An Introduction to Water Distribution System Appurtenances

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1. VALVES AND HYDRANTS

1.1 OVERVIEW. This discussion covers the operation and maintenance of various types of valves. It also addresses hydrant O&M, safety, and testing.

1.2 VALVES AND VALVE OPERATION. Valves are used in water supply systems to start and stop flow, to throttle or control the quantity of water, to regulate pressures within the system, and to prevent backflow. Valves are typically operated using manual, electrical, hydraulic, or pneumatic operators. Most valves used in water systems fall into one of the following general valve classifications: gate, globe, needle, pressure relief, air/vacuum relief, diaphragm, punch, and rotary. The type of valve and the method used to operate it depends on the use of the valve, its function in the water system, and the source of energy available.

1.2.1 VALVE OPERATION

1.2.1.1 MANUAL OPERATION. Small valves or valves that are used infrequently are generally operated manually. Valves operated manually should be opened all the way, then closed one-quarter turn of the handwheel. This prevents the valve from sticking in the open position. Open and close the valve slowly and at an even rate to reduce the hazard of a hammer. Unless otherwise indicated, valves are opened by turning the handwheel or key counterclockwise. Always consult the manufacturer’s instructions for operating a specific type of valve. It is a good practice to operate (exercise) valves periodically.

1.2.1.2 POWER OPERATION. Only minimal attention is required for operating power-operated valves, except in the case of power failure. In this event, consult the manufacturer’s instructions for emergency manual operation. Most power-operated valves are equipped with safety devices to allow for emergency manual operation.

1.2.1.3 GENERAL MAINTENANCE OF VALVES, VALVE BOXES, AND ACCESSORIES. A general valve maintenance schedule is presented in Table 1. Specific maintenance procedures for various valve types and valve accessories are provided in literature supplied by the valve manufacturer. Valve boxes should be maintained on the same basis as the valve maintenance schedule shown in Table 1.

1.2.2 DISTRIBUTION SYSTEM VALVES. Gate valves are normally used in the distribution system. These valves are usually equipped with a 2-inch-square (50-mm.sq.) operating nut that requires a valve key for operation. Most distribution system valves are buried and the operating nut is accessible through a valve box. Common difficulties with distribution system valves are “lost” valves, inoperable valves, and valve boxes that have been covered by road work or filled with foreign matter.

1.2.2.1 LOST VALVES. The lost valve problem can be avoided by using an indexed valve record book in which all pertinent data is recorded, including all valve locations. The location should be referenced with respect to fixed, permanent markers. If a valve is lost, use a dip needle, miner’s compass, or metal detector to locate the valve box. A good valve record includes information on maintenance operations performed, tells whether the valve was opened or closed at the time of inspection, and lists any errors in a specific location. Keep one copy of the valve record book with the maintenance crew, and keep one on file.

Inspection	Action	Frequency (1), (2)
Manually operated valves		
Gate valves Distribution system valves	Locate, check operation, lubricate stem packing; if packing leaks, dig up valve and tighten packing gland or replace packing; check stem alignment; check for broken stem or stripped stem or chewed nut.	SA
Valve bypass	Check for position, inspect, and lubricate.	SA
Gears	Check and lubricate; correct any deficiencies.	SA
Vault	Check condition, clean, check masonry; make repairs as necessary.	SA
Treatment plant valves	Operate inactive valves. Lubricate as required (including gears).	Q A
	Replace or resurface leaking valve seats.	V
	Lubricate chain wheels.	Q
Butterfly valves	Check valve stem for watertightness, and adjust, if necessary.	SA
	Check operation and inspect for tight closure.	A
Rotary valves Cone valves (and ball valves)	Operate; lubricate metal-to-metal contacts in pilot mechanism; lubricate packing glands; lubricate all parts of seating and rotating mechanisms.	M
	Dismantle, remove corrosion products, wire brush plug and valve body; paint valves with corrosion-resistant paints.	A

Table 1

Maintenance checklist for valves and accessories

Inspection	Action	Frequency (1), (2)
Plug valves	Lubricate with lubricant stick.	M or Q
	Operate all valves; check for corrosion and foreign matter between plug and seat; lubricate gearing.	Q
	Inspect; dismantle if necessary; clean, wire brush, re-machine plug and body or replace if condition is beyond re-machining.	A
Curb stops	Remove and replace whenever necessary.	V
Multiport valves	Lubricate with grease.	SA
Globe valves	Operate valve to prevent sticking; check for leakage, adjust packing nut, and replace packing if necessary.	Q
	Check valve closure for tight shutoff; if valve does not hold, remove valve stem and disk and regrind seat and disk.	SA
Diaphragm valves	Operate valve; check valve stem and lubricate as necessary; check for tight closing.	Q
	Check diaphragm for cracks; renew as necessary.	A
Sluice gates	Operate inactive gates; lubricate stem screws and gears.	M
	Clean valve with wire brush and paint with corrosion-protective paint.	A
	Check seating wedges on valves seating against pressure.	A
Backflow preventers Reduced pressure	Test tightness of unit.	M
Power-operated valves		

Table 1 (continued)

Maintenance checklist for valves and accessories

Inspection	Action	Frequency (1), (2)
Hydraulic-cylinder operators Hydraulic cylinder	Check through one valve operation cycle.	M
Piston rod and tell-tale rod	Oil packing; tighten packing gland if leakage exists; replace packing if necessary.	M
Waste line discharge	Check for water flow when valve is wide open and shut; if leakage occurs, disassemble valve and piston, check leathers for wear and replace as necessary.	M
Cylinder and piston	Disassemble; inspect for scoring and corrosion; check cup leathers; polish any scored areas; remove corrosion products from piston surfaces and cylinder heads.	A
Pneumatic valve operators	Check packing and air hose; lubricate as necessary.	M
	Check piston, cylinder, and leathers; clean and maintain similar to hydraulic valve operators.	A
Motorized valve operators	Operate valve and check for tight closing.	Q
	Change gear drive lubricant.	Quarterly or after 500 hours of operation, whichever is more frequent
	Maintain electric motors as described in par. 11.4.4.	

Table 1 (continued)

Maintenance checklist for valves and accessories

Inspection	Action	Frequency (1), (2)
Valve operator pilot controls	Check control through one full cycle of operation.	M
	Lubricate pins, linkage, packing glands, and adjustment rod threads as necessary; remove corrosion products; check for leakage and repair.	M
	Disassemble; inspect unit and clean strainers; examine diaphragm for failure; regrind or replace worn valve seats.	A
Automatic valves		
Air-release valves, valve unit.	Remove valve from service; inspect float for leaks, and pins and linkage for corrosion; remove corrosion products; clean orifices.	A
Vault	Inspect for condition of masonry, steps, and manhole covers; repair as necessary.	A
Altitude valves Pilot controls	Inspect and lubricate.	M
Valve unit and operator	Disassemble; inspect hydraulic cylinder and repair; inspect valve, repair, and paint, as necessary.	A
Check valves	Inspect the closure control mechanism (if any); clean and adjust as necessary; check pin wear if balanced disk type; check seating on ball type.	A
	Disassemble; clean, reseat, and repair as necessary.	V
Float valves	Inspect float; repair as necessary.	M
	Inspect valve and valve operating mechanism.	A

Table 1 (continued)

Maintenance checklist for valves and accessories

Inspection	Action	Frequency (1), (2)
Pressure-regulating valves	Inspect, clean, adjust, disassemble, and repair as necessary (see manufacturer's instructions).	A
Valve accessories Gear boxes	Lubricate gears (see manufacturer's instructions)	M or Q
	Check gear operation through full operating cycle; listen for undue noise, etc.	SA
	Check housing for corrosion; paint as necessary.	A
Valve boxes	Clean debris out of box; inspect for corrosion; check alignment and adjust as necessary.	SA
Floor stands	Lubricate stem and indicator collars.	Q
	Inspect condition; clean and paint.	A
Valve position indicator Post indicators	Lubricate.	Q
Electric position indicators	Check contact points, wiring, etc.	A

(1) W-Weekly; M-Monthly; Q-Quarterly; SA-Semiannually; A-Annually; V-Variable, as conditions may indicate.

(2) The frequencies shown are suggested frequencies that may be modified by local command, as individual installation conditions warrant.

Table 1 (continued)

Maintenance checklist for valves and accessories

1.2.2.2 MAINTENANCE PROCEDURES. Distribution system valves are usually left open and operated only during emergencies. To make sure that distribution valves operate when needed, each valve in the system should be operated twice a year and any indicated maintenance carried out. To check the operation of the valve, first close the valve completely and then open it completely. Back off on the valve about one turn to avoid locking the valve in an open position. If the valve does not operate properly, perform the necessary maintenance and repair at once.

1.2.2.2.1 VALVE SEATING. The usual cause for a valve not seating properly in the closed position is foreign matter lodged on the valve seat. Open the valve slightly to give a high-velocity flow across the valve seat. If necessary, open a hydrant to increase flow enough to flush foreign matter from the valve seat.

1.2.2.2.2 VALVE-STEM SEALING

1.2.2.2.2.1 PACKING. Check and lubricate the valve-stem packing. Dry packing will impede valve closure at all points of the stem movement. Lubricate dry packing by pouring a mixture of half kerosene and half lubricating oil down a 1/2-inch (13-mm) pipe to discharge the mixture onto the stem below the operating nut. If the packing leaks, dig up the valve, tighten the packing gland, or replace the packing as necessary. To reduce leakage while replacing packing, open the valve as wide as possible.

1.2.2.2.2.2 O-RING SEALS. Most modern valves use O-ring seals rather than packing. If water is leaking around the stem, replace the O-rings.

1.2.2.2.2.3 VALVE STEM. Valve stems may be out of alignment or broken, or may have stripped threads. If the valve stem is out of alignment, the valve operates easily near open or closed positions, but not when the valve is partially closed. A broken or stripped stem permits unlimited turning of the stem without closing the valve. All of the above conditions require replacing the valve stem. Follow the manufacturer's instructions for removing and inserting the stem. If the valve-stem nut is missing or damaged, replace it.

1.2.2.2.2.4 VALVE SEAT REFACING. When a gate-valve seat leaks, remove the valve and reface the valve seat. The procedure to follow should be detailed in the manufacturer's instructions and includes these general terms:

- Remove the bonnet then inspect and clean all working parts;
- Check all working parts for signs of wear or deterioration;
- Remove old packing or O-rings;

- Refinish the working parts by grinding, sanding or polishing, and lapping, then replace all parts beyond repair; and
- Replace the valve parts, repack and test the valve for proper operation.

1.3 HYDRANTS. Fire hydrants are mainly used for fire protection. Other uses include flushing water mains and sewers, and filling tank trucks for street washing and tree spraying. Hydrants may also be used as a temporary water source for construction jobs. General information related to types of hydrants, component parts, O&M, common operating problems, records, and hydrant safety, is included herein.

1.3.1 HYDRANT O&M. Maintenance procedures for specific types of hydrants are provided in Table 2. Additional details are provided below.

1.3.1.1 HYDRANT INSPECTION. Hydrants are inspected and tested by water utility personnel accompanied by a fire department representative, according to command and field engineering office directives. Hydrants can usually be maintained by replacing all worn parts and seats through the top of the hydrant. The operator is generally responsible for ensuring that the proper tools are used. Each year, test the hydrant for tightness of joints and fittings in the following manner:

a) Remove one hydrant cap and replace it with a cap fitted with a pressure gage. Open the valve slowly until it is wide open and record the pressure;
b) Check for leakage at the following points:

- **Hydrant Top.** If a leak is found, remove the cover plate and tighten or repack the seal.
- **Nozzles Entering Barrel.** For leaks in this area, caulk the connection with lead.
- **Nozzle Caps.** If the nozzle caps are leaking, replace any defective gaskets.
- **Cracks in Barrel.** For leaks from cracks in the barrel, install a new barrel or a new hydrant.

- **Drain Valve.** Close this valve when the hydrant is open. If water comes out of the drain or saturates the ground around the hydrant when the hydrant valve is open, replace the drain valve facing or gasket.

Inspection	Action	Frequency (1)(2)
Dry-barrel hydrants	Check drain valve to be sure it opens.	A
	Where ground water level rises into barrel, plug drain valve and dewater barrel by a pump.	A
Wet-barrel hydrants	Check packing glands and valve seats; repair as necessary.	A
Pit-type hydrants	Check for water accumulation; dewater as necessary.	A
All hydrants		
On dead ends	Flush; check barrel after flushing.	A
Not on dead ends	Flush; check barrel after flushing.	A
	Check water flow.	A
	Repair as necessary; if main shut down is required, notify fire department.	V
In winter	Check for freezing; thaw if necessary.	W (3) M (4)
Leakage tests	Inspect all places where leaks might occur; repair as necessary.	A
Valve parts		
Operating nut	Check for rounded corners; replace as necessary; lubricate.	A
Nozzle threads	Check for damage; replace as necessary.	A
Chains	Check for paint fouling; clean.	A
Flow tests	Determine hydrant flow.	A

(1) W-Weekly; M-Monthly; A-Annually; V-Variable, as conditions may indicate.
(2) The frequencies shown are suggested frequencies that may be modified by local command, as individual installation conditions warrant.
(3) Weekly near important structures.
(4) Monthly elsewhere.

Table 2

Maintenance checklist for fire hydrants

c) Close the hydrant valve, open the second nozzle, open the hydrant valve, and flush the hydrant. Record the pressure with the hydrant valve open; and

d) Close the hydrant valve slowly and note the lowering of the water level in the hydrant after the valve is closed. If the water level does not drop, then the main valve is leaking or the drain valve is plugged.

1.3.1.2 HYDRANT-FLOW TESTS. Conduct hydrant-flow testing in accordance with the latest edition of the applicable publications and requirements publications. During flow tests, the hydrant nozzle needs to be unobstructed, so the only way of protecting property is to choose the nozzle that will do the least damage. Provide barricades to divert traffic and take any other precautions necessary to minimize property damage and prevent personal injury.

1.3.1.3 HYDRANT FLUSHING. Water flow rates required for flushing water mains is given herein. Before beginning the flushing, plan to divert flushing flow to prevent property damage. Use flow diffusers or a length of fire hose, where necessary, to direct the flow into a gutter or drainage ditch. A rigid pipe connected to a hydrant outlet and turned at an angle to divert flow down a gutter is not considered a good idea. The torque produced by the angular flow could be enough to twist or otherwise damage the hydrant.

1.3.2 HYDRANT SAFETY. In addition to the general safety precautions detailed here, special precautions must be taken to prevent injury and damage to private property during hydrant flushing. The following are several special safety concerns:

- Besides getting people wet, the force and volume of water from a full hydrant stream are sufficient to seriously injure workers or pedestrians.
- If traffic is not adequately controlled, drivers trying to avoid a hydrant stream might stop quickly or swerve, potentially causing an accident.
- If the temperature is below freezing, water that is allowed to flow onto pavement may freeze and cause accidents.

- If flow is diverted with a hose to a sewer, care must be taken not to create a cross-connection.
- If flow is diverted with a hose, the end of the hose must be securely anchored. A loose hose end can swing unpredictably and could cause serious injury.

2. INSTRUMENTATION AND CONTROLS (I&C), AND WATER METERS

2.1 SECTION. This section contains information on primary instrumentation (sensors), secondary instrumentation (transmitters and recorders), control systems as well as supervisory control and data acquisition (SCADA) systems, which are relatively new tools for controlling and monitoring water treatment systems. Special attention is given to O&M of water meters and other flow measuring devices such as weirs and flumes.

2.2 INSTRUMENTATION AND CONTROLS (I&C). The term “instrumentation,” as used in the water works industry, refers to a very wide range of equipment used for observation, measurement and control. Equipment types range from simple, mechanical, direct-reading meters and gages to complex electronic, automatic monitoring/control systems. All I&C systems have some type of a sensing device. More complex systems will include one or more of the following elements: transmitter, indicator and recorder. Modern I&C equipment allows an operator to monitor and control equipment, flow rates, pressures, levels and processes, not only at the water treatment plant, but for all parts of the distribution network as well.

2.2.1 WATER METERS. The primary function of water meters is to measure and record the volume of water flowing in a line. Flow is the most important measurement made at water supply facilities. Flow data is used to account for the water treated and pumped to distribution, chemical flow pacing, long-range planning, etc.

2.2.2 METER READING. Meters are generally furnished with registers that measure water flow in terms of flow rate or total volume. Water meter registers are typically of two general types: the straight-reading type and the circular-reading type. The straight-reading type is read like the odometer on a car. The meter register reports the number indicated by the counting wheels. Fixed zeroes to the right of the counting wheel window should be included in the meter reading. The circular reading dial is somewhat difficult to read and has been gradually replaced by straight registers on new meters. When a hand on any scale is between two numbers of a circular reading dial, the lower number is read.

If the hand seems exactly on any figure, check the hand on the next lower scale. If that hand is on the left side of zero, read the figure on which the hand lies. Otherwise, read the next lower figure. Because the registers are never reset while the meters are in service, the amounts recorded for any given period are determined by subtraction. To obtain the volume of water that passed through the meter since the previous reading, subtract the previously recorded reading from the present reading. The maximum amount that can be indicated on the usual line meter before it turns to all zeroes and starts over again is 99,999 cubic feet, or 999,999 gallons. Thus, to get a current measurement when the reading is lower than the last previous one, add 100,000 to the present reading on a cubic feet meter, or 1,000,000 to the present reading on a gallon meter. The small denomination scale giving fractions of 1 cubic foot or 10 gallons is used for testing purposes only and is disregarded in the regular reading.

2.3 INSTRUMENT MAINTENANCE AND REPAIR. The success of water instrument maintenance procedures is based on knowledge of the construction, operation, and adjustment of the equipment; availability of the necessary special tools; as well as stored spare parts and special instructions from the manufacturer. For the special knowledge necessary, maintenance personnel are advised to consult the manufacturer's instructions.

2.3.1 MAINTENANCE SCHEDULES. The design and intricacy of meters, instrumentation and automatic control systems depend on the function to be performed and the manufacturer's particular equipment. Because there are many manufacturers of meters, instruments and automatic controls, listing specific maintenance procedures that apply to all units is not possible. The procedures here are basic and the minimum required for the most common types of units. When developing maintenance schedules, personnel may adapt the procedures given here to specific directions issued by the manufacturers.

2.3.2 INSPECTION AND MAINTENANCE RECORDS. It is a good idea to keep a log of all inspection and maintenance actions. A particularly useful record system is a card file for each piece of equipment. This card shows the type of equipment, the manufacturer's serial number, the date installed, the location, and the frequency of scheduled maintenance. If these cards are arranged chronologically, each card will come to the attention of maintenance personnel at the proper time for the inspection to be made. Many water suppliers are now using computers in their operation. Information commonly kept on a service or meter history card is entered into a computer to establish a permanent record. A control number is associated with each service or meter. Any future information concerning work on a customer service line or meter testing and repairs can be entered for the appropriate control number.

2.3.3 SENSOR MAINTENANCE. Maintenance procedures for flow, pressure and level-sensing devices are given in Table 3.

Inspection	Action	Frequency (1),(2)
Flow sensors		
Venturi-type devices		
Annular chamber	Flush and clean annular chamber, throat and inlet; purge trapped air from chamber and connecting piping; flush piezometer pressure taps.	Q
Exterior	Clean and paint as necessary.	A
Interior	Check interior for corrosion; dismantle, clean, and restore smoothness of interior surfaces as necessary; for flanged joints, check possible intrusion of gasket into interior; replace if necessary.	A
Orifice plates	Remove plate, dress off roughness; flush sediment traps.	A
Pitot tube	On permanent installations, check tips and clean.	Q
Flow tube	Check instrument taps; flush if necessary.	Q
Pressure sensors		
Diaphragm	Disassemble and check for condition and leaks; also clean, adjust, repair, or renew as necessary; check calibration.	A
Bourdon tube	Check calibration, clean and adjust as necessary.	A

Table 3

Maintenance checklist for flow, pressure and level sensors

Inspection	Action	Frequency (1),(2)
Manometer	Clean tubes and gage unit as necessary.	SA
	Check mercury level and add mercury if necessary; clean or replace mercury if necessary.	A or V
Level sensors		
Floats	Check for bent rod, binding, or other damage; correct undesirable conditions; apply light oil to moving parts; check alarm system.	M
Bubble pipe	Check air discharge pipe for freeness; check air compressor system; clean, repair, or renew worn parts as necessary.	Q
Probes	Check contacts, wiring, and electrical connections; repair as necessary.	Q
	Check probe surface; check calibration; clean, repair, or renew as necessary.	SA

(1) W-Weekly; M-Monthly; Q-Quarterly; SA-Semiannually; A-Annually; V-Variable, as conditions may indicate.
(2) The frequencies shown are suggested frequencies that may be modified by local command, as individual installation conditions warrant.

Table 3 (continued)

Maintenance checklist for flow, pressure and level sensors

2.3.4 TRANSMISSION SYSTEM MAINTENANCE. Information needs to be transmitted from the sensing device, which measures the variable, to the instruments that indicate, record, or total it. The transmission system may be mechanical, hydraulic, pneumatic or electrical. Each system consists of two components: the transmitter and the transmission link. Maintenance procedures for transmission systems are summarized in Table 4.

2.3.5 INDICATOR, REGISTER, AND RECORDER MAINTENANCE. Besides transmission devices, secondary instruments include indicators or gages (momentary indication of discrete information), recorders (chart record of information by time), and registers or totalizers (also termed “integrators”). The latter category expresses the total quantity of measured variable from start to current time. There are many styles and designs of each basic type, as well as various combinations of these types. Therefore, no detailed maintenance procedure can cover all types, designs and combinations. Maintenance procedures depend not only on the type of receiver (indicator, recorder or register), but also on the type of transmission system used. It is recommended that maintenance personnel study the manufacturer’s instructions for detailed procedures, in addition to following the basic maintenance procedures for indicators, registers and recorders summarized in Table 5.

2.3.5.1 RECORDERS. Recording instruments have all of the fundamental elements of an indicator unit and, in addition, contain a clock mechanism (spring or electrical), a chart, and a marking pen. Charts may be either circular or strip and are changed on schedule by operating personnel. Maintenance procedures depend on the type of transmission system employed, as well as on the design and other factors. Consult the manufacturer’s instructions for detailed procedures. General maintenance procedures are included in Table 5.

2.3.5.2 TOTALIZERS OR REGISTERS. This type of receiver has internal components similar to those in recorders. In addition, it contains an integrator mechanism that converts transmitted signals into a sum of the total quantity of material that has moved past the point of measurement from the beginning of the measured period to the time of observation. This total appears on a numerical register similar to an automobile odometer. Clean, service and adjust registers according to the manufacturer’s instructions on the same general schedule as recorders.

Inspection	Action	Frequency (1), (2)
Mechanical	Direct links—make certain pulley, drums, cable, etc., work freely and are not corroded; clean, lubricate, and adjust.	Q
Hydraulic	Pressure links-blow down pressure lines, make certain there are no restrictions; correct adverse conditions.	SA
Pneumatic		
Transmitter	Flush liquid side of air-relay units; clean; if necessary check diaphragm; check air-input orifice, clean, blow out moisture traps.	D
	Disassemble, repair, or renew as necessary.	V
Link	Check connecting tubing for condition; check nozzle system for leaks.	SA
Electrical		
Transmitter	Service transmitter; check signal interval length over instrument range.	M
	Check mercury switch and magnet; adjust as necessary.	Q
	Remove old lubricant, add new.	SA
Link	Check wires whenever necessary.	V
Indicators	Clean cover and glass of gages.	SA
	Check zero setting and calibration	A
Mechanical transmission	Inspect and service as for transmitter.	Q
Hydraulic transmission	Vent air from mercury wells; check pulley shaft, chain, cam, stuffing box, and other parts.	W
	Check mercury wells; add new mercury if necessary; clean or replace mercury if necessary.	A

Table 4

Maintenance Checklist for Transmission Systems

Inspection	Action	Frequency (1), (2)
Pneumatic transmission	Service on same schedule and in same manner as transmitter.	
Electrical transmission	Service generally on same schedule as transmitter.	
	Clean unit, especially dials.	SA
	Check operation, adjust and repair as necessary.	A
Recorders	Clean pen; check ink flow; check cam cycle and pulley freedom.	2W
	Check zero position; adjust and lubricate.	Q
	Check contact points, armature, clutch, clutch cups, etc.; clean, adjust, repair, or renew parts.	SA
	Renew modular unit if necessary.	V
	Renew illumination lamp as necessary.	V
Totalizers	Inspect, clean, adjust or repair on same schedule as recorders.	
Combination	Check, clean, adjust or repair on same schedule as individual components.	

(1) D-Daily; W-Weekly; M-Monthly; Q-Quarterly; SA-Semiannually; V-Variable, as conditions may indicate.
(2) The frequencies shown are suggested frequencies that may be modified by local command, as individual installation conditions warrant.

Table 4

Maintenance Checklist for Transmission Systems (continued)

Inspection	Action	Frequency (1), (2)
Indicators	Clean cover and glass of gages. Check zero setting and calibration.	SA A
Mechanical transmission	Inspect and service as for transmitter.	Q
Hydraulic transmission	Vent air from mercury wells; check pulley shaft, chain, cam, stuffing box, and other parts.	W
	Check mercury wells; add new mercury if necessary; clean or replace mercury if necessary. (3)	A
Pneumatic transmission	Service on same schedule and in same manner as transmitter.	
Electrical transmission	Service generally on same schedule as transmitter.	
	Clean unit, especially dials.	SA
	Check operation; adjust and repair as necessary.	A
Recorders	Clean pen; check ink flow; check cam cycle and pulley freedom.	2W
	Check zero position; adjust and lubricate.	Q
	Check contact points, armature, clutch, clutch cups, etc.; clean, adjust, repair, or renew parts.	SA
	Renew modular unit if necessary.	V
	Renew illumination lamp as necessary.	V
Totalizers	Inspect, clean, adjust or repair on same schedule as recorders.	

Table 5

Maintenance Checklist for Indicators, Registers, and Recorders

Inspection	Action	Frequency (1), (2)
Combination	Check, clean, adjust or repair on same schedule as individual components.	

(1) W-Weekly; Q-Quarterly; SA-Semiannually; A-Annually; V-Variable, as conditions may indicate.

(2) The frequencies shown are suggested frequencies that may be modified by local command, as individual installation conditions warrant.

(3) Caution: Mercury fumes are poisonous. Use caution when handling mercury and avoid spills.

Table 5 (continued)

Maintenance Checklist for Indicators, Registers, and Recorders

2.3.5.3 COMBINATION TOTALIZER INDICATOR-RECORDER. There are various combinations, designs and styles of instruments in this classification. There are also devices that sum totals from various individual totalizers, or show ratios of one flow to another. In general, the maintenance procedures and schedules for this category are a combination of the procedures for the individual units above. Develop a maintenance schedule according to the manufacturer's instructions.

2.3.6 WATER METER MAINTENANCE. Maintenance procedures for water meters are summarized in Table 6.

2.3.7 WEIR AND FLUME MAINTENANCE. All types of head-area meters are used for open-flow measurement, and their proper operation depends on the absence of any kind of interference at the discharge opening. Maintenance procedures for weirs and flumes are summarized in Table 7.

2.4 SAFETY. General hazards connected with servicing I&C systems include the use of hand tools, working in confined spaces, and exposure to electric shocks. Special attention should be given to prevent electrical shock that may be caused by improper grounding of building electrical systems onto the plumbing system. If residential water meters are not mounted on a yoke, or if a permanent jumper wire is not provided across the meter connections, use a separate wire with large alligator clips as a temporary bridge between the pipes when meters are removed or installed.

Inspection	Action	Frequency (1),(2)
Volume meters	Check operation; check for noise. Check mounting and alignment.	M A
Velocity-type meters	Check operation; check for noise.	M
Meter pit	Clean, remove water before freezing season.	SA
Exterior	Paint as necessary.	A
Interior	Check for worn parts; repair or replace as necessary.	V
Proportional meters	Check on same program as velocity meters.	V
Compound meters	Check large-flow component on same schedule as velocity-type meters.	M
Magnetic flow meters	Check electrical connections.	A
Meter pit	Check, clean, remove water to protect against freezing.	A (Fall)
Measuring unit	Check for possible hot water damage.	A
Unit parts	Check for worn parts, repair or replace as necessary; clean and brighten.	V

(1) A-Annually; M-Monthly; SA-Semiannually; V-Variable, as conditions may indicate.
(2) The frequencies shown are suggested frequencies that may be modified by local command, as individual installation conditions warrant.

Table 6

Maintenance Checklist for Water Meters

Inspection	Action	Frequency (1), (2)
Weirs	Check weir edge to make certain it is clean.	D
	Check and open breather pipe, if any.	M
	Drain weir to check evenness of water break-over; check for tuberculation or corrosion; dress-off rough spots.	A
Parshall flume	Check throat section to be sure it is clean and free of growths.	M
	Clean stilling well and connecting pipes.	Q

(1) A-Annually; D-Daily; M-Monthly; Q-Quarterly, as conditions may indicate.
(2) The frequencies shown are suggested frequencies that may be modified by local command, as individual installation conditions warrant.

Table 7

Maintenance Checklist for Weirs and Flumes

3. CROSS-CONNECTION CONTROL AND BACKFLOW PREVENTION

3.1 CROSS-CONNECTIONS AND BACKFLOW. Cross-connections are the physical links through which contaminated materials can enter a potable water supply. The contaminant enters the potable water supply when the pressure of the polluted source exceeds the pressure of the potable source. The flow of contaminated water to the potable system is called “backflow.” Backflow of contaminated water through cross-connections can occur in all water systems and does occur in most water systems. Backflow results from either back pressure or back siphonage. Backflow due to back pressure occurs when the user’s water system is under higher pressure than the public water supply system. Back siphonage is caused by the development of negative or sub-atmospheric pressures in the water supply piping. This condition occurs when system pressure is lowered by pump malfunction or high fire flow.

3.2 CLASSES OF BACKFLOW HAZARDS. Backflow hazards have been divided into three classes: low, moderate and high, as defined below.

3.2.1 CLASS I—LOW DEGREE OF HAZARD. If a backflow were to occur, the resulting health significance would be limited to minor changes in the esthetic quality, such as taste, odor or color. The foreign substance must be nontoxic and nonbacterial in nature, with no significant health effect.

3.2.2 CLASS II—MODERATE DEGREE OF HAZARD. If a backflow were to occur, the esthetic qualities of the water supply would change significantly. The foreign substance must be nontoxic to humans.

3.2.3 CLASS III—HIGH DEGREE OF HAZARD. If a backflow were to occur, the effect on the water supply could cause illness or death if the water was consumed by humans. The foreign substance may be toxic to humans either from a chemical, bacteriological or radiological standpoint. Effects of these contaminants may result from short- or long-term exposure.

3.3 APPROVED BACKFLOW PREVENTION DEVICES. Devices that protect the potable water supply from these backflow hazards are listed in Table 8 and discussed below.

Degree of Hazard	Allowed Approved Devices
Class I	Air gap Atmospheric type vacuum breaker Pressure type vacuum breaker Double check valve assembly Reduced pressure principle device
Class II	Air gap Double check valve assembly Reduced pressure principle device
Class III	Air gap Reduced pressure principle device

Table 8

Approved Backflow Devices

3.3.1 AIR GAP. An approved air gap may be used under any and all conditions of hazard and pressure conditions.

3.3.2 VACUUM BREAKERS. Pressure and atmospheric vacuum breakers are primarily in-plant or end-of-service line solutions to cross-connection. They are not used in water service connections. They are placed at the end of a line, and at fixtures or equipment that discharge to atmospheric pressure. These do not protect against back pressure, only against back siphonage. Valves should not be located downstream from an atmospheric type vacuum breaker. *Note: Vacuum breakers are permitted on irrigation systems regardless of the hazard class for protection from back siphonage only.*

3.3.3 REDUCED PRESSURE PRINCIPLE DEVICE. The reduced pressure (RP) principle device protects against both back pressure and back siphonage, and can be used for any degree of hazard.

3.3.4 DOUBLE CHECK VALVE ASSEMBLY. This device works in a back pressure or back siphonage mode. This device neither discharges water nor provides a visual sign of backflow or unit malfunction. Therefore, it does not offer the degree of protection provided by the reduced pressure principle device.

3.4 SELECTION AND INSTALLATION OF BACKFLOW PREVENTERS. Selecting the proper devices is very important. However, having the proper device on the connection is not sufficient; the device also needs to be installed correctly. Guidance on selecting and installing backflow prevention devices is provided herein. Critical potable water supplies should have parallel installation of the proper approved backflow prevention devices. This avoids interruption to water service when maintenance or testing is required. This type of installation also provides higher flow capacity than is provided by one backflow preventer. Methods and devices occasionally promoted for backflow prevention include the single check valve, the swivel connection, the removable section or spool, and the barometric loop. None of these methods is approved for use in many water systems. Reasons for their unacceptability are discussed below:

- A single check valve offers no visual or mechanical means of determining malfunctioning. Since all such mechanical devices are subject to wear and interference resulting from deposits and other factors, the single check valve is not considered an adequate backflow preventer.
- The swivel connection and removal section or spool are too easily allowed to remain in place to be considered an acceptable means of backflow prevention.
- A barometric loop consists of a vertical section of pipe, extending at least 35 feet (11 m) above the highest fixture. The principle is that a complete vacuum cannot raise water to an elevation greater than 33.9 feet (10.3 m). The device does not

protect against backflow because of back pressure, and installing a pipe loop of this height is usually costly and impractical.

3.5 INSPECTION AND TESTING SCHEDULE. Each installation should create a schedule for inspecting and testing all backflow protection devices, including air gaps. Determine the intervals between inspecting, testing and overhauling each device according to the age, condition of each device, and degree of hazard. It is important to inspect all devices installed on Class III (high degree of hazard) cross-connections at least once every 6 months (Table 9). In general, follow the overhaul intervals recommended by the manufacturer. Ideally, overhaul intervals will not exceed 5 years. Keep the inspection and testing schedule in the recurring work program.

Degree of Hazard	6 Months	12 Months
Class I		x
Class II		x
Class III	x	
Class III (Air Gap)		x

Table 9

Suggested Intervals for Inspecting Backflow Devices

3.5.1 INSPECTION. A certified backflow inspector must inspect all cross-connections and backflow prevention devices to ensure that:

- An approval air gap is maintained;
- Backflow prevention devices are in good condition; and
- New devices are properly installed and debris from the installation does not interfere with the functioning of the device. (This inspection is to be completed within 1 week after acceptance and 3 months after installation.)

3.5.2 TESTING. Complete all testing according to the manufacturer's service instructions. Repair and retest any device found to be defective until it is in satisfactory condition.

3.6 MAINTENANCE OF BACKFLOW PREVENTERS. Maintenance is necessary for any mechanical equipment to keep it operational. Therefore, it is generally best to install any mechanical protective device in a location where it is accessible for routine inspection, testing and required maintenance. These devices are mechanical and subject to breakdown, and they will need to be isolated during inspection and repair. If there is only one service line from the potable system and if water service is required 100 percent of the time, a bypass and a second RP principle backflow preventer will be required to provide an uninterrupted protected supply from the potable system.

3.7 RECORDS OF INSPECTION. Use an appropriate form approved to record data on all cross-connections. Provide the location, degree of hazard, description of air gap or protective device installed, and a sketch of the installation on the form. After each inspection is completed, record the date of inspection, test results, observations, corrective action taken, and name of the inspector on the appropriate form. For an air gap, the test consists of a visual inspection with “OK” recorded. Testing for other backflow devices is more involved.

3.8 LOCATION RECORDS. In general, records of all cross-connection control or backflow prevention devices should be prepared and properly maintained. These records are to include an inventory listing of all locations and an individual record for each location.