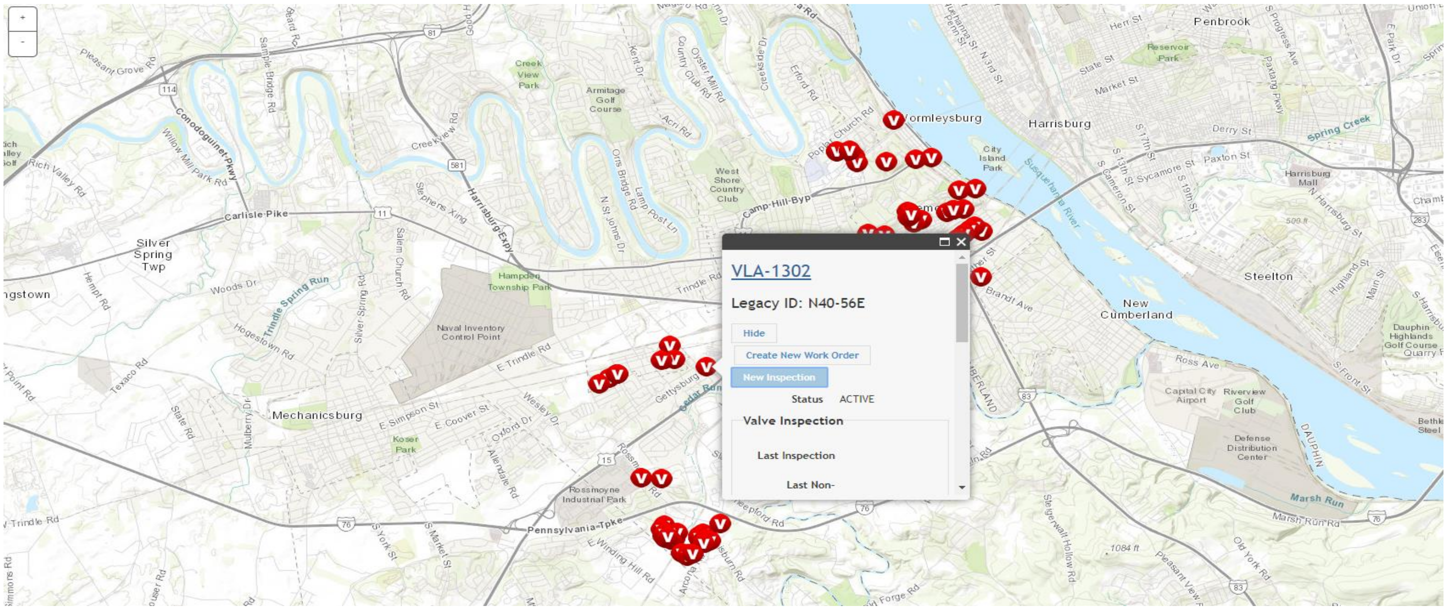
Any employee who violates or circumvents the practice may be subject to disciplinary action up to and including termination.

VII. CONTACT INFORMATION; MONITORING

Contact the Operations Excellence Director for questions and compliance monitoring of this practice.

Locate Valve requiring Inspection and Maintenance in MapCall



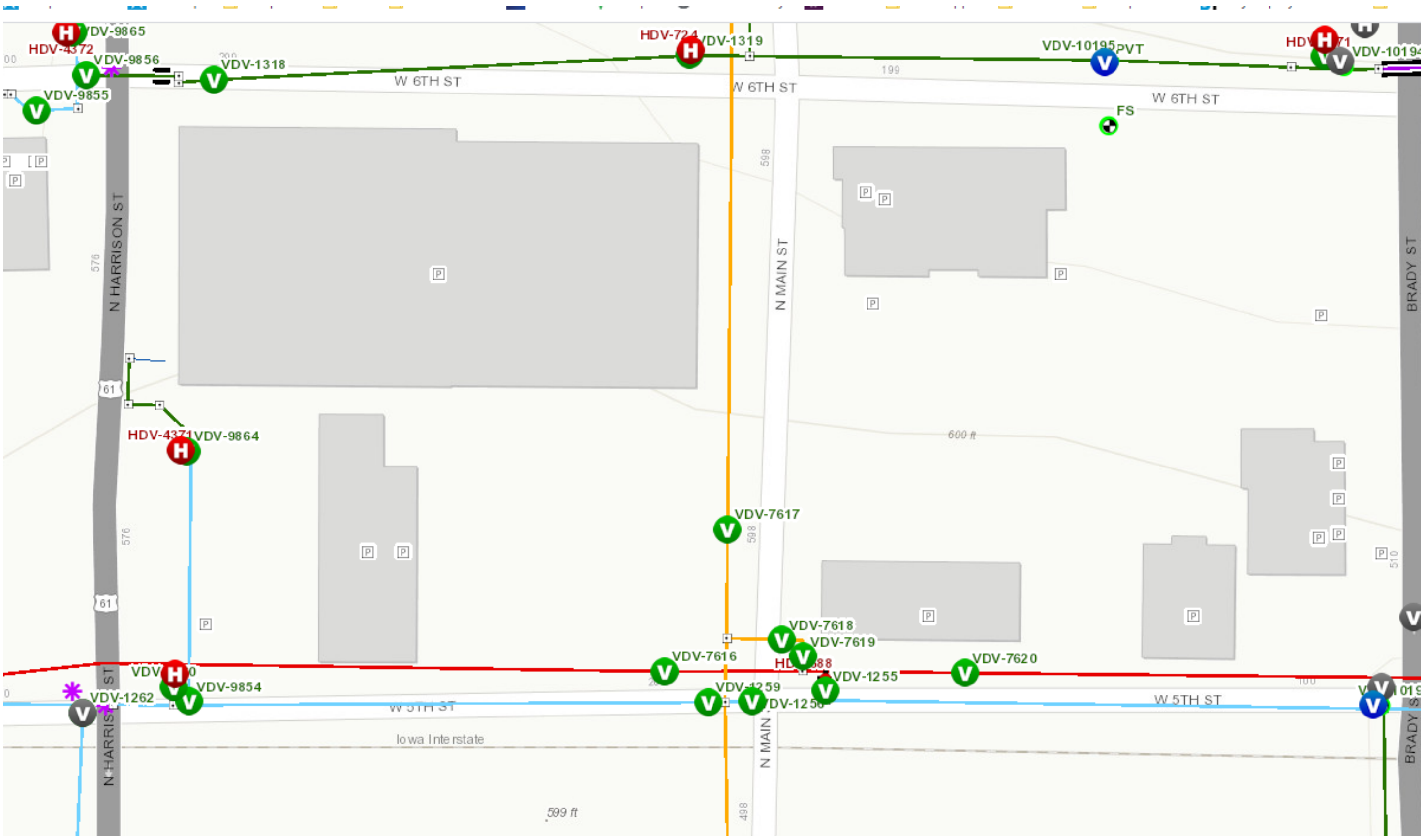


The primary step to employ is to refer to the distribution mapped grid system to begin systematically routing valves by hydraulic flow and adding a route and stop to each valve.

Physically Locate Valve (S)

CAUTION: If system monitors (leak detection) are located in valve boxes, exercise care in removing the valve box lid because instrumentation and wiring may be attached to the lid.

Ensure valve operation will not cause damage to the distribution system by identifying critical areas and taking extra precautions (it is important that valve inspections are coordinated with the Production Department)

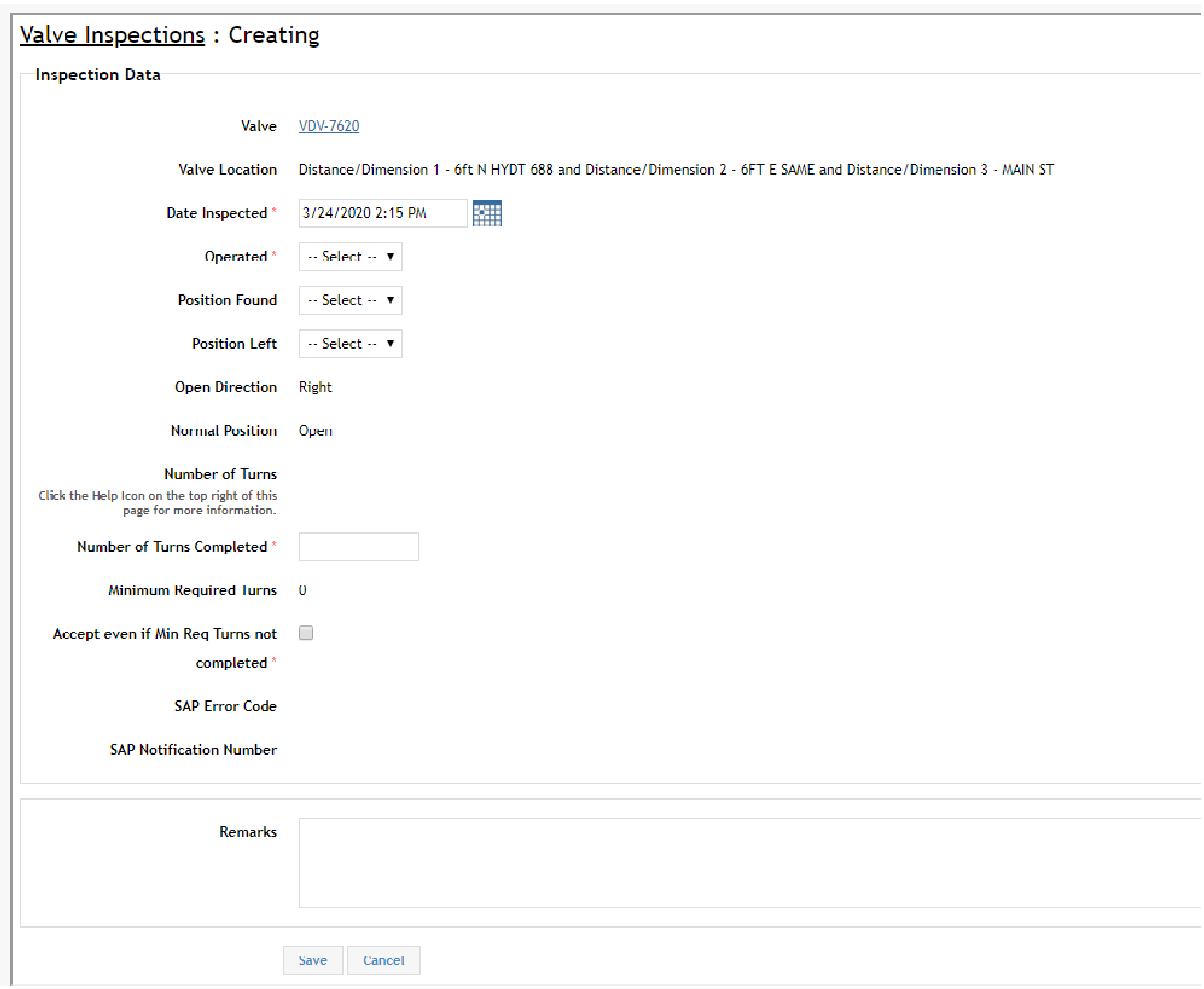


- ❖ Critical notes should be added to valves (where needed) advising to proceed with caution and requiring tight communication & coordination with production operators/supervisors
  - ✦ Ensure critical notes are viewed and observed/followed for each asset

Typical Valve Number of Turns (S)

Valve Size	Typical number of turns for Valver Type and Size																
	2"	2.5"	3"	4"	6"	8"	10"	12"	14"	16"	18"	20"	24"	30"	36"	42"	48"	54"
Gate Valve	8	11	11	14	21	27	33	39	44	49	57	63	75	93	111	131	149	149
Tapping Valve	8	11	11	14	21	27	33	39	44	49	57	63	75	93	111	131	149	149
Butterfly Valve	NA	NA	NA	32	32	32	32	32	30	30	40	40	40	44	44	136	215	
Ball Valve	0.25	0.25	0.25	0.25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Telescopic																		
Pressure Reducing	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Check Valve	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Record Valve Performance



Valve Inspections : Creating

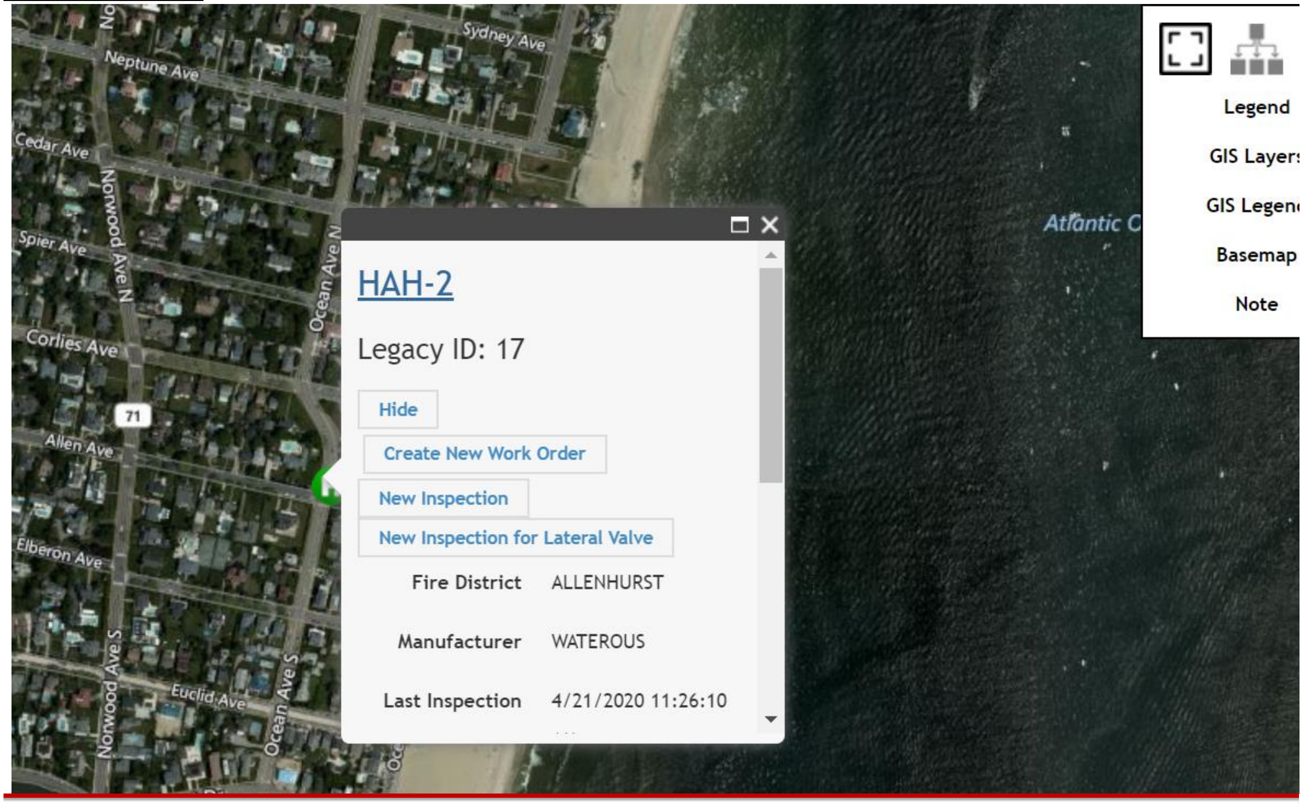
Inspection Data

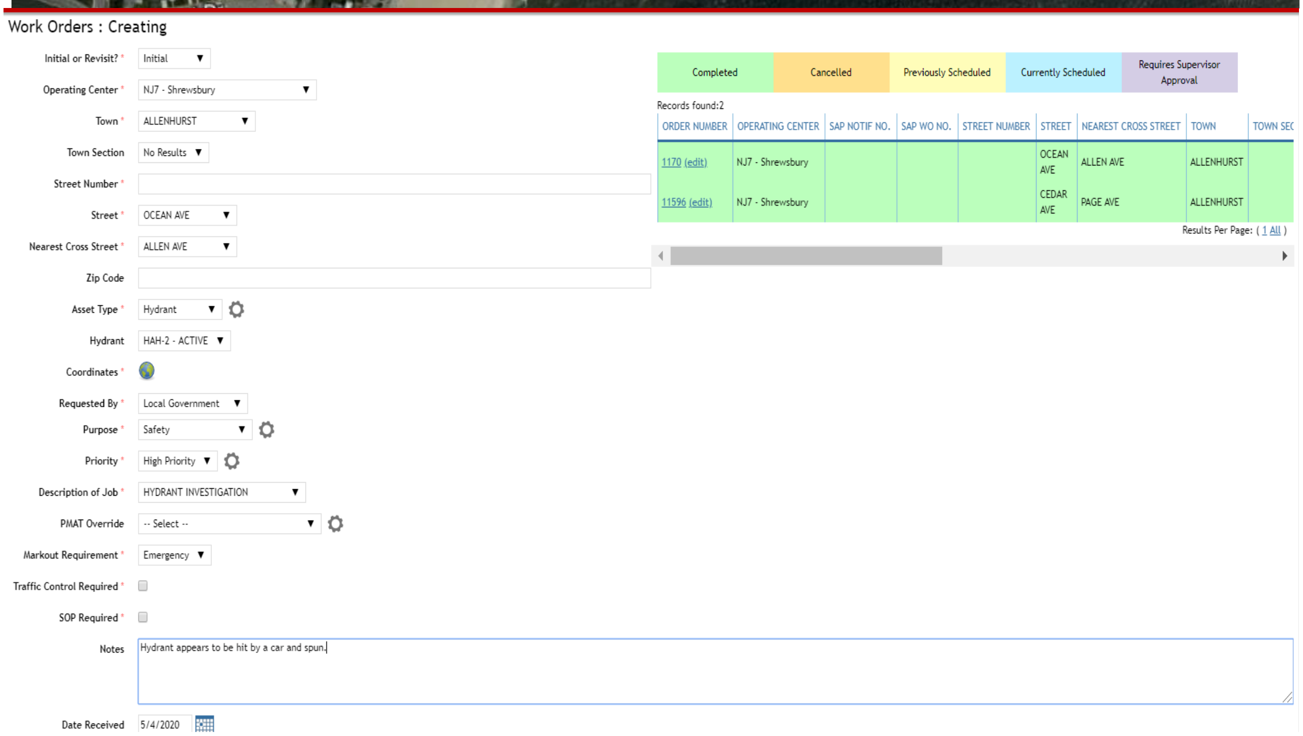
Valve	VDV-7620
Valve Location	Distance/Dimension 1 - 6ft N HYDT 688 and Distance/Dimension 2 - 6FT E SAME and Distance/Dimension 3 - MAIN ST
Date Inspected *	3/24/2020 2:15 PM
Operated *	-- Select --
Position Found	-- Select --
Position Left	-- Select --
Open Direction	Right
Normal Position	Open
Number of Turns Click the Help Icon on the top right of this page for more information.	
Number of Turns Completed *	
Minimum Required Turns	0
Accept even if Min Req Turns not completed *	☐
SAP Error Code	
SAP Notification Number	

Remarks

Save Cancel

Repair Order




Work Orders : Creating

Initial or Revisit? * Initial
Operating Center * NJ7 - Shrewsbury
Town * ALLENHURST
Town Section No Results
Street Number *
Street * OCEAN AVE
Nearest Cross Street * ALLEN AVE
Zip Code
Asset Type * Hydrant
Hydrant HAH-2 - ACTIVE
Coordinates *
Requested By * Local Government
Purpose * Safety
Priority * High Priority
Description of Job * HYDRANT INVESTIGATION
PMAT Override -- Select --
Markout Requirement * Emergency
Traffic Control Required *
SOP Required *
Notes Hydrant appears to be hit by a car and spun.
Date Received 5/4/2020

Completed | Cancelled | Previously Scheduled | Currently Scheduled | Requires Supervisor Approval

Records found:2

ORDER NUMBER	OPERATING CENTER	SAP NOTIF NO.	SAP WO NO.	STREET NUMBER	STREET	NEAREST CROSS STREET	TOWN	TOWN SEC
1170 (edit)	NJ7 - Shrewsbury				OCEAN AVE	ALLEN AVE	ALLENHURST	
11596 (edit)	NJ7 - Shrewsbury				CEDAR AVE	PAGE AVE	ALLENHURST	

Results Per Page: (1 All)

Monitor Progress

Valves Due Inspections

OPERATING CENTER	TOWN	COUNT
IA2	BETTENDORF	3081
IA2	BLUE GRASS	1
IA2	DAVENPORT	19
IA2	LE CLAIRE	637
IA2	PANORAMA PARK	14
IA2	RIVERDALE	79

Frequency Guidelines

Activity/ Task	Criticality	Frequency		Work Load		Specialty Tools/Skills	Comments
		Trigger	Value	Hours	#Staff		
Inspect and Operate distribution system transmission valves	High	Time	Annually	1	1-2	Valve key/operator	Increase reliability, reduce failure, extend valve life
	Medium	Time	Every 2 yrs.	1	1-2	Valve key/operator	Same
	Low	Time	Every 5 yrs.	1	1-2	Valve key/operator	Same
Locate distribution system valves	High	Time	Annually	0.25	1	Map, magnetic locator, valve sketch, valve box cleaners	Ensure accessibility
	Medium	Time	Every 2 yrs.	0.25	1	Map, magnetic locator, valve sketch, valve box cleaners	Ensure accessibility
	Low	Time	Every 5 yrs.	0.25	1	Map, magnetic locator, valve sketch, valve box cleaners	Ensure accessibility
	Low	Activity (new paving, const., etc.)	Within 1 yr. of activity	0.25	1	Map, magnetic locator, valve sketch, valve box cleaners	Ensure accessibility
Inspect and Operate distribution system valves	High	Time	Annually	0.33	1-2	Valve key/operator	Determine accessibility and operating condition
	Medium	Time	Every 2 yrs.	0.33	1-2	Valve key/operator	Determine accessibility and operating condition
	Low	Time	Every 5 yrs.	0.33	1-2	Valve key/operator	Determine accessibility and operating condition
Inspect and Operate hydrant auxiliary valves	High	Time	Annually	0.33	1-2	Valve key/operator	Determine accessibility and operating condition
	Medium	Time	Every 10 yrs.	0.33	1-2	Valve key/operator	Determine accessibility and operating condition
	Low	Time	Every 10 yrs.	0.33	1-2	Valve key/operator	Determine accessibility and operating condition

This table indicates the valve maintenance activities to be performed, the frequency that the activities should be performed based on valve criticality rating, the estimated number of hours and staff members needed for the work, and the need for any specialty tools/skills.

In the column marked "Work Load," the Practice sets forth an estimate for the hours required for the maintenance work along with an appropriate number of employees to perform the work. In reviewing these guidelines and in determining the proper number of employees needed, a supervisor should consider the individual characteristics of the needed maintenance including the traffic conditions, safety of employees in the given area, and the difficulties that may be anticipated because of valve size, condition, location, and any other relevant information. The estimations are not meant as the enactment of any rule upon supervisors. Rather, the estimations are meant as a guide.

Additionally, the following criteria is offered for supervisors when applying the Frequency Table:

- The triggers for locating low criticality valves are paving reconstruction programs, new construction projects, main extensions, etc;
- The Practice attempts to provide a general framework for valve inspection even though local and/or state regulatory requirements may differ. Where such regulatory requirements differ, it is suggested that the implementation of this Practice may encourage regulatory agencies to reconsider the requirements that the law may currently impose. In other words, the regulations may be antiquated and not reflect current practice in the water industry. The successful implementation of a valve maintenance practice that differs in some manner from the regulatory requirements may support modifications in the regulatory environment.
- Frequency value for operating and locating low criticality transmission or distribution system valves (every five years) is the recommended value. Varied state regulatory compliance issues are to be considered when determining the actual frequency value to be implemented at a specific operating unit.
- Frequency value for operating hydrant auxiliary valves (every ten years) is the recommended value based on the scouring action of valve seats during hydrant inspection. Varied state regulatory compliance issues are to be considered when determining the actual frequency value to be implemented at a specific operating unit.

Appendix A – Summary of Policies Related to The Valve Operation Inspection and Maintenance Practice

Practice	Related Policy
	none

EXHIBIT UWUA-2

Distribution Valves: Selection, Installation, Field Testing, and Maintenance

Manual of Water Supply Practices

M44

Distribution Valves:
Selection, Installation, Field Testing, and Maintenance

Third Edition

American Water Works Association

Manual of Water Supply Practices

M44

Distribution Valves:

Selection, Installation, Field Testing, and Maintenance

Third Edition

American Water Works Association

Manual of Water Supply Practices—M44, Third Edition

Distribution Valves: Selection, Installation, Field Testing, and Maintenance

If you find errors in this manual, please email books@awwa.org. Possible errata will be posted at www.awwa.org/resources-tools/resource-development-groups/manuals-program.aspx.

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Figures

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Tables

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Preface

The importance of valves in the water distribution system cannot be overstated. Their effective selection, installation, operation, maintenance, repair, and replacement are vital to appropriately conveying an essential product to the customer. The primary focus of M44 is distribution valves; however, other valves essential to plant operations are also discussed. Specific to distribution systems, M44 is a guide for the selection, installation, field testing, and maintenance of water distribution valves.

This manual offers a brief history of valves and an overview of their theory and flow characteristics. It is a discussion of recommended practice rather than an AWWA standard calling for compliance with certain specifications. It provides guidance on generally available valve alternatives. Questions about specific situations or the applicability of a particular valve should be directed to the manufacturer or supplier.

Information contained in M44 is useful for operators, technicians, and engineers for all sizes of utilities, but it is particularly useful for small- and medium-sized organizations. The manual primarily discusses the more commonly used valves, but some of the "specialty" or "special use" valves are covered as well. The extent of the presentation of the specialty valves is only to introduce their availability and applications.

This manual provides general information to utilities and contractors on the proper installation and field testing of valves. Essential procedures related to operation and maintenance are also covered within this document. Additionally, procedures for determining valve criticality to assist an agency to establish, implement, and maintain an effective utilization of valves during their response to emergencies is provided as well.

Fire hydrants, although technically considered valves, are not covered in this manual. The reader is referred to AWWA Manual M17, *Installation, Field Testing, and Maintenance of Fire Hydrants*. This manual (M44) refers to AWWA standards for various types of valves. Copies of these standards may be purchased from the AWWA Bookstore.

Several manufacturers graciously provided valve illustrations and other documentation. AWWA does not endorse any manufacturer's products, and the names of the manufacturers have been removed from the material provided.

Metrication note: Valve sizes are listed in their current US designation; i.e., nominal pipe sizes in inches. To obtain an exact metric equivalent, use a conversion factor of 25.4 mm/in.

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Chapter 1

History and Design Considerations

A water distribution system is a piping network that delivers water at service pressure from the source to the end-user connection. Generally, the system originates at a treatment plant or pumping station and ends at a residential, industrial, or commercial service connection. The system may also terminate at a fire hydrant or connect to a subordinate system. Valves are a significant component of any water distribution system and are most commonly used for isolating a section of a flow line, controlling the flow, releasing air, and preventing backflow.

The topics in this introductory chapter include a brief historical review of valves and major design considerations, such as flow resistance, flow-control elements, and sealing mechanisms.

HISTORY

Valves have been a vital component of every water system from the water systems of Greece in 600 BC, which used flap valves to control water for showers, to the London Water Works and the first practical gate valve in the 1800s, to most modern water distribution systems used today. What is believed to be the earliest form of the mechanical valve, the bellows, is shown in hieroglyphs on the wall of an Egyptian tomb built more than 3,500 years ago. These wall paintings depict a bellows with bamboo piping used to smelt ore. Ever since, people have been refining and designing valves to fit different applications.

As water distribution systems became larger and more complex, particularly after the development of cast-iron pipe, designers met the challenges of water flow requirements with improved valve designs. However, many of the valve types currently used in water utility systems were developed in the 1800s and are still used with little change in their basic features. Nonetheless, hundreds of new designs and refinements are available to system designers. Figure 1-1 shows a historical timeline for valve development.

600 BC
Grecian illustrations show evidence of a flap-type valve used in showers for bathing.

400 BC
Plug-type valves are used by both the Greeks and Romans in water mains and supply pipes.

250 BC
Greeks develop a two-cylinder pump that employs a valve in each cylinder.

100 BC
Hero of Alexandria develops the first workable hinged valve. He advises that the seat facings should be smooth and polished to ensure a reasonably tight closure.

1400s
Leonardo da Vinci draws valve constructions, including a multiport check valve with four pairs of hinged gates.

1455
First cast-iron pipe is manufactured in Viegerland, Germany, for installation at Dillenburg Castle.

1600s
King Louis XIV of France orders a cast-iron distribution system to supply water to Versailles.

1700s
Pressure conduits are in general use.

1795
Joseph Bramah designs the first screw-thread valve stem. It is used to open and close sluice-type valves.

1800s
The designs of most commonly used valves are developed during this century. Solid wedge, taper seat valves are introduced in the United States, and most of the changes and refinements take place before 1900.

1839
James Nasmyth designs the first practical metal gate valve, which consists of a cast-iron body and bonnet, a threaded valve stem, and a solid tapered plug. It is immediately employed in England by the East London Water Works.

1875
S.J. Peet patents the double-disc, parallel-seat, bottom-wedge-type gate valve.

1900s
The butterfly, ball, and diaphragm valves are designed and their use becomes common.

Figure 1-1 A historical timeline for valve development

System designers have many choices when they select valves for use in the water distribution system. Making the right valve choice depends on many factors, including the size of the pipeline, the hydraulic pressures the valve will control, the material from which the valve is made, the material with which it will come in contact, what it will be used for, and cost. The following section describes basic design considerations when selecting a valve.

DESIGN CONSIDERATIONS

This section discusses important factors to consider when selecting valves. The first factor discussed is flow resistance, or friction, which causes head loss (loss of pressure) as the water flows through the system. The consideration of the loss of pressure through the system can directly impact the type and size of valve selected for a portion of a design project or for the entire design project. The other factors discussed are general valve elements involved in flow control, such as adjusting the flow and the sealing mechanism.

Flow Resistance

The term flow resistance refers to a fluid's resistance when moving through the piping system. Flow resistance plays an important role when designing a water distribution system. Flow resistance impacts flow pressure, pumping requirements, pipe size, and water volume, as well as the selection or type of valve needed for the specific application. A pressure drop caused by friction impacts the amount of water that can move through the pipe and valves. This drop is caused by fluid particles rubbing against each other and against the pipe. One can observe the effect of friction by connecting pressure gauges to a pipe system at both the beginning (upstream) and the end (downstream) of the system or to an isolated portion of the system; with gauges at the same elevation, the upstream gauge will show higher pressure than the downstream gauge.

Different pipe materials experience different levels of friction and so are said to have different friction factors. For example, a copper pipe is smoother than an iron pipe, and water flowing through the copper pipe will encounter less friction. In addition, for a given nominal diameter, the inside actual diameter may vary depending on pipe material. Flow is affected not only by the roughness of the pipe but also by the pipe diameter; friction increases as the diameter of the pipe decreases. The pressure drop associated with flow through a valve, i.e., the friction loss in the valve, depends on the type of valve.

Many equations allow distribution designers to calculate the pressure drop in a given system. System designers can calculate average flow resistance based on the turbulence of the flow, the roughness of the pipe, pipe diameter, valve and bend types, and other factors. Generally, the flow resistance of a valve is expressed in terms of the length of straight steel pipe that would have an equivalent resistance. For example, a 12-in. gate valve is rated at about a 13.2-ft (4-m) equivalent length of clean schedule 40 steel pipe, and a 12-in. globe valve is rated at about 340 ft (100 m). The relative resistance of PVC is about half that of steel.

The considerable complexity of the flow resistance of valves is beyond the scope of this manual. For more information, consult the sources listed in the additional readings at the end of the manual and manufacturers' technical data.

Flow-Control Elements

The many different types of valves have basic functions and elements that are similar. This section will discuss those basics. Figure 1-2 shows the basic valve elements.

Flow control. A valve controls flow through one of four basic closure methods:

- A disc or plug moves against or into an opening
- A flat, cylindrical, or spherical surface slides across an opening
- A disc or ellipse rotates across the diameter of a pipe or circular element
- A flexible material moves into a flow passage

The valve parts that control the flow element, or closure member, are the stem and the operating mechanism—a handwheel, lever, or key that attaches to the operating nut.

Stems. Most valves employ a threaded stem to move the flow element. Although there are exceptions, such as safety valves and check valves, most valves have stems that extend to the outside of the valve. A rotating stem provides movement for nonrising-stem gate valves, ball valves, rotating-disc gate valves, butterfly valves, and most plug valves. Quick-opening gate valves, rising-stem gate valves, globe and diaphragm valves, and outside-spring safety and relief valves operate with a stem that moves axially.

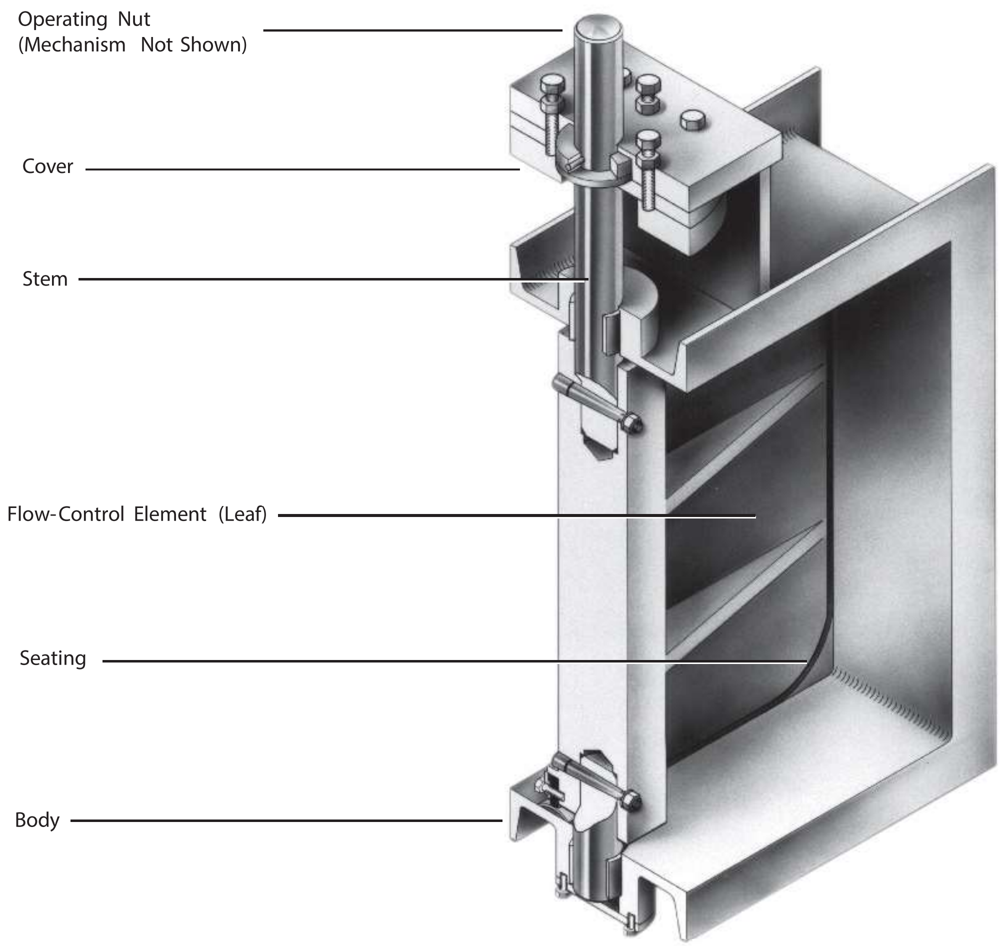

Figure 1-2 Valve elements (rectangular butterfly valve)

Some stems both rotate and move axially, such as globe and needle valves, lift-type cone or plug valves, and most pinch valves. The factors that influence stem design and selection include torque, thrust, valve size, and physical parameters.

Valve operation mechanisms. Most valves are operated with a handwheel (Figure 1-3), operating nut, or lever. Not every application lends itself to such a simple solution, so designers have devised a variety of methods for both manual and automatic valve operation. Special methods are usually needed when special conditions exist, such as:

- The valve must be operated remotely.
- The secure operation of the valve is critical.
- The valve is inoperable using normal methods.
- The size of the valve makes it impossible for one person to operate the valve.

The bury depth of valves may vary. Stem extensions or adjustable valve keys have been designed to operate most valves. Stem extensions usually consist of a steel rod and a coupling that attaches to the valve stem. If the extension must be very long to reach a valve, extra support is provided to keep the extension rigid and to prevent bending or breaking. Operators can use adjustable shafts or steel rods and universal joints to reach valves in difficult locations.

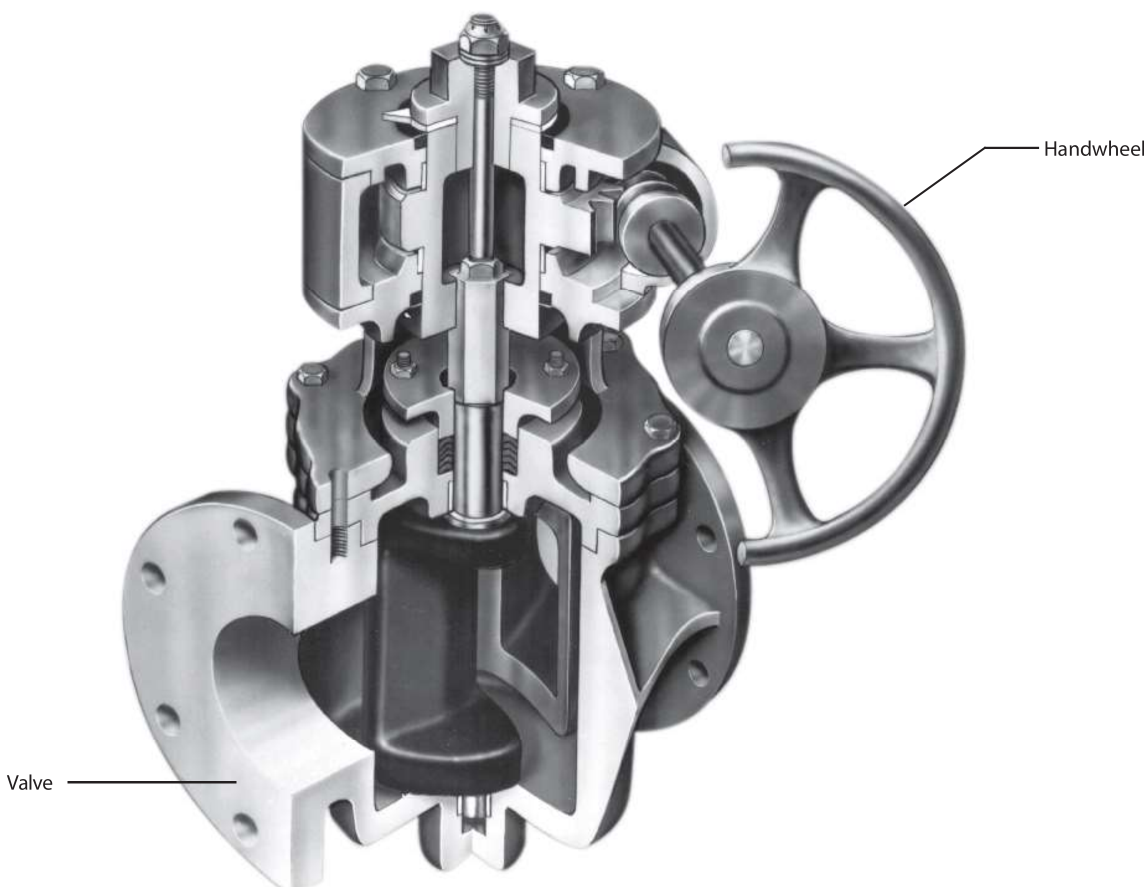

Figure 1-3 Eccentric plug valve with handwheel actuator

Floor stands, gear operators, and wheel operators give personnel a mechanical advantage in opening or closing valves that are inconvenient to reach or are large and difficult to operate. Position indicators may be installed on nonrising-stem valves to show how far open the valve is.

Accessories for automatic operation are also available. They can be used simply to open or close a valve or to throttle flows. Hydraulic or pneumatic actuators, which operate with a diaphragm or piston construction, are common. In a piston type, two chambers in a cylinder are isolated from each other by a piston. The valve stem is connected to the piston. As hydraulic fluid or air is pumped to one side or the other of the piston, the piston is forced back and forth inside the cylinder, which operates the valve. A typical hydraulic operator installation is shown in Figure 1-4. Electric motors are also used to operate valves.

Sealing Mechanisms

Valves are employed to control the flow of fluid through a piping system. Valve seatings are the portions of the valve that contact the valve body to form a seal that stops or diminishes the flow of liquid. Because they undergo wear during the sealing process, they will become less effective over time. Valve-sealing mechanisms used in water distribution systems are usually metal seatings or soft seatings. Another sealing mechanism involves using a sealant such as that used in a lubricated plug valve.

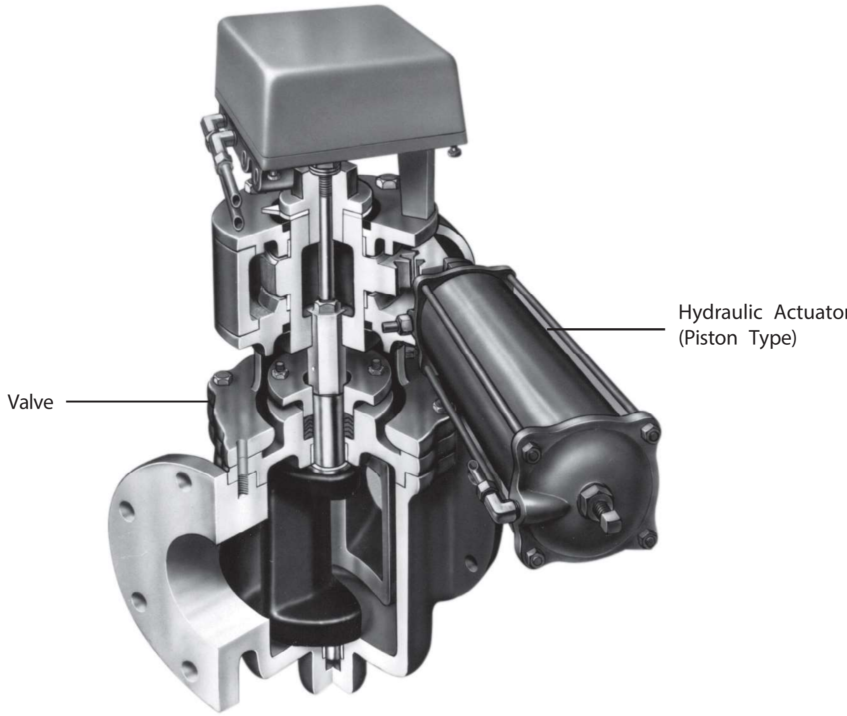

Figure 1-4 Eccentric plug valve with hydraulic actuator

Metal seatings. The material for metal seatings should be carefully chosen because the seatings are prone to damage by corrosion, erosion, abrasion, and deformation. The type of metal chosen for an application should be considered in relation to the types of fluids with which it will come in contact, replacement capabilities, how often it will be operated, and other factors that may cause damage or wear to the sealing mechanism. Different metals offer various sealing abilities and resistance to damage. System designers should choose a valve that has seatings offering the best compromise between sealing ability and wearability based on the environment for which it is designed.

Soft seatings. Soft seatings are sealing mechanisms generally made from various natural or synthetic rubbers or plastics. The soft material readily conforms to the mating surface, creating an effective seal. This type of seating should be designed to prevent the seating material from being moved or deformed by fluid pressure. Presently there are limitations on the use of soft seatings on large valves.

Sealant. Valve passageways can be sealed by a substance (the sealant) injected into the space between the seatings after the valve is closed. The sealant fills any spaces that might be left open by the seatings and thus prevents leakage. Sealant is also used in emergencies to provide a seal when the original seal has failed.

Based on advancements in material and product development, new ways of sealing valves are being implemented and evaluated to enhance the reliability of valves and all their components. Two examples of the newer approaches for coating valves are the fusion-bonded epoxy process as well as the use of the powder coating technology.

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Chapter 2

Types and Selection of Valves

This chapter introduces the major types of valves and the parameters that should be considered when selecting a valve. These parameters include the purpose of the valve, size, operation, and application.

Although certain valve types can be used for many different applications, designers should choose a valve that carefully balances the number of times the valve is operated, maintenance requirements, efficiency, and cost for the specific application. Factors to be considered in the valve selection and specifying process include:

- The requirement that the valve either control or shut off the flow in the manner demanded by service conditions
- The frequency of the valve's operation
- Conformance to appropriate American Water Works Association (AWWA), American Society of Mechanical Engineers (ASME), American National Standards Institute (ANSI), and other product standards
- Ability of the valve to withstand maximum working or test pressures, as set forth in the AWWWA standards
- The need for an unobstructed waterway to maximize flow or accommodate cleaning operations such as "pigging"
- Design and material selection to resist attack by corrosion and/or erosion
- Adaptation requirements for actuator mounting (if any)
- Installation considerations such as weight, accessibility, and dimensional clearances
- Maintenance needs and costs

This chapter will cover only the most common types of valves and their functions. Valves can be grouped based on their method of flow regulation. The general types of flow regulation and the common valves for those types are as follows:

- Flow-control or regulating valves—designed to withstand the demands of usage in the partially open position
    - Globe
    - Piston
    - Diaphragm
    - Butterfly
    - Pinch
- Isolation or shutoff valves—designed to be used primarily in the fully open or fully closed positions
    - Multiturn—gate
    - Quarter turn
        - Plug
        - Ball
        - Cone
        - Duckbill

VALVES USED FOR ON-OFF OPERATION AND FLOW CONTROL

Some valves can be used for both on-off operation and flow control. Most valves are more efficient for either throttling (ball, cone, and globe valves) or on-off (gate valves) applications. The following sections describe the major types of valves and list their best applications. The advantages and disadvantages are somewhat subjective and may not strictly apply in all situations; the information should be used together with engineering data and operational judgment.

Globe Valves

Advantages:

- Suitability for flow regulation
- High sealing capacity
- Resistance to wear

Disadvantages:

- Have a greater ability to allow material to get trapped in the seat
- Produce a higher resistance to flow through the valve
- More prone to reducing the ability to fully close the valve when material is trapped in the seat

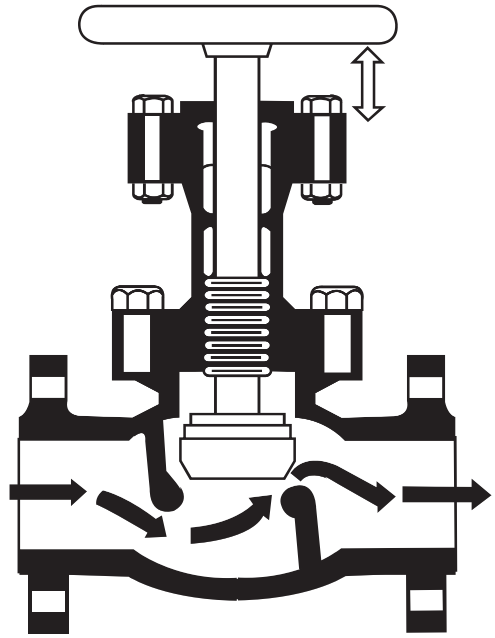


Figure 2-1 Globe valve

Description. Globe valves are regulating valves in which the closure member is moved directly on or off the seat, generally by a rotating threaded stem. The closure member is commonly referred to as a disc. This valve is well suited for flow regulation because of the short distance between the open and closed positions. It also has a high sealing capacity. Because little friction is encountered in opening and closing the seats, the valve is resistant to friction wear. However, globe valves tend to trap particulates in the seat, and the flow resistance is high in these valves. This flow resistance, in turn, usually reduces the flow (see Figure 2-1).

Piston Valves

Advantages:

- Suitability for on-off operation
- Suitability for some flow regulation

Disadvantages:

- High head loss
- Sediment entrapment causing wear

Description. Piston valves use a piston-shaped closure member that intrudes into the seat bore. Sealing is achieved between the sides of the piston and the seat bore. Therefore, flow cannot start until the piston is completely withdrawn. This type of valve is most effective for on-off operation and is somewhat useful for flow regulation. Solids that might be deposited on the seat tend to be wiped away during closing. A primary advantage is that the sealing surface of the piston is protected from flow when the valve is in the fully open position.

Butterfly Valves

Advantages:

- Suitability for both on-off and flow control, 90° operation
- Ease of operation
- Short face-to-face dimension
- Relatively light weight as compared other valve types
- Accept multiple types of actuation
- Lower initial cost
- Can be used for larger-diameter pipes
- More cost-effective in larger diameters

Disadvantages:

- Some head loss
- Partially blocked waterway when valve is fully open
- Incompatibility with pigging (described in this section)
- High-velocity limitations

Description. A common valve in the distribution system, especially in larger sizes, the rubber-seated (sometimes called *resilient-seated*) butterfly valve (see Figure 2-2) has been used in distribution systems since the 1950s. In the butterfly valve, a circular disc or vane that has a diameter less than or equal to that of the pipe is fastened to a shaft running through the valve body and extending outside to an actuator. The disc or vane rotates 90° in the waterway. In the full-open position, the disc is parallel to the flow. The flow, split by the disc, continues on either side of the disc. In the closed position, the disc is perpendicular to the flow and stops the flow. The clearance between the disc and the valve body is sealed by a rubber seat. For additional information on butterfly valves consider AWWA Manual M49, *Butterfly Valves: Torque, Head Loss, and Cavitation Analysis.*

Figure 2-2 Butterfly valve

The rubber seat may be attached to either the disc or the valve body. Butterfly valves are covered by ANSI/AWWA C504, Rubber-Seated Butterfly Valves 3 In. (75 mm) Through 72 In. (1,800 mm); C516, Large-Diameter Rubber-Seated Butterfly Valves, Sizes 78 In. (1,800 mm) and Larger, and AWWA Manual M49, *Butterfly Valves: Torque, Head Loss, and Cavitation Analysis.*

A butterfly valve shuts off pressure as though it were a gasket. The seat holds until the pressure exceeds the seal compression, after which the seal leaks. The valve is set at the factory to hold the rated working pressure (the pressure at which the valve is designed to operate) and should not be expected to seal at higher pressures. The reduction in flow of the butterfly valve is a function of the angle of the disc opening in the pipe. The valve is generally effective for flow control in the range of 20° to 70° open, depending on the difference in pressure across the valve and other characteristics of the valve. Butterfly valves may be used for throttling in some situations; however, they are not intended for long-term throttling. The designer should consult the manufacturer before specifying a butterfly valve for throttling applications.

Advantages of butterfly valves are that they provide shutoff capabilities, some throttling capabilities, and ease of operation, particularly in sizes 12 in. and larger. The actuators required by larger valves increase the mechanical advantage to allow for ease of operation. Additionally, butterfly valves that are 12 in. and larger generally have a lower initial cost than other valve types.

However, butterfly valves do not provide a clear waterway. Restriction of flow in a fully open butterfly valve is greater than in some other types of valves because the disc remains in the waterway. As the valve size increases, the proportion of the open flow area to the cross-sectional area of the disc increases. If a large number of butterfly valves are used, pressure loss in a distribution system can be significant. When flow resistance is critical, other types of valves may be required.

Another disadvantage is that butterfly valves prevent the use of pigging, which involves using line pressure to force a bullet-shaped plug through a water line to locate and clean flow restrictions.

Plug Valves

Advantage:

- Suitability for both throttling and flow regulation

Disadvantage:

- Cause some flow resistance

Description. Plug valves (Figure 2-3) are primarily used in systems where slurries, grit, or solids will flow through the valve. The eccentric plug valve is a quarter-turn valve allowing a cost-effective low-torque actuation for shutoff and throttling applications. These valves can be adapted to operate with various types of manual or automated actuation. Plug valves are available in flanged, mechanical joints, or threaded-end configurations in standard or 100 percent ported design per ANSI/AWWA C517.

Flow restriction in a plug valve depends on the size and shape of the plug opening. For example, some plug valves have tapered openings where the opening is smaller at the bottom than at the top. Tapered plugs cause more flow restriction than a rectangular design of the same size because there is more plug area blocking the flow. Flow resistance can range from that which is slightly more than a gate valve to more than that of a butterfly valve. Advantages of the plug valve include that it can be installed in any position without special consideration and, when utilizing a rectangular port design, change in flow is consistent throughout travel of the plug.

Figure 2-3 Eccentric nonlubricated plug valve

Larger plug valves require an actuator for 90° rotation. Smaller plug valves may be operated with either a 90° rotating lever handle or actuator.

Conically tapered metal (often *brass*) plug valves are often used as simple shutoff valves in household *natural gas* lines.

Cone Valves

Advantages:

- Full waterway opening with low flow resistance
- Good flow-control characteristics
- Suitability for throttling or flow modulation

Disadvantages:

- Large physical size and weight require facility to be preplanned to accommodate the valves
- More costly when compared to other types of valves, such as ball, gate, or butterfly valves
- Maintenance of this valve is more difficult and costly than maintenance of some of the other valves

Description. The cone valve (Figure 2-4) is a quarter-turn (90°) rotary valve for which the flow-control device is a cone seating in a conically shaped body. The seating surfaces are commonly metal to metal. Cone valves have a tolerance for high velocities. Cone valves are typically used to control flow and in pump discharge where high head and high velocities occur; this can require single or multiple configurations. These valves can work well in areas where controlling the variations of flow or where higher velocities within the system are experienced. These valves are often used in dam structures, hydroelectric facilities, and water treatment plants and systems, as well as in spillways.

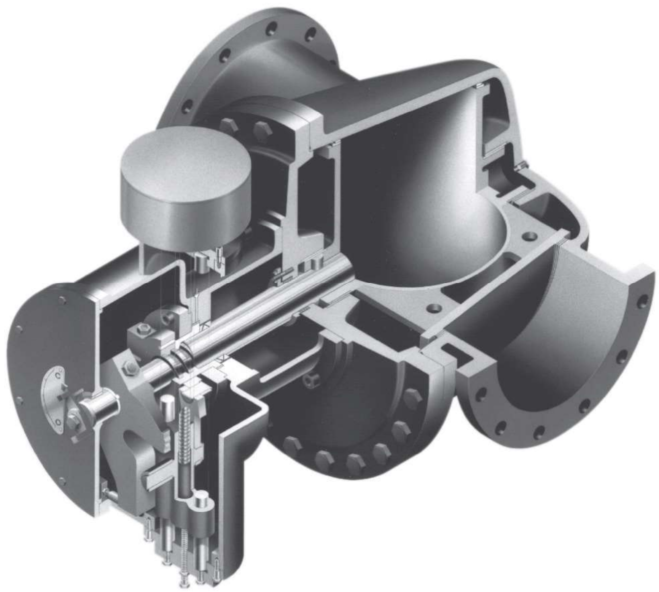


Figure 2-4 Cone valve

Ball Valves

Advantages:

- Low flow resistance
- Suitability for throttling where pressure reduction is important
- High-pressure capability
- 100 percent flow area equal to pipe size
- Energy savings caused by less friction loss
- Adaptability available with metal-to-metal or resilient seating
- Multiple types of actuators can be used

Disadvantages:

- In larger-diameter ball valves, the physical size and weight require facility to be preplanned to accommodate the valves
- Higher initial cost
- Do not offer the best flow control option in every situation
- More susceptible to water hammer

Description. The flow-control mechanism in the ball valve is a sphere that has a waterway opening. The sphere is connected to shafts perpendicular to the waterway, and there is 90° of rotation from the closed position to open position. The seating surfaces are either resilient on a noncorrosive metal or noncorrosive metal to metal. Valves are capable of bidirectional pressure ratings because when ball valves are furnished with port openings of the same size as the pipe opening, they have a very low head loss (see Figure 2-5). Ball valves are typically used in pump discharge, high head, high velocity applications

Figure 2-5 Resilient-seated ball valve

where typical flow control and antisurge control are critical. These valves are adaptable with manual actuation, electric motor actuation, or hydraulic cylinder actuation, depending on the specific application.

Small rubber-seated ball valves are used in consumer service connections as corporation stops, curb stops, and meter isolation valves. Larger ball valves are generally installed in applications where the pressure or velocity exceeds the capability of a butterfly valve or gate valve. Ball valves are used extensively for control or throttling service where a moderate reduction in pressure or flow control to reduce the potential for water hammer is required. In such service, the actuator is constructed to provide a mechanical advantage for minimal torque requirements so that the valve operates smoothly and easily. Ball valves are covered by ANSI/AWWA C507, Ball Valves, 6 In. Through 60 In. (150 mm Through 1,500 mm), and by ANSI/AWWA C800, Underground Service Line Valves and Fittings.

Pinch Valves

Advantages:

- Ease of operation
- Resistance to corrosion

Disadvantages:

- Effective for flow control only when they are at least 50 percent closed
- Typically more expensive than many other types of valves
- Used generally for small pipe size applications
- Do not allow the effective operation of the cleaning or pigging process

Description. Pinch valves are simple in design. They shut off flow by pinching and sealing off a synthetic or natural rubber tube. They are similar to the pinch cock used in laboratories. The operating mechanism is separated from the fluid, so these valves are useful where corrosion and contaminated fluids are a problem, which should not be a consideration in water distribution systems (see Figure 2-6).

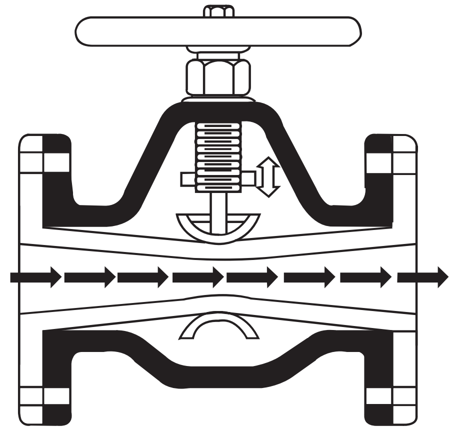


Figure 2-6 Pinch valve

Diaphragm Valves

Advantages:

- Ease of operation
- Resistance to corrosion
- Resistance to erosion

Disadvantages:

- Only effective for flow control after 50 percent closed
- More expensive than most other valves
- High head loss
- Generally only available in small sizes
- Not effective for the cleaning or pigging process

Description. Diaphragm valves (see Figure 2-7) contain a flexible diaphragm attached to a compressor. The diaphragm is lowered by a valve stem onto a weir, which seals and shuts off the flow, similar to how a pinch valve operates. Diaphragm valves are used to handle corrosive, erosive, or contaminated fluids, which should not be a consideration in water distribution systems. Their primary application and use are in industrial environments as well as in some water and/or wastewater treatment facilities.

Control Valves

Advantages:

- Accurate proportioning

Disadvantages:

- Possible cavitation resulting in excessive wear if wrong type of valve used
- High head loss
- Limited application and/or use
- Require a lot of maintenance to be effective

Description. Control valves provide accurate proportioning control by automatically varying the rate of flow that passes through the valve according to signals received from sensing devices. Some valves are designed specifically as control units. Most types of valves, however, can be used as control valves when combined with actuators, positioners, and other accessory devices. See Figure 2-8 for a photograph of a typical flow-control valve. Control valves function very similarly to a globe valve and are typically used to control either flow or pressure. Control valves are used typically to manage flow, pressure, and the various levels of reservoirs, tanks, and so on.

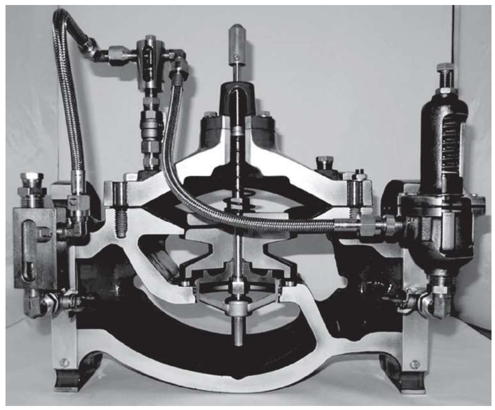


Figure 2-7 Diaphragm valve

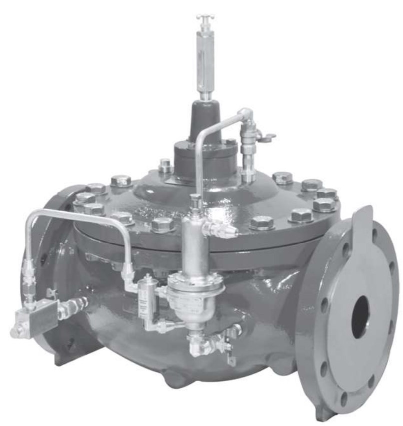


Figure 2-8 Flow-control valve

VALVES USED PRIMARILY FOR ON-OFF OPERATION

The valves discussed in this section are used primarily for on-off control of water, rather than for flow control.

Gate Valves

Advantages:

- Clear waterway for low flow resistance
- Bidirectional drip tight seal
- Lower pumping cost
- Low to no restriction/friction (i.e., low head loss)

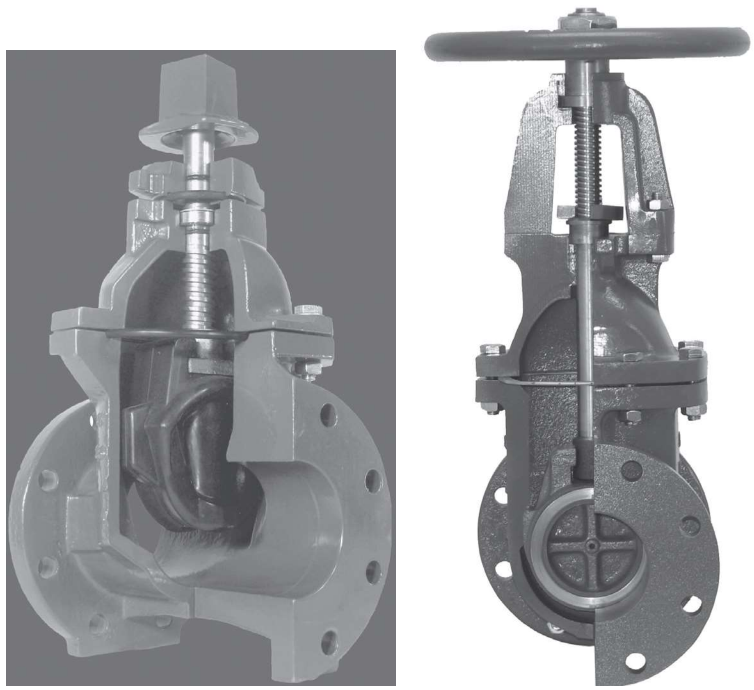
Disadvantages:

- Some designs are not suitable for flow regulation
- Metal-seated valves may require more frequent exercising than resilient-seated gate valves
- Are not designed for throttling applications
- Can be more expensive in larger sizes
- Size consideration/additional expenses (for instance, larger-size valves are more cumbersome and harder to move around, and bigger equipment must be used to get them in place)

Description. Gate valves are the most commonly used type of valve for isolating portions of the distribution system. Gate valves block the passage of water with a disc sliding perpendicular to the flow. Primarily used for open or closed service, gate valves are typically not recommended for flow regulation or for throttling. Gate valves are not well suited for precise flow control because flow reduction is not proportional to travel (the extent to which the valve is open); very little flow resistance occurs until the valve is about 75 percent closed. Large gate valves should never be utilized in a severe throttling application given cavitation forces created by compressed flow under the gate. In the full-open position, the gate has a clear waterway that keeps flow restriction to a minimum. See Figure 2-9 and Figure 2-10 for illustrations of gate valve operation. The most common type of gate valve is the resilient-seated gate valve. Older style designs, including double-disc and solid-wedge gate valves, are rarely used today and have limited availability.

Double-disc gate valves. Covered by ANSI/AWWA C500, Metal-Seated Gate Valves for Water Supply Service, double-disc valves have been in general use since the early 1900s. The design consists of two relatively loose fitting discs that, when closed, are pressed against metal seats by a wedging mechanism. The wedging force is released when the valve is opened. Traditional double-disc valves are not recommended for throttling or flow-control applications.

With double-disc valves, water pressure pushes past the upstream disc and allows the area between the two discs to become pressurized when the discs are in the closed position. This pressure then forces the downstream disc against the seat. Generally, the higher the pressure, the tighter the seal. Larger valves are usually equipped with a bypass valve for pressure equalization to ease main valve operation. The addition of gearing is common on valves 16 in. and larger to reduce the effort required to operate the valves. If valves 16 in. and larger are installed horizontally, rollers, tracks, and scrapers should be



A B

Figure 2-9 Gate valves: (A) Solid wedge and (B) resilient wedge

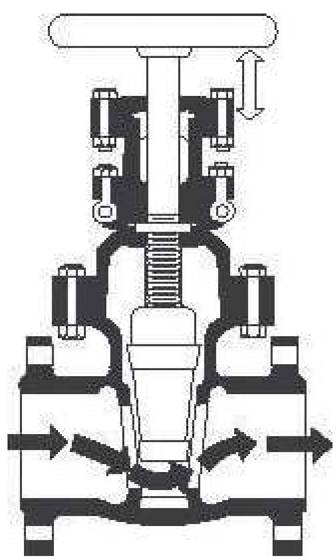


Figure 2-10 Gate valve

used to make operation easier. Fluids with any debris (grit or mineral deposits) clog these tracks over time. Gate valves that have revolving discs do not require rollers.

The advantage of double-disc valves is that they are bidirectional, providing flow shutoff in either direction. A principal disadvantage of double-disc valves is the large frictional force that must be overcome to move the downstream disc off the seat. Two people or an actuator may be required to operate the larger valves (more than 12 in. in size). Also, when using an actuator, the operator must be concerned with excessive torque that may damage the valve system. In some waters, corrosion may damage the valve and make it more difficult to operate.

Solid-wedge gate valves. Also covered by ANSI/AWWA C500, the solid-wedge design involves a closure member that is a single wedge guided into fitted, tapered body seats. The wedge seats do not contact the body seats until final closure. High pressure may cause the upstream seat to allow water into the valve body but, as with the double-disc valve, the downstream seat will seal even tighter with additional pressure.

Although this type of valve is best suited for isolation or full-open use, the wedge gate may be somewhat more acceptable than the double-disc valve in a throttled position because of the close guiding between the wedge and body. This type of valve also provides a clear waterway that minimizes flow restriction.

Resilient-seated gate valves. Resilient-seated gate valves are used to cover both gray-iron and ductile-iron bodied valves, which are now commonly referred to as the full-wall valve standard. Resilient-wedge valves are the most common type of resilient-seated valves being produced today.

In an effort to reduce the weight of larger valves being introduced into water systems, a newer standard—ANSI/AWWA C515, Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service—was developed to cover ANSI/AWWA Standard C509, Resilient-Seated Gate Valves for Water Supply Service. From the new standard "reduced-wall" gate valves were produced in ductile iron only. By separating "full-wall" and "reduced-wall" valves into different standards, purchasers are now able to clearly identify their preferences. The resilient-seated gate valve has a closure member consisting of a gate that may be encapsulated with a resilient material (rubber, urethane rubber, or others). ANSI/AWWA C509 also allows designs for which the resilient seat is attached to the body. The first illustraton in chapter 3, Figure 3-1, shows a sample shop drawing of a resilient-seated gate valve with an outside stem and yoke.

These valves are bidirectional and provide a clear waterway when open. Because of their smoother waterway, the head loss is usually less than the head loss for metal-seated gate valves. These valves should not be used for throttling because throttling may damage the valve.

SPECIAL-PURPOSE VALVES

For specific system applications, valves are available to make operation simpler, more efficient, or automatic. Special-purpose valves are designed to prevent backflow, automatically control pressure, release air, or allow tapping of water lines without isolating flow.

Check Valves

The check valve is a single-direction valve that allows flow in one direction (forward) and stops reverse flow (see Figure 2-11). It opens under the influence of forward pressure and flow, and it closes automatically when flow ceases or reverses, making operation semiautomatic. In some check valve designs, an external lever with a weight or lever spring helps close the valve prior to flow reversal. Check valves are used in pump discharge and flow applications where it is of importance to stop the reverse flow of a liquid prior to pump and/or in water column reversal in order to reduce the chance of water hammer. Typical applications include treatment plants, pump stations, and lift stations.

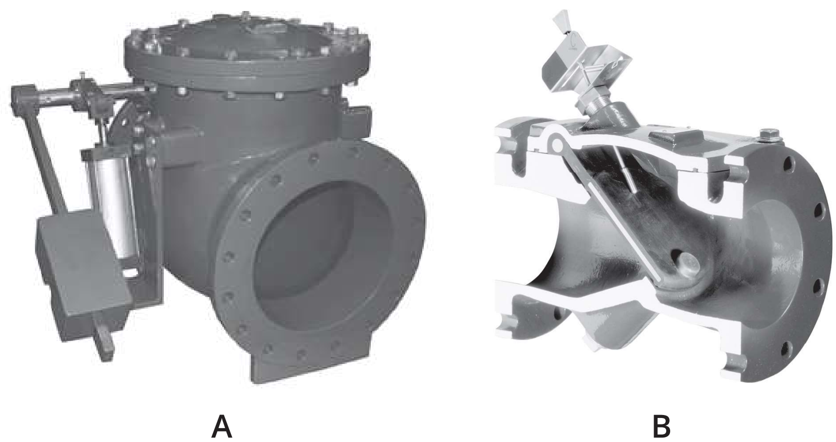


Figure 2-11 (A) Swing-type check valves with lever and weight and (B) air cushion device/ standard swing-check per C508

Many other types of check valves, such as swing-check valves, ball check valves, and others, are available; but these are considered specialized valves and will not be discussed here. Horizontal swing-check valves are covered by ANSI/AWWA C508, Swing-Check Valves for Waterworks Service, 2-In. (50-mm) Through 24-In. (600-mm) NPS.

Air Valves

Air valves are used in transmission and distribution pipelines to increase operating efficiency and provide pipeline protection. They are generally divided into three types of valves: air-release, air-vacuum, and combination air valves per ANSI/AWWA C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service, and AWWA Manual M51, *Air-Release, Air/Vacuum, and Combination Air Valves.*

Air-release valves. An air-release valve (see Figure 2-12) is generally a self-actuated valve that automatically vents small pockets of air that accumulate at the high point in a water distribution system when the system is operating under pressure.

After an air-release valve is installed at the high point in a system, it fills with water and closes. During system operation, small amounts of air enter the valve from the system. As air displaces water within the valve, the water level drops. When the water level falls to the point where the float associated with the valve is no longer buoyant, the float drops. This action opens the valve orifice and allows the air that has accumulated in the upper portion of the valve body to be released into the atmosphere. As this air is released, the water level within the valve rises, lifting the float and closing the valve orifice. This cycle repeats itself whenever air accumulates in the valve.

The ability of the valve to open and release accumulated air under pressure is achieved through the use of a leverage mechanism. As the water level and float drop, the weight of the float acting on the mechanism produces a greater force to open the valve than the system pressure exerts to hold the valve closed. Generally, the higher the system pressure, the smaller the orifice diameter needed in the air-release valve.

Air-vacuum valves. Air-vacuum valves (see Figure 2-13) are often referred to as *large-orifice air valves*. The valve is designed to allow large volumes of air entrapped in the pipeline to escape during filling. Once the float is closed, the valve will not operate again until a negative pressure occurs within the pipeline caused by draining or a column separation. When this occurs, the float will drop open to allow large volumes of air to enter the pipeline, preventing the loss of pressure, which could cause the pipeline to collapse and/or which could cause damaging water column separation.

Figure 2-12 Air-release valve

Figure 2-13 Air/vacuum valve

Combination air valves. Combination air valves (see Figure 2-14) incorporate the use of both a small-orifice air-release valve and a large-orifice air-vacuum valve either in a single-housing or dual-body design. The combination valve provides the function of both an air-release and an air-vacuum valve. When in doubt of which valve type to use, the combination valve will ensure the proper protection and efficiency of the pipeline.

Inflow Preventer

Water distribution systems are equipped with air valves at multiple locations to release and admit air into pipelines and reservoirs to allow filling and draining, control surges, and maintain flow efficiency. If the valve or reservoir outlets become flooded or the target of malicious tampering, the air entry point may be compromised and allow the entry of flood water or the intentional introduction of a contaminate into the water system.

Figure 2-14 Combination air valve

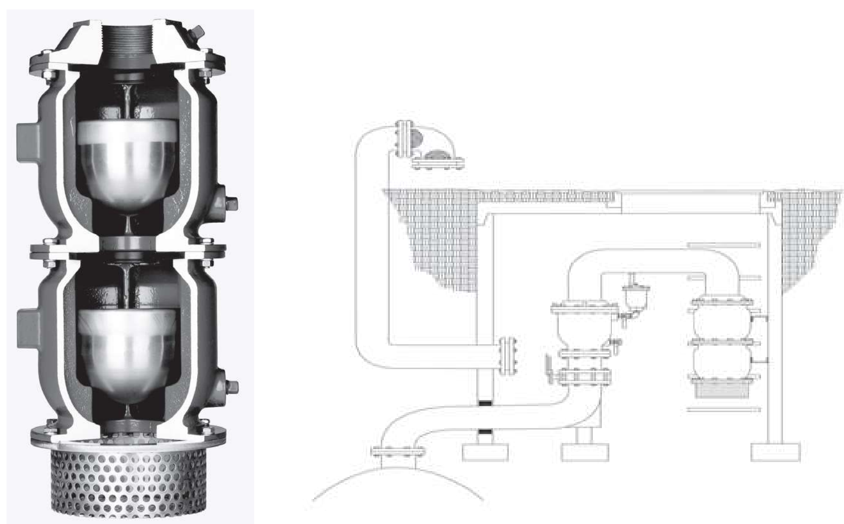


Figure 2-15 Flood-safe inflow preventer

The inflow preventer (see Figure 2-15) is directly connected to air-valve outlets in valve vaults and reservoir vent pipes. This device is normally open to allow unrestricted airflow in and out of pipelines and reservoirs during normal operating conditions. When a flood occurs in a valve vault or reservoir vent, a float-operated closure member automatically closes to prevent entry of the contaminated fluids. A redundant float-operated closure member automatically closes if the first one fails.

Altitude Valves

Altitude valves are mostly globe-type body valves normally installed in storage tank inlet-outlet lines; they remain open until the tank is filled. The valves are then closed during normal flow conditions. They open again when the pressure in the distribution system becomes less than the static head of the height of water in the tank. These valves are usually equipped with a hydraulic pilot system that senses pressure and operates the valve.

Pressure-Relief Valves

Pressure-relief valves are used to protect against excess pressure in water lines. They lower the pressure by releasing water when the designated pressure safety limit is exceeded. They close again when the line pressure falls below the safety limit (see Figure 2-16). These types of valves are commonly used to relieve high pressure conditions.

Pressure-Reducing Valves

Pressure-reducing valves are used to provide water to a pressure district (or zone) of lower elevation from a district of higher elevation. They are often globe valves equipped with hydraulic pilot systems similar to those of altitude valves. The valves do not close under normal flow conditions, unless doing so is required to shut off flow. Typically, a large-volume valve and small-volume valve are used in parallel because of the possibility of a wide variation of pressures to be reduced. A photograph of a pressure-reducing valve is shown in Figure 2-17.

Tapping Valves

Valves used for tapping service are usually resilient-seated gate valves, which are covered by ANSI/AWWA C509 and C515. Tapping valves are designed to be used in conjunction with a tapping sleeve or tapping saddle and a standard tapping machine. Operators can install the sleeve and valve and make the tap under pressure in a takeoff line from an existing main without shutting down or otherwise interrupting the flow of water in the main. To ensure the proper installation of the tapping valve and tapping sleeve, the assembly should be tested with water with the gate closed. This test will determine if the saddle is watertight prior to drilling the water main. The test should be conducted prior to the installation of the tapping machine and prior to making the tap. Under no circumstances should the assembly be tested with air. If air is used, the operator may face serious injury or even death.

One end of the tapping valve consists of a modified flange with a raised pilot. This flange mates with the recess or counter-bore in the corresponding flange of the tapping sleeve or saddle. This feature enables proper alignment of the valve on the sleeve or saddle and ensures that the shell cutter of the tapping machine meets no interference as it passes through the valve and saddle. The mating dimensions are standardized by the Manufacturing Standardization Society (MSS) in Standard Practice 60, Connecting Flange Joint Between Tapping Sleeves and Tapping Valves.

The other end of a tapping valve attaches to the tapping machine. This end can be furnished with a flange, a standardized mechanical joint, or a proprietary push-on joint. The interface dimensions for tapping valves and tapping machines for nominal sizes up to 48 in. are described in MSS Standard Practice 60. When selecting a tapping valve, operators should determine whether the valve can be closed without the gate striking the retracted pilot drill; they should also make sure the valve is compatible with the tapping machine. The distance from the tapping machine to valve interface to the valve gate is not standardized among valve manufacturers. Tapping machine travel should be determined by the tapping machine using the size of the pipe being tapped with the machine being used.

Other pertinent MSS standard practices include SP-111, Gray-Iron and Ductile-Iron Tapping Sleeves, and SP-113, Connecting Joint Between Tapping Machines and Tapping Valves.

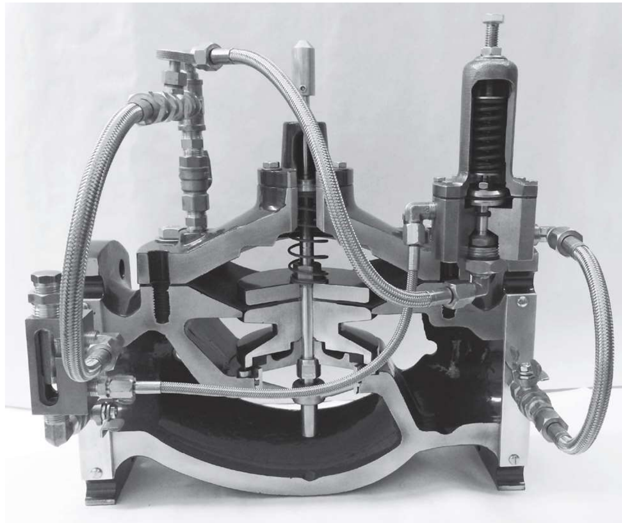


Figure 2-16 Pressure-relief valve

Figure 2-17 Pressure-reducing valve

Insertion Valves

An insertion valve (Figure 2-18) is a specially designed gate valve that, when used with suitable valve-insertion equipment, can be installed in an existing pipe system under full operating pressure without interrupting service. Insertion valves are placed on a previously unvalved line to control flow. Some valve sizes require a companion sleeve. These valves are produced in sizes 4 in. through 54 in. for installation in cast-iron or ductile-iron mains. They may also be used with certain sizes of steel pipe, concrete pressure pipe, and asbestos-cement pipe, depending on the wall thickness and the outside diameters of the pipe. Because of the specialized equipment required to use an insertion valve, many utilities hire a contractor to perform the work.

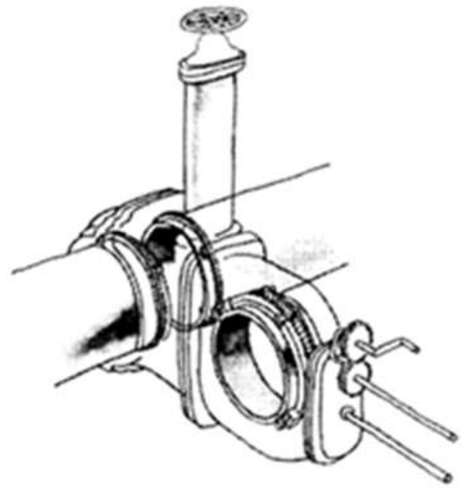


Figure 2-18 Insertion valve

ACTUATORS

A manual actuator is any lever, gear, or wheel used to facilitate movement of a valve's control element as shown in Figure 2-19. An automatic power actuator uses an external power source that provides the torque (turning or twisting force) necessary to operate a valve automatically or remotely. Automatic power actuators are often used on valves that are frequently operated; they are a necessity on pipeline valves in remote areas. Certain power actuators can quickly shut down a pipeline in case of an emergency. Refer to chapter 1, Figure 1-4, for an illustration that shows a plug valve with an actuator attached.

Hydraulic and Pneumatic Actuators

Hydraulic actuators (see Figure 2-20) and pneumatic actuators are often simple devices, with a minimum of mechanical parts. These actuators are used on quarter-turn valves and other rotary devices. Air or fluid pressure provides the required thrust or torque, acting on a piston linked to the valve stem to open or close the valve. Both types of actuators can be supplied with a fail-safe feature that turns the valve on or off as required if there is a sudden drop in operating pressure or a power failure. Because air is compressible, it should not be used on high-torque applications or where smooth operation of the valve is essential. If these actuators are installed underground, a vault should be installed that will allow future maintenance.

Electric Actuators

Electric actuators have motor drives that provide the thrust or torque to operate a valve. Electric actuators (see Figure 2-21) are an alternative to air-type or fluid-type actuators. They are most frequently used on multiturn valves and on quarter-turn valves. Finally, the valve actuator may require maintenance or repair periodically. It should be placed in a vault or an easily accessible location.

Figure 2-19 Manual actuators/traveling nut/worm gear

Figure 2-20 Hydraulic cylinder actuator

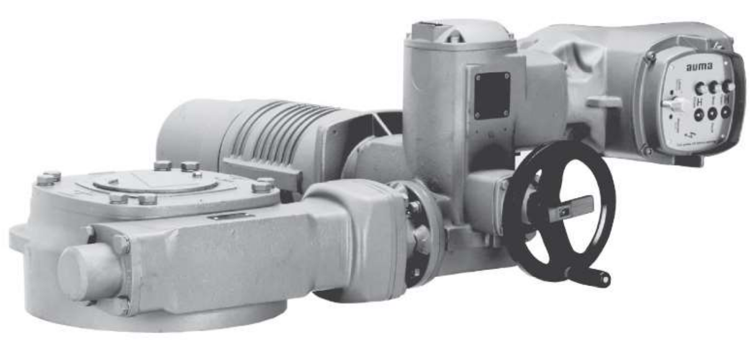


Figure 2-21 Electric actuator

VALVE-END CONNECTIONS

Valve ends of the mechanical joint, proprietary push-on joint, or flanged joint types are commonly available and can be found in combination. Other valve ends such as threaded, caulk hub, shoulder joint, and straight-spigot types are typically less available. Valve ends (joints) must be compatible with the adjacent piping component and should be installed properly to achieve a leak-free joint.

In addition to flanged joint ends, special restrained push-on and mechanical joint designs are available with one or more of their joint components modified to provide mechanical locking between the valve end and the pipeline.

Detailed design information, pressure ratings, and assembly procedures can be obtained from the valve manufacturer. Some joints are proprietary, and the manufacturer has exclusive rights to their designs. Other information on joints can be obtained from the appropriate AWWA standard. Some typical valve-end connections are shown in Figure 2-22.

Valve body material is typically stainless steel, ductile iron, or cast iron. Wall thicknesses vary and should be analyzed. Valve body coatings should also be analyzed for specific use and durability. Bolts and nuts are typically zinc-coated mild steel. Many manufacturers will use stainless steel or other types of material for bolts and nuts on valves if specified by the user. Appropriate measures should be taken to protect the valves, bolts, and nuts against corrosion. A typical approach to this is the use of polywrap secured completely around these components.

Figure 2-22 Valve-end connections

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Chapter 3

Valve Tests, Unloading, Inspection, and Storage

Most valve components are manufactured to standards set by the American Water Works Association (AWWA) or other organizations such as the American Society of Mechanical Engineers (ASME) and the American National Standards Institute (ANSI). These standards typically include test requirements or testing procedures to ensure that the valves are manufactured to specifications, and the manufacturer must meet all such requirements and procedures. Valve inspection at the manufacturing facility ensures that valves meet those standards and that the valves are in working order when they are shipped. However, valves should also be tested operationally when they arrive at the utility and before they are installed.

MANUFACTURING PLANT VALVE TESTS

When valves are manufactured, the work is available for inspection and approval by the purchaser's duly authorized inspector. Notice of this requirement should be in the purchaser's valve specifications. In-plant inspections provide additional assurance to the purchaser that the valves meet the requirements of the specification. For in-plant inspections, the manufacturer provides full facilities for inspection and observation of tests. The purchaser's inspector should have access to all places of manufacture where materials are being produced or fabricated or where tests are conducted. An affidavit of compliance with the appropriate product standard may be required from the manufacturer even if the purchaser has an inspector at the plant.

After manufacture, each valve should be subjected to operation and hydrostatic tests (pressure tests of the valve to ensure that there is no leakage) at the manufacturer's plant as specified in the appropriate product standards. Testing assures the buyer that the valve will perform properly. Tests conducted by the manufacturer vary based on valve type and product standard. Some of those tests are described in the following paragraphs.

Operation Test

Each valve should be operated one or more times in the position for which it was designed to ensure correct functioning of all parts. If the valve does not meet standards, it must be rejected. All defects in assembly or materials must be corrected and the test repeated until satisfactory performance is demonstrated.

Valve Body Test

With the valve in the open position, a hydrostatic test pressure equal to twice the rated working pressure (or that specified by the product standard) of the valve should be applied to the body. No leakage is permitted through the metal, joints, or stem seals.

Valve Seat Test

A test should be made from each direction at the rated working pressure (the pressure at which the valve is designed to operate) for the time specified by the standard to prove the sealing ability of each valve from both directions of flow. No leakage is permitted through the metal, through the seats, or past the seat, unless otherwise indicated in the specific standard. The seats of check valves are tested in the stopped-flow direction.

Valve Torque Test

A sample of each valve should be torqued in both the open and closed positions to ensure that there is no stem damage or seating damage and a resulting failure to seal. The specific product standard for each valve type specifies the amount of torque that should be applied. Deviations in the methods used in conducting these tests are specified in the appropriate AWWA standard.

MANUFACTURER'S DOCUMENTS

The purchaser may specify that the manufacturer provide documents to help the buyer properly use the valves. The documents may include an affidavit of compliance with the appropriate product standards, shop drawings, and installation, operations, and maintenance manuals to show dimensions, construction, and materials used. This information is vital to ensure proper installation and operation of the valves.

Shop Drawings

The buyer may request that the manufacturer provide assembly drawings (shop drawings) for all valves delivered. The drawings should include clearance requirements, dimensions, and construction type. They should be sufficiently detailed to show that the valve meets the requirements to comply with standards. Figure 3-1 shows a sample shop drawing. The drawings are especially important when the number of turns, input torque, actuator data, and protective coating are not specified in the standard. Knowledge of the exact number of turns and direction to open or close a valve is essential to the correct operation of the valve (isolation or modulation) as well as to prevent actuator failure.

Installation, Operations, and Maintenance Manuals

Installation, operations, and maintenance manuals from the manufacturer should be provided for each significant order and for all valves. The manuals should include specific instructions for assembly, installation, and operation. The manuals should include suggested maintenance procedures for the operation of valves in service. Proper maintenance can then be scheduled to maximize the service life of the valve and ensure proper operation. Many manuals also include troubleshooting tips and repair instructions. Often actuators can be adjusted in the field to improve closure. Actuators can be damaged by over-torquing. This should be a consideration when selecting actuators and valves. Figure 3-2 shows some typical information from an operations and maintenance manual.

Packaging and Marking

The manufacturer is required to package valves for shipment to prevent damage in moving the materials to the utility and to mark valves with information useful to the user. As detailed in the appropriate standards, such markings may include the name of the manufacturer, the rated working pressure, the year of manufacture, and the size of the valve. Serial numbers on large valves (12 in. and larger) should be recorded in utility records to allow parts to be ordered in the future.

UNLOADING AT THE UTILITY

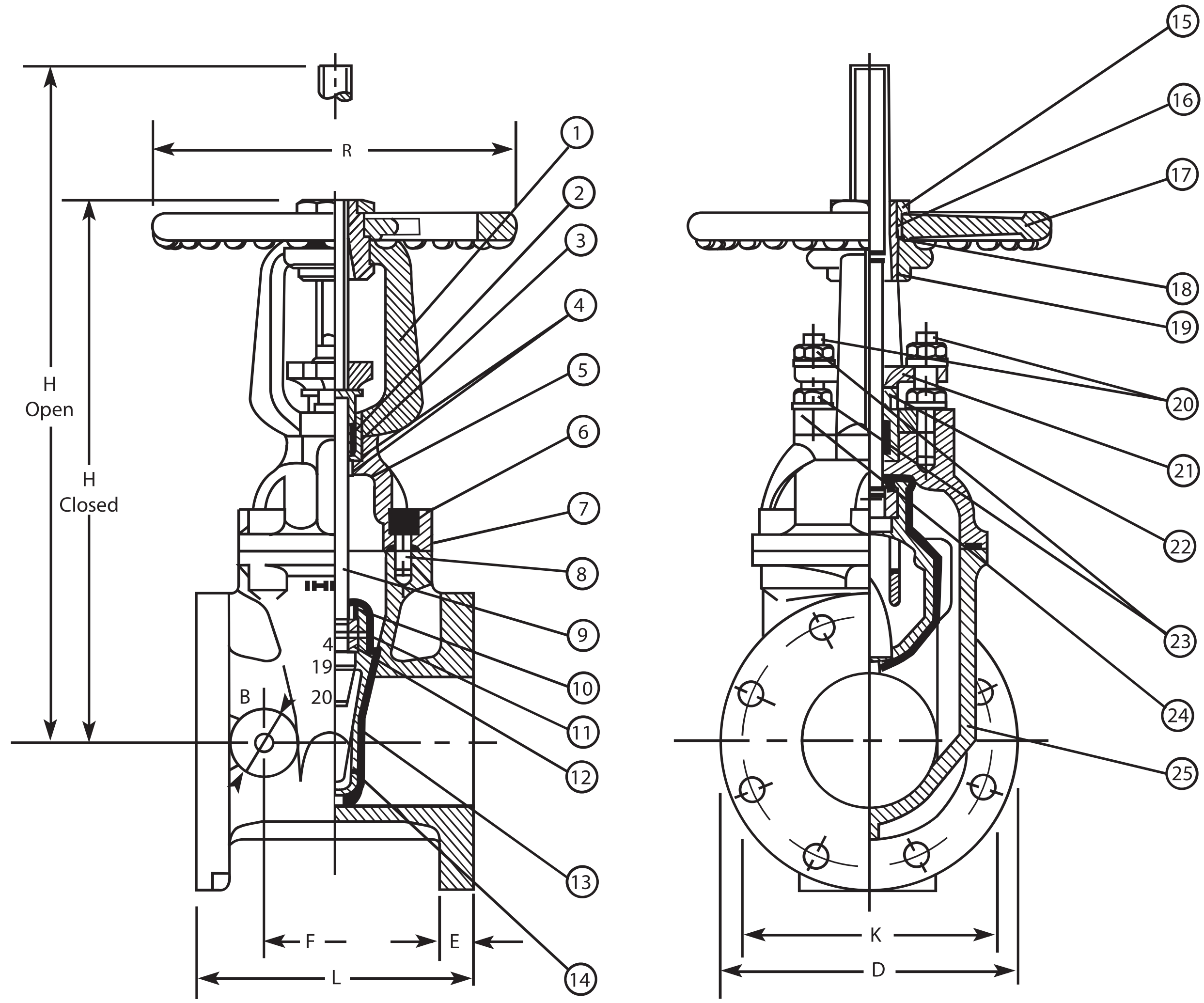
All valves should be unloaded carefully and lowered gently from the truck to the ground, not dropped. The expanded use of pallets, shrink wrap, side-load trucks, and forklifts has simplified receipt and unloading of large quantities of valves. However, the handling of single valves or uncrated valves is still prevalent and the proper use of rigging (slings, chains, or strapping) is critical. In the case of larger valves, forklifts under the skids or slings around the body of the valve should be used for unloading. Only hoists and slings with adequate load capacity to handle the weight of the valve should be used. Hoists should not be hooked into or chains fastened around stems, bypasses, yokes, gearing, motors, cylinders, or handwheels.

To prevent damaging or chipping special coatings, such as epoxy, valves should be protected from lifting devices with padding. If a special coating is damaged, it should be repaired with the original coating material or a material specified by the coating manufacturer.

Some manufacturers make special lifting devices that minimize valve damage during movement or installation of valves.

Resilient Wedge Flanged OS & Y Gate Valves

GENERAL SPECIFICATIONS
- Resilient-Seated Gate Valves to AWWA C509 (OS&Y)
- Flanged Ends to ANSI B16.1-1975 class 125
- Working Pressure 200 psi
- Test Pressure 400 psi



	H	H										Turns to	Weight
Ref Nos.	Size	Open	Closed	R	L	E	D	K	Holes	F	B	open	lb
25-065-46	2.5″	15.66″	13.06″	9.00″	7.50″	0.71″	7.00″	5.50″	4	3.94″	2.0″	17	50
25-080-46	3″	16.88″	13.78″	9.00″	8.00″	0.79″	7.50″	6.00″	4	4.33″	2.0″	20	55
25-100-46	4″	20.63″	16.53″	11.00″	9.00″	0.98″	9.00″	7.50″	8	4.96″	2.0″	21	85
25-150-46	6″	28.98″	22.88″	13.00″	10.50″	1.06″	11.00″	9.50″	8	6.22″	2.5″	26	139
25-200-46	8″	37.10″	29.00″	14.00″	11.50″	1.14″	13.50″	11.75″	8	7.13″	2.5″	35	214
25-250-46	10″	44.82″	34.72″	18.00″	13.00″	1.22″	16.00″	14.25″	12	7.99″	2.5″	37	346
25-300-46	12″	51.84″	39.74″	18.00″	14.00″	1.30″	19.00″	17.00″	12	8.50″	3.0″	44	525

Figure 3-1 Sample shop drawing (figure continues)

Parts List

No.	Part	Material
1	Yoke	Ductile iron, ASTM A536
2	Packing	Asbestos free
3	Bushing	ASTM copper alloy no. C35330, CZ 132
4	O-ring seals	Nitrile rubber, ASTM D2000
5	Valve bonnet	Gray iron, ASTM A126 class B Ductile iron, ASTM A536
6	Bonnet bolt seals	Wax
7	Bonnet gasket	Nitrile rubber, ASTM D2000
8	Bonnet bolts	Zinc coated steel, ASTM A164
9	Stem - A	ASTM copper alloy no. C35330, CZ 132
	Stem - B	ASTM copper alloy no. C99500, low zinc
	Stem - C	Stainless steel 13% chromium
10	Support ring	ASTM copper alloy no. 836, low zinc
11	Pin	Stainless steel
12	Stem holder	ASTM copper alloy no. C35330, CZ 132
13	Wedge, vulcanized	SBR-rubber compound, AWWA C509
14	Wedge body	Gray iron, ASTM A126 class B
15	Nut	ASTM copper alloy no. C35330, CZ 132
16	Pin	Stainless steel
17	Handwheel	Gray iron, ASTM A126 class B
18	Washer	ASTM copper alloy no. C35330, CZ 132
19	Stem nut	ASTM copper alloy no. C35330, CZ 132
20	Stud bolt	Zinc coated steel, ASTM A153
21	Gland follower	Ductile iron, ASTM A536
22	Gland	ASTM copper alloy no. C35330, CZ 132
23	Hexagon nut	Stainless steel, ASTM A320B18
24	Washer	Zinc coated steel
25	Valve body	Gray iron, ASTM A126 class B Ductile iron, ASTM A536

Figure 3-1 Sample shop drawing (continued)

OPERATING INSTRUCTIONS

WATER PRESSURE REDUCING VALVE

FIG. 4500

GENERAL:

The Figure 4500 Valve is designed to maintain a constant delivery pressure regardless of the valve's inlet pressure. The valve is factory tested and set for the required delivery pressure, but field adjustments can be easily made.

INSTALLATION:

The valve is installed with the inlet pressure entering the main valve in accordance with the arrow indication on the drawing or underneath the main valve piston - part #2. Care should be taken to avoid damage to control piping or valve position indicator rod during installation. If the valve is to be repainted, do not paint the indicator rod as it should be smooth and clean to avoid scoring the indicator packing during operation.

OPERATION:

The main valve operates on the differential piston principle such that the area on the underside of the piston is equal to the pipe area while the area on top of the piston is somewhat greater. When equal pressures are applied to both surfaces of the piston, a closing force results that is greater than the opening force, regardless of the line pressure.

To open the main valve, all that is required is to discharge the pressure on top of the piston to the downstream side of the main valve and the inlet pressure acting on the underside of the piston will force the piston open. Trapping pressure on top of the main valve piston will cause the valve to remain in its present throttled position. The downstream pressure should be less than about 80 percent of the inlet pressure for good operation.

SEQUENCE OF OPERATION:

Inlet pressure is constantly being admitted to the top of the main valve piston through a needle valve that is the closing speed control.

A downstream pressure-sensing pilot controls the main valve position by opening, when necessary, and exhausting the pressure above the piston to the valve's downstream side more quickly than water can enter the area above the piston through the needle valve. An increase in the downstream pressure will cause the pilot valve to close slightly. The flow through the needle valve will then exceed the exhaust through the pilot valve, resulting in a downward movement of the piston to a new throttling position.

The needle valve must be in some degree of opening at all times. This valve affects the main closing speed, and generally ¼- and ½-turn opening of the needle valve is adequate. A "hunting tendency of the main valve can usually be dampened by the needle valve. All other hand valves are usually fully open.

ADJUSTMENTS:

Needle Valve	— Closing Speed Control
Hand Valve	— Affects Main Valve Opening Speed If Necessary
Pilot Handwheel	— Turn Counterclockwise to Lower the Downstream Pressure Setting

MAINTENANCE:

When first installed, a slight drip may appear from the air vent tube. This drip should stop when the seals wear themselves in. Should the leakage become excessive, this usually implies that one or both of the seals need replacing.

Failing to maintain a constant pressure into a closed system may indicate the main valve piston seat rubber needs replacing or possibly the pilot seat #2 is damaged.

Erratic operation usually implies the pilot seat or seals are worn or damaged.

If seal replacement seems to occur too frequently on valves 12 in. and larger, the factory can provide different leather seal treatments such as "Thiokol treated leather seals, which are more abrasive resistant. On valves 2½ in. to 8 in. a high hardness rubber may be tried.

Anytime the valve is dismantled, it is recommended that the piston, liner, and seat crown machined surfaces be sanded shiny with a fine emery cloth. This will prolong seal life significantly. A light film of waterproof grease or petroleum jelly should be applied to the leather seals and sliding surfaces.

Periodic inspection of the valve is suggested so that repairs can be anticipated before a malfunction occurs and a system becomes overpressurized.

Figure 3-2 Information from an operations and maintenance manual

INSPECTION AFTER UNLOADING

Inspect valves to verify they are in working order after they are unloaded.

Operation

Large valves should be cycled through one complete opening and closing cycle in the position in which they are to be installed. This process will confirm the following:

- Ease of operation
- Complete travel of the shutoff mechanism direction
- Correct direction of opening
- Required number of turns

Smaller valves may also be cycled, or they can be tested after installation.

Specifications

The initial inspection also should verify compliance with specifications, including the following:

- Size and pressure class (cast in the valve sides so they can easily be confirmed)
- Direction of opening
- Size and shape of operating nut
- Number of turns to open or close
- Type of end connections

Verification of end configuration requires inspection by a person familiar not only with the local specifications and requirements but also with the various end configurations available, such as flanges, mechanical joints, push-on joint ends (various configurations), and combinations of the preceding. ANSI/AWWA C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings, and its references are invaluable in performing this inspection.

Shipping Damage

Inspectors should also check for shipping damage, such as:

- Scoring of the seated surfaces
- Bent stems
- Broken handwheels
- Cracked parts, chipped coatings
- Missing parts and accessories
- Missing lubrication on exterior actuators
- Coating problems, which can be detected with a simple "holiday detector"

After the valves have been inspected, accurate records must be created. Records should include the size and type of valve, time and date of receipt, where the valve is to be stored, comments on inspection and verification, and any comments about the shipment and the way it was received. Chapter 5 discusses record keeping in more detail.

STORAGE

Once records have been made, valves should then be stored in a way that protects them from the environment.

- Valves that are large physical size and weight require the facility to be preplanned to accommodate the valves.
- Metal-seated valves should be stored in the fully closed position to prevent entry of foreign material that could cause damage to the seating surface.
- Resilient-seated valves should be stored in the nearly closed position (rather than fully closed) to avoid unnecessary compression of the resilient material.
- Resilient seats should be protected from sunlight, ozone, and chemical exposure.
- Whenever practical, valves should be stored indoors. If outside storage is required, the operating mechanisms, such as gears, motors, actuators, and cylinders, should be protected from the weather and foreign elements.
- In colder climates, valves should be drained and left slightly open before storage. Failure to do so may result in a cracked valve casting.
- Valves stored outside in cold climates should be stored with the discs in a vertical position. If the discs are in a horizontal flat position, rainwater can accumulate on top of the top disc, seep into the valve body cavity, and then freeze and fracture the casting.
- Electric motor–operated valves should never be stored outdoors because of the sensitivity of electrical contacts to corrosion.

BOLTS

If experience, tests, or observations indicate bolts may be exposed to corrosive environments, the valve may be wrapped or encased with polyethylene sleeving as detailed in ANSI/AWWA C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems. Alternatively, the valve should use specially coated bolting, such as galvanized, cadmium, or special baked-on resin. Stainless-steel bolts may also be used.

Chapter 4

Installation

Many valve problems and failures can be traced to improper installation, operation, or maintenance procedures, or improper valve application. Valve failure can result in customer disruptions and extensive, costly excavations and repairs.

This chapter presents guidelines for valve installation that usually apply with a focus on buried gate valves installed throughout a water distribution system. Of course, each situation is unique and may require special construction techniques or design.

INSPECTION BEFORE INSTALLATION

At the jobsite, installers should establish a step-by-step routine to ensure that valves are properly inspected before they are installed. The routine should include the following steps:

1. Ensure that the proper valve(s) have been delivered to the jobsite. This includes proper type, size, and pressure rating for the application.
2. Determine the direction of flow in the line to ensure proper installation. Some valves are not bidirectional. Direction of flow is critical when swing-check valves are being installed. Swing-check valves should be mounted with flow in the upward (vertical) flow direction (never the downward flow direction); however, with lever and weight valve styles, the configuration of the weights must assist in closing the valve. Gate valves generally can be installed for flow in either direction.
3. Visually inspect each valve and remove any foreign material in the interior portion of the valve. Foreign material left in the valve can damage internal working parts and may create a contamination problem.
4. Conduct a detailed inspection of the valve similar to the one done on receipt, as discussed in chapter 3.
5. When valves with exposed gearing or operating mechanisms are installed belowground, a vault must be provided to allow pipe clearance and prevent settling on the pipe.

INSTALLATION

Once the preliminary steps have been completed, proper installation generally involves the following steps:

1. Support piping systems and components to minimize alignment issues at the valve connections.
2. Install valves in the closed position to prevent any foreign material from entering the valve.
3. Place the valve on firm footing by providing support in the trench to prevent settling.
4. Install the valve in alignment with the pipe to prohibit excessive strain on the connection to the pipe. Preventing any strain on the connection is critical in flanged installations. Flange fracture can result from unequal tightening of the joints. Figure 4-1 shows the proper technique for installing and tightening the bolts of flanged valves. Important details include the following:
    a. Support and align valves.
    b. Clean dirt and grit particles from all parts.
    c. Insert bolts and nuts and tighten by hand.
    d. Tighten bolts and nuts by using the crossover method shown in Figure 4-1. Tighten the bolts and nuts across the connection from each other until the joint is uniformly tight (do not tighten the bolts and nuts in rotation). This crossover method will load both pipe and valve evenly and eliminate any concentrated stresses.
    e. Ensure that all bonnet bolts are properly tightened to design/manufacturer specifications. Bonnet bolts may have loosened during transportation. Use the same crossover method to verify tightness.
5. Provide a valve box or vault for each valve used in a buried-service application. The valve box should be installed so as not to transmit shock loads or stress to the valve or valve actuator. When valves with exposed gearing or operating mechanisms are installed belowground, a vault must be provided to allow pipe clearance and prevent settling on the pipe.
6. If groundwater or surface water enters the vault, the vault floor should include a recessed drainage area or sump pump to allow for removal of water from the vault. Figures 4-2 through 4-6 show one utility's drawings of its standard valve casing, extension and plug, top and bottom sections, and bonnet. Figure 4-7 shows a cross section of a valve vault.

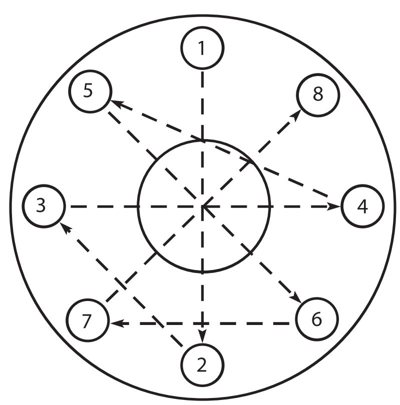


Figure 4-1 Crossover tighten method

7. Center the valve box over the operating nut of the valve. The box cover should be flush with the surface of the finished area. The operating nut should be accessible from the top opening of the vault with a valve key. The valve box should be installed in a manner that will not exert force created from street traffic to the valve.
8. If installing a larger valve that uses smaller bypass valves, install a second valve box over the bypass valve operating nut. Make sure to record the specifics of the bypass valve in the permanent records. The bypass valves play a critical role during shutdowns and startup operations.
9. If the valves must be buried in an unusually deep trench, install a riser on the stem to permit a normal key to be used or make a notation in the valve records (discussed later in this chapter) that a long key will be required for operation.

The following are additional elements for consideration during the installation process related to the corrosion protection of the components:

1. Depending on the corrosiveness of the soil, a passive anode can be inexpensive insurance for aggressive soils, dissimilar metals, stray current, and other conditions that potentially result in external corrosion.
2. Another inexpensive corrosion control method is to poly wrap the pipe and appurtenances, including valves, prior to backfilling in accordance with AWWA standards.

PRESSURE TESTING THE WATER MAIN AND VALVES AFTER INSTALLATION

Where possible and to avoid spending valuable time searching for leaks, crews should wait to backfill valve excavations until pressure tests have been completed. They should perform tests on newly installed piping sections and conduct valve tests at pressure levels higher than the system design pressure. The engineer's or manufacturer's recommended test pressure should be used. Test pressure and allowable leakage for given lengths and types of pipes and joints are given in AWWA standards and manuals.

1. After installation and before pressurization, inspect and tighten all bolts (bonnet, seal-plate, bypass, and end connections) for adequate tightness to prevent leakage. Also, all air must be removed prior to pressure testing the water main. This is generally accomplished by flushing the system. Make sure that all valves that are within the test section (except the end valves) are in the open position.
2. Inspect all tapped and plugged openings of the valve interior for adequate tightness. Proper inspection at this time will minimize the possibility of leaks once the piping system is pressurized.
3. The test pressure should not exceed the rated valve pressure when resilient-seated gate valves or butterfly valves are used to isolate a test section.
4. When metal-seated gate valves are being used as closure pieces for a test, the pressure should not exceed twice the rated valve pressure. Metal-seated valves have an allowable leakage, and this should be determined before the test. For tests at pressures greater than the rated valve pressure, the test setup should include a reduction of the line pressure to the rated valve pressure (independent of the valve) on completion of the test. The valve can then be opened enough to release trapped pressure and equalize it with the line pressure. The valve should not be opened or closed at differential pressures above its rated working pressure.
5. Pressure tests should not be performed on sections of the system that have been connected to the water distribution system, as this could be a source or potential for cross connection and contamination of the potable system. Caution should be taken to ensure proper restraint is provided for all pipe and valve joints especially at dead

ends. The connection to an existing system should be done after the pressure test and biological test are completed.

6. When installation is finished, a complete record of the installation should be made to serve as a reference during maintenance and repair.
7. Once the pressure test is complete, the pipeline section must go through a disinfection test, which needs to be performed according to the engineer requirements, before it is operational.

BEFORE REPLACING AN EXISTING VALVE

Although installation and replacement are very similar, there are a few additional considerations. The routine for a valve replacement should include the following steps:

1. As part of the planning process, several items need to be field verified. Pipe size and material are both important information for planning and ordering replacement parts. It is important to verify the need for restrained joints. Unrestrained pipe has the potential to come undone, quickly flooding the excavation and overwhelming dewatering systems. Field verification can identify other interferences that may need to be addressed before or during the valve replacement.
2. The planning process for replacing a valve needs to include determining how the existing pipe and new valve will be connected. This will ensure the correct parts are on hand. Generally this means either mechanical joint fittings with a short piece of pipe on either side of the new valve, using couplings with a short piece of pipe on either side of the new valve, or replacing a flange valve with another flange valve. Replacing a flange valve with a flange valve will require sufficient space to slide the valve into place for installation.
3. Determine the direction of flow in the line to ensure proper installation. As mentioned previously, some valves are not bidirectional. Direction of flow is critical when swing-check valves are being replaced. Swing-check valves should be mounted with flow in the upward (vertical) flow direction (never the downward flow direction); however, with lever and weight valve styles, the configuration of the weights must assist in closing the valve. Control valves often are designed to flow in one direction.
4. Usually gate valves can be installed to handle flow in either direction.
5. Conduct a detailed inspection of the valve similar to the inspection on receipt, as discussed in chapter 3.

REPLACEMENT VALVE INSTALLATION

Once the preliminary steps have been completed, proper installation generally involves the following steps:

1. Support piping systems and align components to minimize bending at the valve connections.
2. Visually inspect each valve and remove any foreign material in the interior portion of the valve. Foreign material left in the valve can damage internal working parts and may create a contamination problem. Also, clean all pipe sections and coupling as needed. To clean and sanitize the valve, use a 2 percent chlorine solution to clean and disinfect all areas that will come into contact with potable water.
3. Place the valve on firm footing in the trench to prevent settling. The use of a brick or a concrete block may suffice. Do not use wood blocking.
4. Install the valve in alignment with the pipe to prohibit excessive strain on the connection to the pipe. Preventing any strain on the connection is critical in flanged

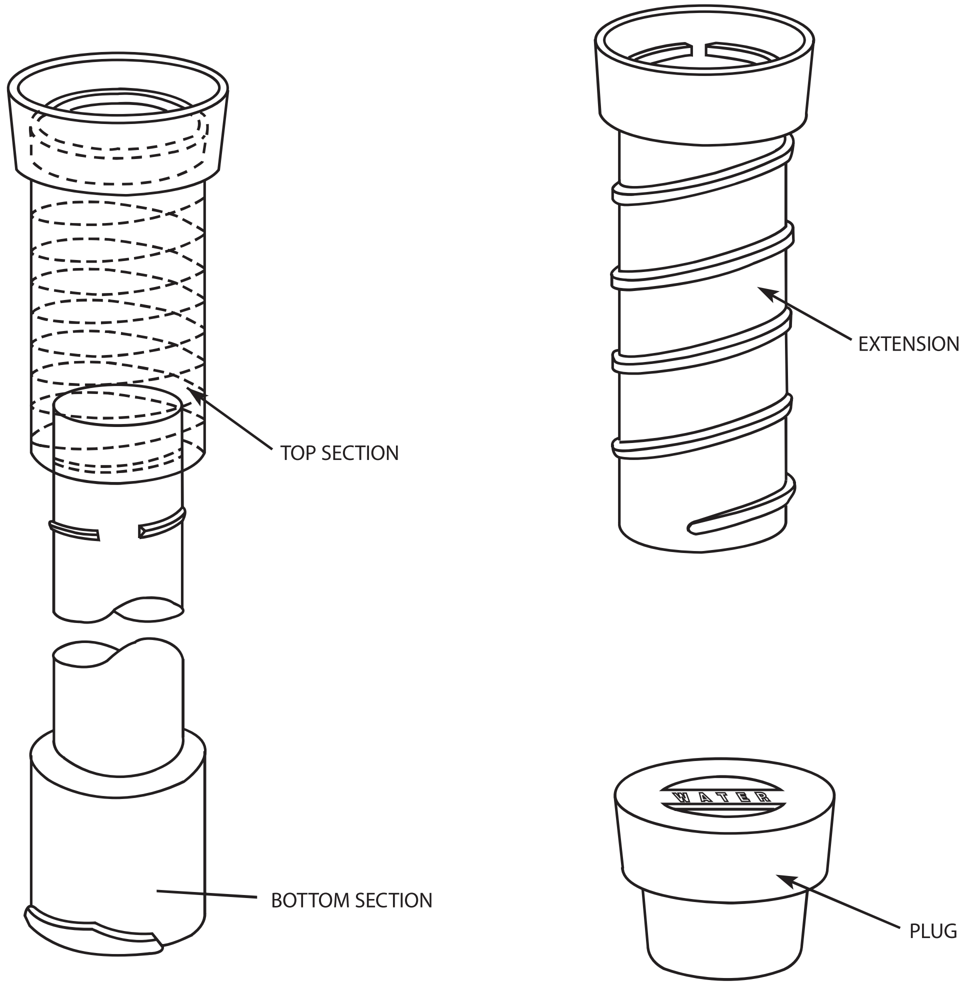
installations. Flange fracture can result from unequal tightening of the joints. Figure 4-1 shows the proper technique for installing and tightening flanged valves. Details of installation include the following:

   a. Support and align valve.
   b. Insert bolts and nuts and tighten by hand.
   c. Tighten bolts and nuts by using the crossover method shown in Figure 4-1. Tighten the bolts and nuts across the connection from each other until the joint is uniformly tight (do not tighten the bolts and nuts in rotation). This crossover method will load both pipe and valve evenly and eliminate any concentrated stresses. Use the manufacturer's recommended torque specifications.

5. Provide a valve box or vault for each valve used in a buried-service application. The valve box should be installed so as not to transmit shock loads or stress to the valve or valve actuator. When valves with exposed gearing or operating mechanisms are installed belowground, a vault must be provided to allow pipe clearance and prevent settling on the pipe. The valve box and/or vault must be of proper height to allow these components to be flush with the final grade or roadway.

Some additional elements for consideration during the installation process related to the corrosion protection of the components include the following:

1. Depending on the corrosiveness of the soil, a passive anode can be inexpensive insurance for aggressive soils, dissimilar metals, stray current, and other conditions that potentially result in external corrosion.
2. Another inexpensive corrosion control method is to poly wrap the pipe and appurtenances, including valves, prior to backfilling in accordance with AWWA standards.



DESIGN SPECIFICATIONS:
TOLERANCES OF ± 3mm ALLOWED FOR CASTING DIMENSIONS OF 25mm OR LESS.
TOLERANCES OF ± 6mm ALLOWED FOR CASTING DIMENSIONS IN EXCESS OF 25mm.
ALL CASTINGS TO BE IN ACCORDANCE WITH ASTM A48.
MINIMUM TENSILE STRENGTH 207 Mpa (30,000 psi)

The Public Water Utility — ENGINEERING

DRAWN BY ______ DATE ______ SCALE ______	STANDARD DETAIL DRAWING VALVE CASING
DESIGN ______ DATE ______ CHECKED ______ DATE ______ SENIOR ENGINEER	APPROVED ______ DATE ______ CHIEF ENGINEER — DWC: 60-012 — REVISION 0

Figure 4-2 Drawing of a typical valve casing

Source: Courtesy Kanwal Oberoi.

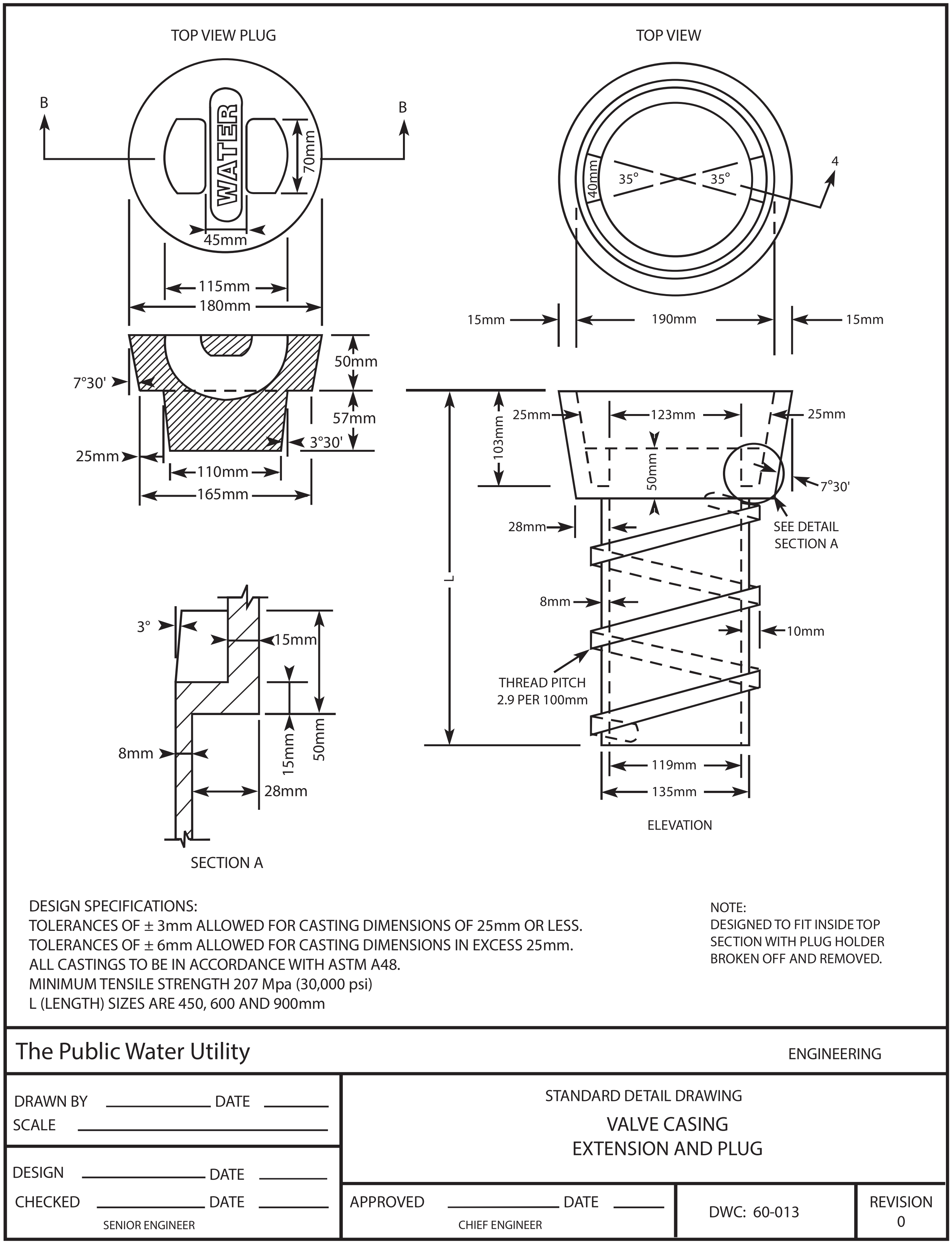


Figure 4-3 Drawing of a typical valve casing extension and plug

Source: Courtesy Kanwal Oberoi.

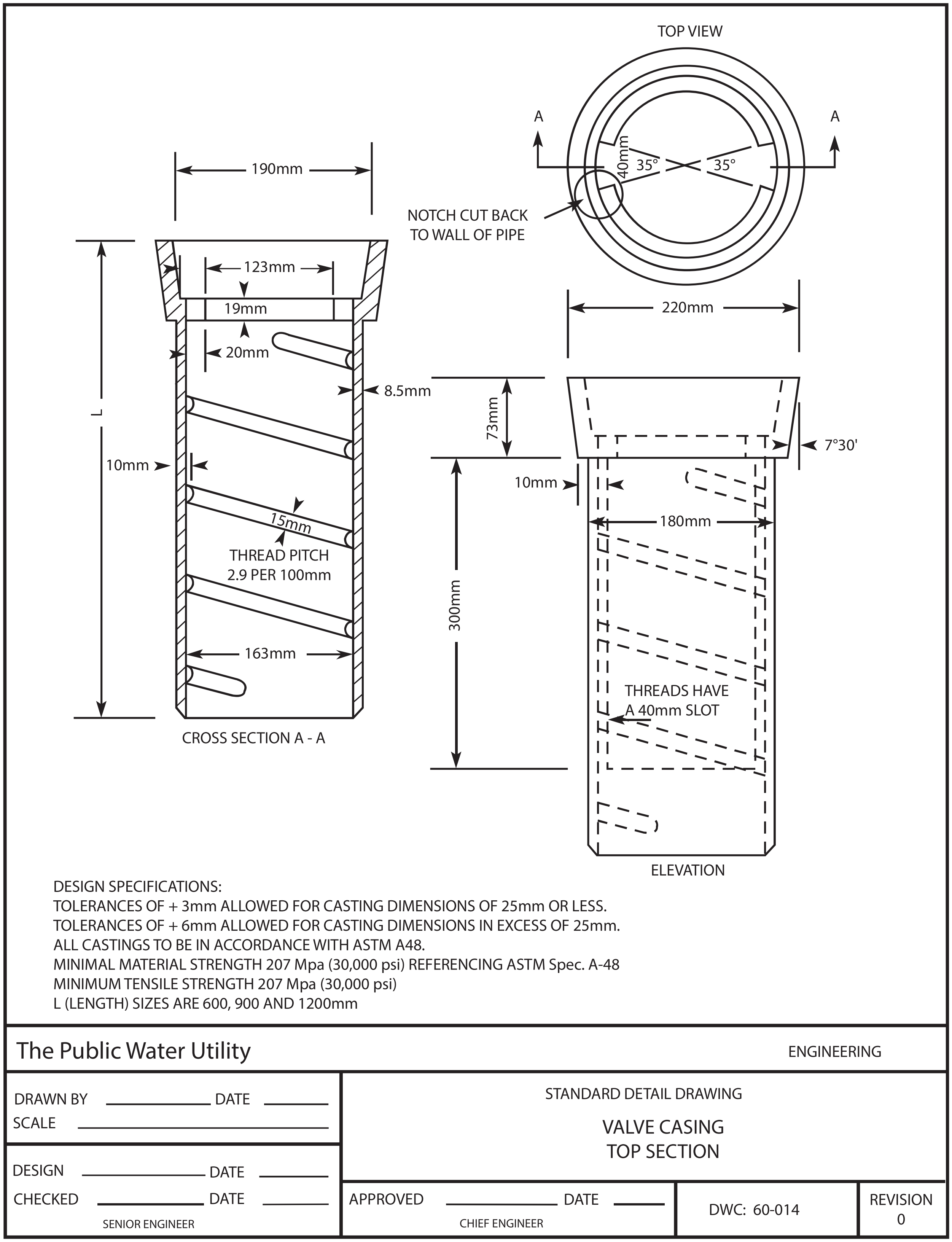
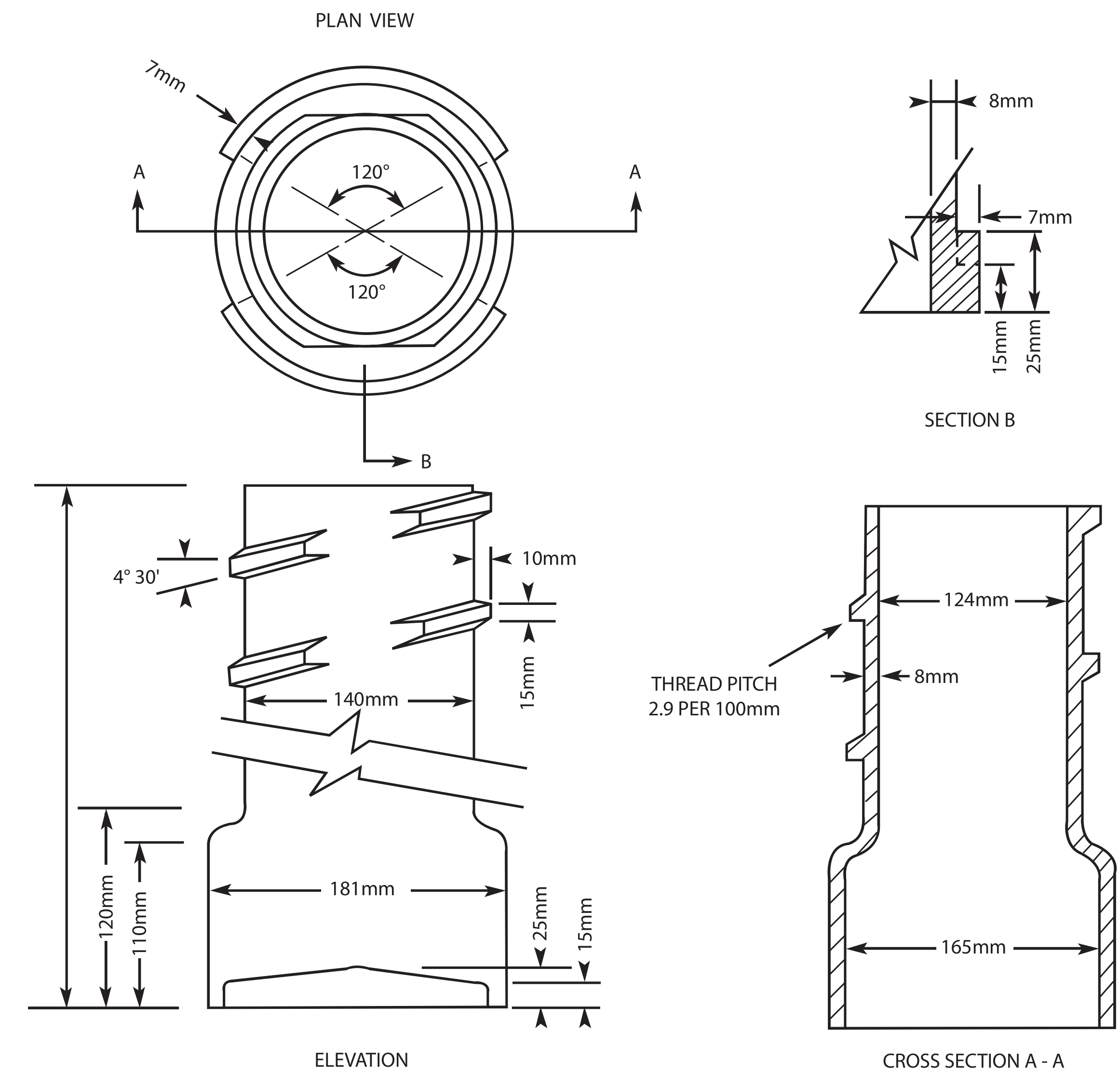


Figure 4-4 Drawing of a typical valve casing top section

Source: Courtesy Kanwal Oberoi.



DESIGN SPECIFICATIONS:
TOLERANCES OF ± 3mm ALLOWED FOR CASTING DIMENSIONS OF 25mm OR LESS.
TOLERANCES OF ± 6mm ALLOWED FOR CASTING DIMENSIONS IN EXCESS OF 25mm.
ALL CASTINGS TO BE IN ACCORDANCE WITH ASTM A48.
MINIMUM TENSILE STRENGTH 207 Mpa (30,000 psi)
L (LENGTH) SIZES ARE 900, 1200 AND 1500mm

The Public Water Utility — ENGINEERING

DRAWN BY ______ DATE ______ SCALE ______	STANDARD DETAIL DRAWING VALVE CASING BOTTOM SECTION		
DESIGN ______ DATE ______ CHECKED ______ DATE ______ SENIOR ENGINEER	APPROVED ______ DATE ______ CHIEF ENGINEER	DWC: 60-015	REVISION 0

Figure 4-5 Drawing of a typical valve casing bottom section

Source: Courtesy Kanwal Oberoi.

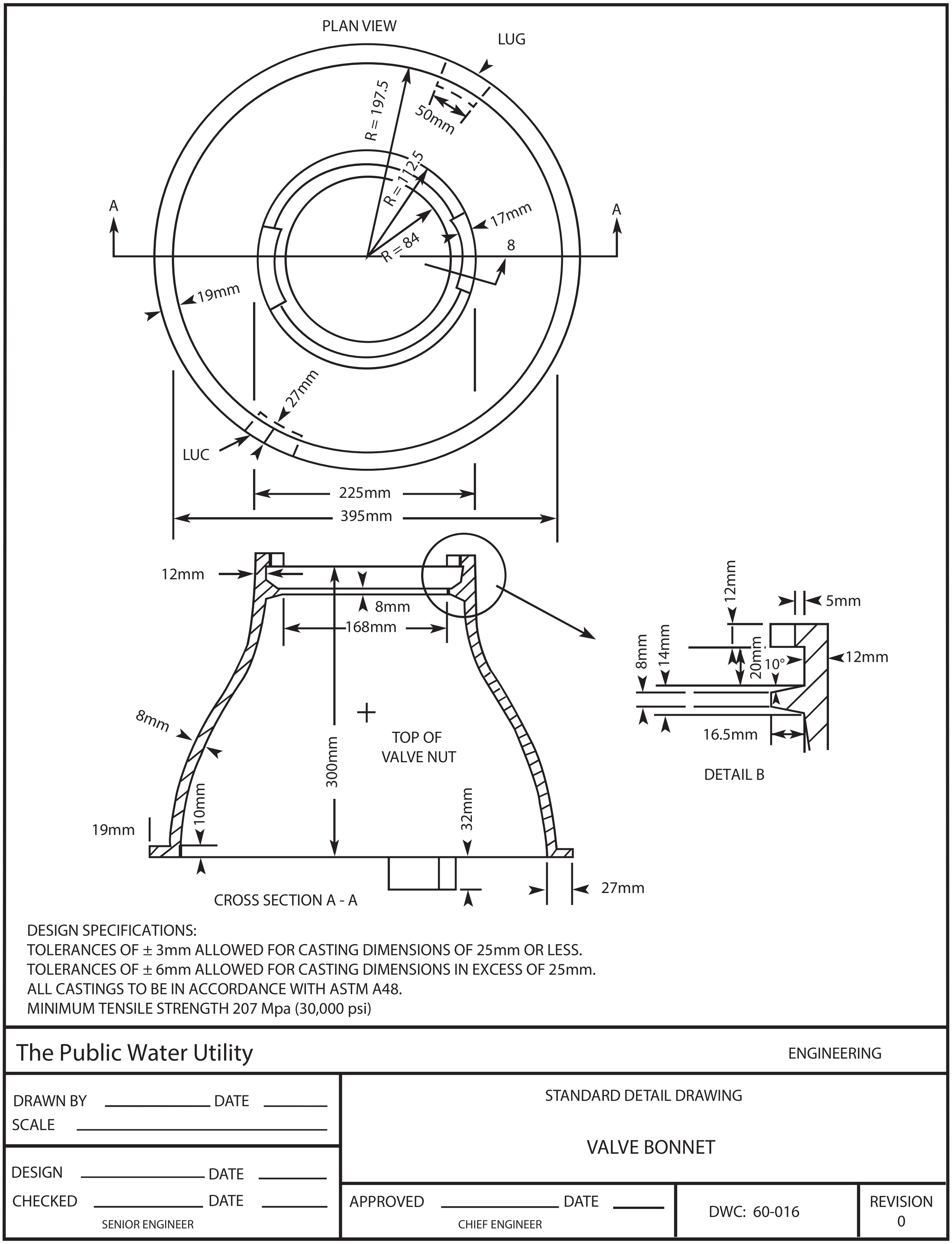


Figure 4-6 Drawing of a typical valve bonnet

Source: Courtesy Kanwal Oberoi.

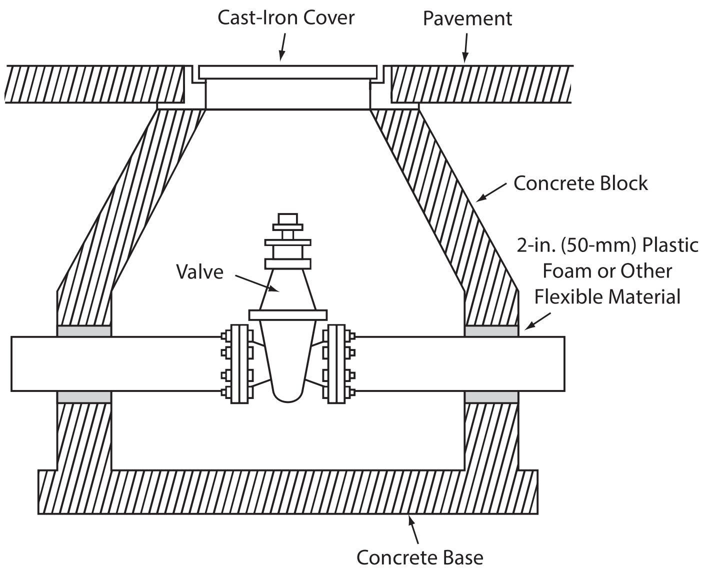


Figure 4-7 Valve vault cross section

Typically, valves placed in a vault as depicted in Figure 4-7 should include a sump area for dewatering purposes. This will facilitate working in a dry environment.

There is great value and importance to torqueing a valve according to the manufacturer's required standard. Correspondence with the manufacturer to get proper torquing specification should be done to facilitate the valve's effective installation and operation. See Table 4-1 for an example of torquing standards.

Table 4-1 Flange bolting specifications*

Valve Size	ANSI/PN Class Rating	Bolt Length (*inches/cm*)	Torque for Low Strength (*ft. lbs./joules*)	Torque for Intermediate Strength (*ft. lbs./joules*)
1-in.	150/PM 16	2.50/6.35	25/31	61/83
DN 25	300/PN 40	3.00/7.62	46/62	122/165
	600/PN 100	3.50/8.89	46/62	122/165
1.5-in.	150/PN 16	2.75/6.99	23/31	61/83
DN 40	300/PN 40	3.50/8.89	82/111	218/296
	600/PN 100	4.25/10.80	82/111	218/296
2-in.	150/PN 16	3.25/8.26	46/62	122/165
DN 50	300/PN 40	3.50/8.89	46/62	122/165
	600/PN 100	4.25/10.80	46/62	122/165
3-in.	150/PN 16	3.50/8.89	46/62	122/165
DN 80	300/PN 40	4.25/10.80	82/111	218/296
	600/PN 100	5.00/12.70	82/111	218/296
4-in.	150/PN 16	3.50/8.89	46/62	122/165
DN 100	300/PN 40	4.50/11.43	82/111	218/296
	600/PN 100	5.75/14.61	132/179	353/479
6-in.	150/PN 16	4.00/10.16	82/111	218/296
DN 150	300/PN 40	4.75/12.07	82/111	218/296
	600/PN 100	6.75/17.15	199/270	531/720
8-in.	150/PN 16	4.25/10.80	82/111	218/296
DN 200	300/PN 40	5.50/13.97	132/179	353/479
	600/PN 100	7.50/19.05	296/401	789/1070
10-in.	150/PN 16	4.50/11.43	132/179	353/479
DN 250	300/PN 40	6.25/15.88	199/270	531/720
	600/PN 100	8.50/21.59	420/570	1119/1517
12-in.	150/PN 16	4.75/12.07	132/179	353/479
DN 300	300/PN 40	6.75/17.15	296/401	789/1070
	600/PN 100	8.75/22.23	420/570	1119/1517

Source: Courtesy of Valtek International.
*Note: Lengths are based upon ANSI Standard B16.5 studs used with raised face bodies

Chapter 5

Valve Asset Management

This chapter focuses on the asset management of valves with specific reference to valve operations and maintenance. Valves are designed to control the flow of water through pipes. Valves are one of the few transmission and distribution system assets that are accessible from the surface. The importance of valve assets continues to increase as buried infrastructure continues to age. If not consistently operated, the probability of effectively opening and closing an older valve decreases over time. Furthermore, properly functioning valves protect the entire distribution system and ultimately the customer. The focus of this chapter is on how to most efficiently and effectively manage valve assets and the risks associated with those assets.

VALVES—DYNAMIC ASSETS

Valves (control assets) are dynamic assets—they are designed to open and close, thereby controlling the flow of water through pipes. Pipes (delivery assets) are static assets—they are designed to be always open and continually allow the flow of water. The dynamic valve assets are point assets, and the static pipe assets are line assets. In water systems, valve assets protect and control static assets. Because valve assets (or at least their operators) are accessible from the surface, valves can be specifically located, assessed, improved, and documented.

Importance of Valve Assets

Asset management is a risk-based management approach in which risk can be characterized as follows:

$$\text{Risk} = \text{Consequence of Failure} \times \text{Probability of Failure}$$

When water systems are newer, there is significantly less probability of failure (breaks, leaks, water quality problems, fire flow reductions, etc.) and the overall risks to the transmission and distribution systems are relatively low. However, with aging underground infrastructure and in some cases inadequate proactive maintenance, the probability of failure increases dramatically. The industry frequently experiences the consequence of inoperable valves. When system valves are broken or inoperable, the section to be isolated becomes much larger, impacting more customers. Additionally, the time required to isolate (and stop the damage) may become much longer because valves are not working. Proactively managed valve systems reduce the consequence of inoperable valves and failures by reducing the area that requires isolation. This reduces the impact to customers while expediting repair time.

Valves—the Physical Asset

There are two primary aspects of the ability for a valve to "control." First, the physical asset must be useable. In order for a physical valve asset to be useable (be able to turn off water flow), the valve must be:

1. *Locatable* (you need to be able to find the right valve in a reasonable period of time even in areas impacted by weather events)
2. *Accessible* (once the correct valve is found, you must be able to access the operating nut on that specific valve)
3. *Operable* (once the correct valve is found and the operating nut is accessible, you must be able to close and open the valve)

If any one (or more) of these critical physical attributes is not achieved, the valve cannot be used to turn on or turn off water. Any failure (locatability, accessibility, or operability of an individual valve) will prevent the valve from fulfilling its purpose. Asset management of valve assets takes into account all three physical facets: locatability, accessibility, and operability.

Valves—the Information Asset

In addition to the physical valve being locatable, accessible, and operable, the information on the specific valve asset must be:

1. *Accurate* (correct and complete information on valve attributes)
2. *Meaningful* (the right attributes are documented and are correct)
3. *Accessible* (the meaningful and accurate information is accessible to the specific person who is going to locate, access, and operate the valve)

If any one (or more) of these critical information attributes is not achieved, the effectiveness of the valve is significantly degraded.

VALVE ASSET MANAGEMENT

Asset management has been described as "a combination of management, financial, economic, engineering, and other practices applied to physical assets with the objective of maximizing the value derived from an asset stock over the whole lifecycle, within the context of delivering appropriate levels of service to customers, communities, and the environment and at an acceptable level of risk" (*International Infrastructure Management Manual* [IPWEA 2006]). Proactive valve asset management is by definition proactively maintaining the level of service required while extending the useful life of a control asset.

Valve Asset Management Components

Asset inventory. The first step to building an asset management program is to compile the known data on the assets. This is usually called an *asset inventory*. It includes items such as the asset indentification (ID); location; GIS (geographic information system) coordinates; size; date of installation; manufacturer; accessibility; valve turns; direction to close; and torque required to turn the valve. Table 5-1, at the end of this chapter, contains a sample asset inventory for valve assets.

Additional elements in prioritizing/managing valve assets are outlined in the following sections and include risk, frequency, geography, and the proactive/planned approach.

Risk. As mentioned previously, risk can be characterized as:

$$\text{Risk} = \text{Consequence of Failure} \times \text{Probability of Failure}$$

As previously discussed, valves control the flow of water and thus protect pipes, tanks, fire hydrants, pump stations, and customers. Much has been discussed in AWWA publications with respect to the criticality of pipe and pipe segments. Like pipes, valves have measurable dimensions of risk and can also be prioritized.

Typical factors that contribute to the *consequence of failure* of valves are:

- The fire protection disruption when shutting down a larger area will be more severe as a result of broken valves
- The area and the number of customers served by the valves that are needed to isolate the section of water main
- The types of customers served by the impacted area can be schools, manufacturers, and hospitals (large number of critical customers)
- The probability of nearby pipe failure (or the probability of a nearby problem such as low pressure or poor water quality)
- The business disruption caused by increasing the area impacted by the shutdown
- The additional traffic disruption caused by a valve not being operable
- The environmental impact of a valve not being usable

Typical factors that contribute to the *probability of failure* of valves are:

- The age of the valve
- The work history or known condition of that valve
- The type of valve, e.g., gate, butterfly, cone, and so on
- The accessibility of the valve (is it in a chamber or buried below the street)
- The manufacturer of the valve
- The utility's history with valves of similar type, size, manufacturer
- The depth of the buried valve
- Corrosive soils or scaling water
- Stray currents

Each water system can have different dimensions and weightings when calculating the risk of valves. In most cases in-line transmission main valves are obviously critical (high risk), but it is not always immediately apparent that a 6-in. sideline isolation valve (off of a transmission main) can also be just as critical. If sufficient detailed system data exists, there are software packages that can help a utility calculate valve criticality. A sample summary criticality matrix (see Table 5-4) showing the probability of failure and consequence of failure for valve assets is included at the end of this chapter.

Frequency. Many utilities use the criticality approach to prioritize asset management activities on valve assets. Typically, valves deemed critical are inspected and exercised on an annual basis, and other less critical valves in the system should be inspected and exercised based on the level of service established by the agency. The intent of valve asset management is to proactively and selectively schedule and perform condition assessment and operations of valve assets in a preplanned manner. Metrics for valve asset management should include written goals and objectives on the process of scheduled asset management activities as well as a tracking mechanism to measure the actual number of assets (by category) per year.

Valve asset management can be a daunting undertaking especially if the utility has not previously systematically performed these activities. Implementing written measurable goals and objectives is an excellent starting point for implementing a sustainable valve asset management program. Each agency should establish its own schedule of valve operation that is consistent with its capacity to perform the work to guarantee the effective operation of the assets. In the end, success not only is a matter of the frequency of inspections but also depends on each agency having a plan in place to regulary inspect its valve assets.

Geography. An alternative to taking a criticality approach, is to methodically work through the entire network from north to south, east to west, tile by tile, or plat by plat. A geographic approach (coupled with criticality) is an excellent sustainable approach to systemwide valve asset management.

Proactive and planned approach when time is available. A preferred approach to valve asset management, and the one demonstrated most successful, is one that provides a written plan, with goals and objectives and dedicated resources directed to proactive asset management activities.

An alternative approach to valve asset management is one in which utility resources (personnel, equipment, processes) are utilized during "down times" to perform proactive asset management activities. The daily demands of system operations and customer service rightly trump proactive activities, and therefore it is difficult for many utilities to drive continuous measurable progress using this approach.

When repair/rehabilitation or replacement is necessary. One of the outcomes of a proactive valve condition assessment and operation program is assets are identified that are evaluated as "unusable" and need some type of repair, rehabilitation, or replacement. Using the criticality analysis, coupled with a cost comparison (of repair versus rehabilitation versus replacement), the utility can also prioritize repairs. If a valve is not usable (and it is open), it acts just like another piece of pipe. Not all valves have the same importance or criticality, and therefore not all repairs/rehabilitations/replacements have the same importance or criticality. How the utility prioritizes and addresses valve work orders is highly dependent on the business processes in place in the agency. Some organizations have crews that operate only, or provide maintenance only, or perform replacements only. Other agencies have crews that provide either a combination of these services or all of them during the course of their assigned work.

Guidelines for Valve Operation and Replacement

Critical elements in valve operation and replacement are outlined in the following sections.

Valve condition assessment and operation. The following is a list of key elements in the assessment and operation of valves:

- Condition assessment includes locating, accessing, and operating the valve, and accurately documenting meaningful information in a location that is accessible.

- Condition assessment and operation of each critical valve and all valves 16 in. and larger should be completed on a regularly scheduled (annual if possible) basis.
- Condition assessment and operation of the majority of valves in a distribution system should be conducted on a three-year to five-year cycle or based on the criteria established by the agency. With historical performance data, the usability decay rate (the rate at which valve assets are rendered unusable due to locatability, accessibility, and/or operability challenges) can be modeled, and this cycle can be further refined to make the best use of asset management investments.
- All gate valves should be physically cycled from full open to close and back open at least once every five years or on a timetable based on the criteria established by the agency.
- When operating a valve, use the lowest torque possible. Do not force the valve.
- If a gate valve is difficult to operate, apply low torque in the closed, then open, then closed direction up to 20 times in an attempt to free up the valve before increasing torque.
- If a gate valve is difficult to operate and has not been operated for an extended period of time, begin with the lowest torque required to turn the valve in the closed direction, moving through 5 to 10 rotations. Reverse for 2 or 3 rotations. Reverse again and rotate 5 to 10 more turns in the closing direction. Repeat this procedure until full closure is attained. Once the valve is fully closed, it should be opened a few turns so that high velocity water flowing under the gates can move the remainder of the sediment in the valve seat. The reason for this cautious approach is that in many gate valves, debris and sediment can build up on the gates, stem, and slides. If this material is compacted while the valve is being closed, the torque required to close the valve continues to build as the material is compacted. If the procedure above is used, the stem and other parts are "scrubbed" by the series of back-and-forth motions, and water in the system can flush the debris that has broken loose away from the stem gate and slides or guides.
- Condition assessment includes examining the condition of the valve box or vault.
- When proactively operating a valve, the valve should be slowly closed, opened, closed, and then reopened. This cycling of the valve should continue until the turn count and the torque required to operate the valve stabilizes.
- Preventive maintenance should be performed as necessary or as suggested by the manufacturer. Some valves (such as butterfly valves that have a seating where a resilient coating meets stainless steel, or valves with actuators isolated from the contents of the line) may need less exercise. The manufacturers' guidelines should be followed.
- During the condition assessment and operation, valves on transmission mains that are associated with the primary source of supply or the only source of supply in a particular area, should only be cycled partially. (In order to not cause an inadvertent outage or hydraulic lock of a gate valve.)
- Caution should be exercised when large valves in critical single-source transmission mains are cycled to the fully closed position.

Valve information. Key information needed about valves may be summarized as follows:

- Condition assessment includes accurately documenting valuable information, including the specific location of the valve asset.

- Some information may only need to be documented once (such as GPS position, type of valve, manufacturer, year of installation, etc.).
- Condition assessment and operation information should be updated in GIS, CMMS (computerized maintenance management system), and/or the utility's EMS (enterprise management system).
- Valve physical data (size, type, manufacturer, date of installation, etc.), location (GPS position), and operational data (torque, turns, close direction, etc.) should be documented digitally. Paper valve cards are useful for documenting historical valve information and this data and future data should be tracked digitally, minimally in an electronic tabular format and preferably in a GIS, CMMS, or EMS. Accurate and up-to-date valve data and information are an integral part of an agency's ability to validate the effectiveness, integrity, and reliability of its system. This information has great value to local fire departments, oversight agencies, and/or regulatory agencies, along with organizations providing ratings for insurance purposes to businesses and homes in the impacted areas.
- The record of the valves should be detailed enough to provide information to reflect the history and reliability.
- Valve records should include, at a minimum, the following information:
  - —Physical characteristics
    - *Size:* 6 in., 8 in., and so on
    - *Type:* double-disk gate, resilient-seated gate, butterfly, cone, check, and so on
    - *Function:* in-line main, hydrant isolation, service line, bypass, division, pressure reducing, and so on
    - *Access:* roadway box, vault, pit, and so on; and lid size
    - *Actuator:* external geared, internal geared, torque reduction device, remote operated, and so on
    - *Cover:* asphalt, concrete, dirt, and so on
  - Location characteristics
    - *GPS coordinates:* submeter or less; from this position the valve can be located via any electronic mapping system or software, and distances from street centerlines can be calculated, as can the street, address, and so on
    - *Asset unique identifier:* ties the unique valve asset to databases and systems
  - Operational characteristics
    - *Direction to close:* close right, close left
    - *Turns:* number of turns required to fully open or close the valve
    - *Position:* open, closed, partially open
    - *Date last operated:* date
    - *Operable:* yes, no
    - *Deficiencies:* detail on any deficiency outstanding that is required to bring the valve assembly back into full usability, such as frozen, requires cleanout, broken stem, rounded operating nut, packing leak, and so on

Additional information, such as manufacturer, year installed, model, depth to operating nut, whether there is a stem extension on the operating nut, and existing work orders, should be documented if the information is available. When documenting valve assets, it is important to realize that much of the information is static (such as the location, size, type, etc.) while a portion of the data is dynamic over time (position, date last operated, operable, etc.).

Valve repair/rehabilitation/replacement. Two observations about valve repair/rehabilitation/replacement are worth noting here:

- Similar to determining the criticality of valves for ongoing asset management (condition assessment and operation), all problems with valves should be prioritized. Repair/rehabilitation/replacement prioritization decisions are dependent not only on the criticality of the valve itself but also on the cost of returning the asset to usability. For example, the highest priority repairs are those where the valve has high criticality and the repair activity is low cost.
- Condition assessment and operation information should be updated in GIS, CMMS, and/or the utility's EMS.

VALVE ASSET MANAGEMENT—SAMPLE RISK SCORING PLAN

The first part of a valve asset management risk scoring plan is the valve asset inventory (see Table 5-1). This inventory is a list of the valves and their respective attributes such as the ID, location, size, year installed, manufacturer (if known), number of turns, torque, and any other attributes the utility wants to record.

The second section of a valve asset management risk scoring plan is the consequence of failure matrix (see Table 5-2). The intent of the matrix is to capture the consequences to the overall water distribution system if the valve is not functional. It is important to remember that while some of the attributes (such as function and redundancy) can be calculated relatively easily, there might be attributes (such as community impact) that require asset managers to use their best judgment.

Table 5-1 Example valve asset inventory

Valve Asset Hierarchy – Sample Plan

Valve ID	Location	Coordinates		Size	Date installed	Manufacturer	Type	Accessability	# Turns	Original Torque
(#)	(Address)	(X)	(Y)	(in)	(Year)	(Name)	(Name)	(type)	(#)	(lb)
V-1	14 Charles HR Drive	2453.55	5682.46	36	1951	ABC Co.	Gate	vault	120	unknown
V-2	78 AM Boulevard	2765.44	5673.22	12	1984	ABC Co.	Butterfly	buried	39	hand op
V-3	3941 Nuxhall RTHFH	5342.67	2326.43	6	1977	ABC Co.	Gate	buried	21	hand op
V-4	069 TK Heart	7843.23	5732.79	8	1965	ABC Co.	Gate	buried	27	hand op
V-5	55 Davis St	6541.73	4527.35	12	2010	ABC Co.	Ball	buried	39	700
V-6	6 Freel Memorial	5626.78	7825.91	48	1954	ABC Co.	Gate	vault	348	unknown
V-7	7 Boomer Way	7235.67	6713.83	16	1999	ABC Co.	Butterfly	buried	51	hand op

Table 5-2 Example consequence of failure matrix

Consequence of Failure Matrix – Valve Asset Management Sample Plan						
Sequence	Valve ID	Function *	Redundancy†	Critical Needs ‡	Community §	Consequence Score **
(#)	(#)	(1-5)	(1-5)	(1-5)	(1-5)	(0-50)
Weight factor:		30%	40%	15%	15%	
1	V-1	5	5	5	4	48.5
2	V-2	3	3	1	5	30.0
3	V-3	1	1	1	1	10.0
4	V-4	1	1	1	1	10.0
5	V-5	3	3	3	2	28.5
6	V-6	5	5	3	1	41.0
7	V-7	5	3	5	4	40.5

Assign Consequence of failure weight factors for your utility.
* Assign function factors such as Transmission Mains = 5, Cross Conections = 3, Distribution Mains = 1
† Assign redundancy factors: No redundancy = 5; One Redundant Pipe = 3; Lots of Redundancy = 1
‡ Assign factor to represent Critical Needs Consumers: Hospital Affected = 5; Dialysis Unit = 3; Minimal Critical Consumers = 1
§ Assign factors to represent Community Impact: Severe = 5; Moderate = 3; Minimal = 1
** Consequence score is the sum of each weight factor (%) times the criticality factor (1-5). This number is then multiplied by 10.

The third section of the risk scoring plan is the probability of failure matrix (see Table 5-3). Similar to Table 5-2, this matrix is developed by using a combination of known valve attributes and sound engineering judgment to determine the probability that the valve asset will fail within a predetermined timeframe.

As with Table 5-2, the utility will need to determine the appropriate attributes to be scored for each matrix along with the appropriate weight factors to be used. The examples provided herein should be modified to fit the specific needs of the utility.

Table 5-3 Example probability of failure matrix

Probability of Failure Matrix – Valve Asset Management Sample Plan						
Sequence	Valve ID	Age *	Type †	Soil Type ‡	Work History §	Probability Score **
(#)	(#)	(1-5)	(1-5)	(1-5)	(1-5)	(0-50)
Weight factor:		25%	5%	20%	50%	
1	V-1	5	3	0	1	19.0
2	V-2	2	1	3	5	36.5
3	V-3	2	3	3	2	22.5
4	V-4	4	3	1	3	28.5
5	V-5	0	2	5	5	36.0
6	V-6	5	3	0	4	34.0
7	V-7	0	1	5	0	10.5

Assign the weight factor % as appropriate for your utility.
* Assign factors for age such as (60+) = 5, (50-59) = 4; (40-49) = 3; (30-39) = 2; (20-29) = 1; (below 20) = 0
† Assign factors for type such as Cone = 5; Piston = 4; Gate = 3; Ball = 2; Butterfly = 1
‡ Assign factors for soil type such as Highly Corrosive = 5, Moderate = 3; Valves in a Vault = 0
§ Assign factors for work history such as Many Problems = 5, No Problems = 0
** Probability score is the sum of each weight factor (%) times the criticality factor (1-5). This number is then multiplied by 10.

The last step is to multiply the consequence of failure score by the probability of failure score to determine the total risk score for the asset (see Table 5-4).

As stated previously, evaluating buried assets can be very difficult. The utility might elect to place the assets into groups by adjusting the total risk score and performing a more detailed field evaluation on the high risk assets.

Table 5-4 Total risk score

Total Risk Score - Valve Asset Management Sample Plan

Sequence	Valve ID	Location	Size	Date Installed	Consequence Score	Probability Score	Raw Risk Score	Final Risk Score
(#)	(#)	(Address)	(in)	(Year)	(0-50)	(0-50)	(0-2,500)	(1-10)
1	V-1	14 Charles HR Drive	36	1951	48.5	19.0	922	8
2	V-2	78 AM Boulevard	12	1984	30	36.5	1,095	8
3	V-3	3941 Nuxhall RTHFH	6	1977	10	22.5	225	1
4	V-4	069 TK Heart	8	1965	10	28.5	285	1
5	V-5	55 Davis St	12	2010	28.5	36.0	1,026	8
6	V-6	6 Freel Memorial	48	1954	41	34.0	1,394	9
7	V-7	7 Boomer Way	16	1999	40.5	10.5	425	4

NOTE: The Raw Risk Score is dertermined by multiplying the Probability Score by the Consequence Score. This can be used as the final risk score.

However, the Asset Manager might want to develop a weighted Final Risk Score to make comparitive analysis easier. One approach is to divide up the total number of assets into incremental blocks. For example, the top 10% assets all receive a score of 10, the second 10% receive a score of 9. This approach can help to minimize the impact of the subjective scoring system inherent in evaluating buried assets.

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Chapter 6

Distribution Valves Emergency or Shutdown Response Planning

Water distribution system operators are faced with the challenge of efficiently achieving a shutdown to prevent water loss and to restore service to their customers in a timely manner, whether responding to a natural disaster, man-made disaster, water main break, or a scheduled water system shutdown. The implementation of a well-documented maintenance program for distribution valves will greatly enhance an agency's ability to prepare for and quickly recover from all of these situations.

This response can be accomplished by the utilization of the following:

- Accurate valve mapping and valve maintenance records
- Properly maintained valves and appurtenances
- GIS/GPS integration of system infrastructure
- Computerized hydraulic and water quality modeling programs
- A regularly exercised emergency response plan

The identification of critical valves has a greater value than just knowing where these components are located. It provides the ability to isolate sections of the infrastructure using these valves in the repair/replacement process, and this information should be updated regularly. Determining the needed equipment, materials, and personnel to restore service can be more effectively planned with this information. These valves need to be properly mapped, their valve boxes cleaned and uncovered, and exercised regularly. See chapter 5, Valve Asset Management, of this manual for more information on identifying critical valves.

PLANNING A RESPONSE

Regardless of the emergency, the distribution system valving must be relied on to allow access to the system to inspect and repair the mains with minimal water loss and customer outages. As part of the planning process, various scenarios should be considered to better equip the agency for system recovery. Depending on the situation, there are tasks that can be done prior to, during, and after the event to help in the process of bringing the system back into service.

PRIOR TO AN EMERGENCY OR SHUTDOWN EVENT

Prioritizing levels of service is a vital component when planning a response to emergencies. The needs of critical customers such as medical facilities and/or other emergency institutions should be determined to produce an effective response.

The isolation valves can be utilized to separate a portion of the system to reduce the impacted areas in certain disasters. For instance, if the affected area of an emergency or event can be determined prior to its occurrence, specific valves can be identified to be operated to lessen the number of customers who may experience a disruption of service and to reduce water loss from the event. This determination of impact can also be useful during modeling or developing repressurization, chlorinating, and sampling plans. The identified valves need to be labeled and located appropriately in the mapping system or GIS to facilitate their use during an emergency.

When possible, affected customers should be notified of the impending shutdown a minimum of 12 hours before its occurrence as the utility deems appropriate.

DURING THE EVENT

Certain hazards have different impacts on the infrastructure based on their severity, type, and the preparedness of the system. Established goals for the system and particularly the operation of valves help to determine the amount of time it will take when the restoration process begins.

Staff knowledge in the following areas will have a direct impact on the recovery of service:

- Proper operational procedures
- Component and/or system capabilities/complexities
- Redundancy and operational flexibility
- Inventory and location of spare and replacement parts
- The contact information for potential contractors that can assist
- The location and availability of potential required equipment

The operation of valves to isolate the area impacted by the emergency is essential. This isolation could reduce the portion of the system contaminated and reduce water lost during the event, as well as lessening the amount of time necessary to get the components fully operational.

Customers should be notified after service has been restored including any necessary public notifications about the restoration of service and backflow devices, clearing air or discoloration from plumbing, boil advisories, and so on.

AFTER THE EVENT

If the agency has properly planned and practiced its emergency response plan, it will be better prepared to bring the system back online in a timely manner. This preparation, along with the effective maintenance and operation of infrastructure valves, will allow the agency to provide a quality product to the people it serves as well as to reduce the negative impact of any emergency or shutdown. Prior to service restoration, as required by regulators, it is critical that water quality meets regulatory compliance.

An important part of restoring service is making an assessment of the condition of the system. As it relates to valves, this assessment entails the following:

- Determining the number and location of valves impacted
- Evaluating the condition of these valves
- Verifying all valves were reopened
- Verifying that work orders were created to repair/replace the valves that were hard to turn, had rounded hubs, needed to be reset, would not shut off completely, or were free-spinning
- Prioritizing the repair/replacement of valves
- Repairing or replacing the valves if possible before restoring service to customers to prevent future shutdowns and minimize service disruptions
- Utilizing the *necessary* parts and equipment
- Documenting the damage incurred, including loss of service to large areas, to plan to insert needed valves to minimize these out-of-service areas in the future
- Documenting the repair/replacement work completed and restoring any repair parts or other consumables that were expended during the shutdown

POSTINCIDENT REVIEW

After fully restoring the system capacity, conduct a postincident review. Prepare a report documenting the outcome of the review to include:

- A chronology of the event
- A listing of impacted components including water lost
- A condition assessment of the components
- The identification of repair/replacement parts used and whether the current inventory levels were sufficient
- The equipment and supplies utilized
- The number of employees used and their hours worked
- A list of contractors used and an evaluation of each one's response, mobilization time, competence, and job performance
- An assessment of what worked during the process

- The identification of what did not work throughout the event
- A recommendation of what should have been done differently

This review should incorporate the presentation of the information gathered to all appropriate parties, including agency personnel, elected officials, regulatory agency individuals, and the general public. This information can be helpful to the agency in identifying ways to improve efficiency, to operate more safely, and to be appropriately prepared for the next emergency.

The completed incident report should then be stored in an easily retrieved location, ideally within an asset management system, GIS, or CMMS.

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