Technical Guideline for Drinking Water Distribution Network Valves (Selection and Management) in Kenya

Foreword

Pumps, valves & pipes are essential inputs in the normal operations of water utilities. Pumps for instance enable water service providers draw water from either underground sources or surface areas and push it through transport lines (pipes) to treatment facilities and eventually to consumers.

It is imperative that proper selection and sizing of pumps has a direct correlation to energy consumption. While the market delivers several variety of products, the Energy Regulatory Commission in Kenya is keen to have energy consuming entities improve on the applications installed in their facilities which impact negatively on energy efficiency. With ageing pipe networks, the water sector is ripe for new and modern technologies especially to match the requirements for durability, malleability and water quality standards.

It is for this reason that the Water Services Providers Association (WASPA), as the umbrella body of water utilities, resolved to ameliorate the existing pump, valve and pipe management procedures for the Kenyan market. Through an intensive consultative process, the initiative sought to identify and build on existing meter management practices, establish the underlying challenges and -subsequently- and establish these technical guidelines for these appliances - informed by international standards and leading practices of Kenyan water utilities.

We envision that with the established guidelines, suppliers will be challenged to deliver high quality products to the market. In turn, utilities will be better equipped to procure the high quality products that they require. More so, the guidelines will assist them in making effective use of them - by providing guidelines for the selection (sizing), installation, calibration, servicing and replacement within the context of a wider asset management agenda. The guidelines are meant to form the basis upon which the Kenya Water Service Providers (WSPs) can develop and customize their utility specific technical specifications for the relevant equipments as well as influence management policies and procedures on use of the same.

It is important to bear in mind that the guidelines are important to all stakeholders, particularly the Water Service Providers. The Kenyan government through technical departments in the Ministry of Water and Irrigation, Energy Regulatory Commission as well as the Kenya Bureau of Standards have attested and contributed enormously to this final product. This should serve as a quality assurance to the consumers and the general public as to the specific intent to improve the reliability of products in use moving forward.

The Water Services Providers Association is committed to quality and will continue providing support towards these and other noble initiatives aimed at increasing the effectiveness and efficiency of water, sewerage and sanitation service delivery in Kenya.

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- Water Services Regulatory Board

Abbreviations

ERC - Energy Regulatory Commission

KEBS – Kenya Bureau of Standards

NRW – Non Revenue Water

PE – Public Entity

PPRA - Public Procurement Regulatory Authority

PRV - Pressure Reducing Valve

Specs – Specifications

TOR – Terms of Reference

WASPA – Water Services Providers Association

WASREB – Water Services Regulatory Board

WSP – Water Service Provider

1 Introduction

Kenya has made good strides in expanding access to safe and clean drinking water, sanitation, and sewerage. With respect to Non Revenue Water (NRW), a primary performance indicator for water utilities, water services providers (WSPs) have reduced NRW from 47% in 2008/2009 to 44% in 2011/12. However, more improvements are needed to reach the national target of 30% set in the National Water Services Strategy (NWSS, 2007-2015) [1]. As a recent performance review reported, "Despite the positive trend, NRW levels remain unacceptably high despite the increase in sector investment over the years. The total amount of money lost in 2012/13 can be estimated at a staggering *KSh 11.4 billion*" [2]. With further improvements, it is possible for WSPs to go beyond the NWSS goal of 30% to reach the sector benchmark of 20%. Reducing NRW is essential in order to decrease drinking water wastage, increase revenue, extend coverage, and ultimately ensure a more efficient provision of water to consumers, and should therefore be the number one priority for WSPs in Kenya.

In order to achieve this ambitious goal, this Technical Guideline addresses the observation made in the NWSS that the "missing standardization of water equipment has resulted in a multiplicity of technologies which is not only a disincentive for private sector involvement but also a reason for lengthening break downtimes" [3].

Valve malfunction is one of the major causes of disruptions in delivery of drinking water iin Kenya. Reasons for valve malfunction include improper selection of valve types, substandard valves, poor installation, and improper maintenance of valves. In addition, improper valve installation and use lead to unintended pressure variations in the water distribution system. Pressure variation, in turn, is a primary cause of pipe and joint breaks in addition to increased water loss and energy consumption. Hence, proper installation of appropriate, high-quality valves is critical to reducing service down time, minimizing water loss, and increasing the energy efficiency of the water delivery system.

This Technical Guideline comprises recommendations for the procurement process, the selection of valves used in the drinking water distribution network, the establishment of technical specifications, and the installation and maintenance of valves used in the drinking water distribution network.

The Guideline is designed to correct the shortcomings of Kenya's current system, based on an assessment of the current water distribution network conducted through questionnaires (completed by approximately 25% of WASPA's member WSPs), interviews with stakeholders, and reviews of relevant documents and best available practices in the local and international market. The Guideline is intended to support and guide the WSPs through each step of procurement, installation, and maintenance of all relevant valves needed for the provision of water services.

We recommend a regular update (every two years) of this Guideline based on emerging evidence from the field, such as changes in the types and specification of valves and/or common practices with regard to procurement, selection, installation, and maintenance of valves used in the drinking water distribution network. Updating of the Guideline should automatically result in vocational training of water utility personnel.

2 Recommendations for a Generic Procurement Process

Within Kenya, each WSP has established its own procurement process based on its specific requirements and experience. We therefore offer recommendations for further improvements rather than a “one size fits all” solution. These recommendations are based on the Kenyan Public Procurement and Asset Disposal Act (2015), its subsidiary legislation entitled Public Procurement and Disposal Regulations (2006), and the ISO standard 10845-1:2010 – *Construction Procurement – Processes, methods and procedures*. These documents support the establishment of procurement processes that are fair, equitable, transparent, competitive, and cost effective.

The Public Procurement and Disposal Act and its subsidiary legislation provide a legal framework for regulating public procurement. To ease its implementation, a Public Procurement and Disposal General Manual and a User Guide have been established. Both the Act and Regulation apply to “Procurement by a Public Entity (PE),” which applies to WSP’s procurement of valves used in the drinking water distribution network. WSPs are classified as “Class B” PEs. PEs must carry out their procurement and disposal activities in accordance with the Public Procurement Regulatory Authority (PPRA), the Regulations, Standard Tendering Documents (available on www.ppoa.go.ke), Manuals, and any directions of the Public Procurement Regulatory Authority [4].

2.1 Basic Procurement Process

This compliance includes the basic procurement process, consisting of 17 steps to be followed by all PEs, shown in Table 1. The main roles and responsibilities for these steps fall to the PE’s user department, accounting officer, tender committee, procurement unit, and evaluation committee.

Table 1: Roles and responsibilities in the procurement cycle [4]

	Steps	Roles & Responsibilities
Step 1	Procurement Plan & Budget	Accounting Officer
Step 2	Procurement Requisition Filled with clear Specs/TOR	User Department
Step 3	Confirmation of Availability of Funds	Accounting Officer
Step 4	Review of Specifications/TOR, Procurement Method, Evaluation Criteria, Potential Supply Market	User Department & Procurement Unit
Step 5	Procurement Method Approval	Tender Committee
Step 6	Preparation of Tendering Documents	Accounting Officer; User and other relevant departments
Step 7	Approval of Tendering Documents	Accounting Officer Tender Committee
Step 8	Advertisement & Invitation for Tender	Accounting Officer
Step 9	Receipt & Opening of Tenders	Tender Opening Committee 3 member
Step 10	Evaluation of / Proposals (testing of provided samples)	Evaluation Committee
Step 11	Review of Evaluation Report (Approval or Rejection)	Accounting Officer
Step 12	Award of Contract	Accounting Officer
Step 13	Communicate Award	Accounting Officer
Step 14	Review	Public Procurement Regulatory Authority (optional)
Step 15	Sign Contract	Accounting Officer

	Steps	Roles & Responsibilities
Step 16	Contract Monitoring	Accounting Officer
Step 17	Contract Performance Evaluation	Accounting Officer; User Department & Procurement Unit

For those steps associated with shortcomings identified during the assessment, recommendations are given in the Section 2 of the 'Technical Guideline for Water Meter (Management) in Kenya'. More detailed information on each of the steps and the main roles and responsibilities associated with them can be found in the "User Guide to The Public Procurement and Disposal Act, 2005" [4].

2.2 Documentation

The following documents must be submitted with tenders in order to be eligible for evaluation:

a) Name of the standard(s) used to certify the product(s);
b) Certificates of manufacturing quality testing (e.g., methods of manufacturing);
c) Certificates of final product quality testing;
d) Kenya Bureau of Standards (KEBS) certificates of testing (note that KEBS marks must also appear on the product);
e) Proof of suppliers' approval status:
    i. Obtained from the supplier, and
    ii. Obtained from the manufacturer;
f) Warranty documents with clear terms and conditions;
g) Service contract documents with clear terms and conditions (to be obtained regardless of the WSP's intent to include these terms and conditions in the final contract; this document offers additional evidence of the supplier's credibility);
h) Spare parts availability contract with clear terms and conditions;
i) Supplier's rating by WASPA; and
j) References provided by suppliers from previous projects.

2.3 Inspection and Acceptance of the Goods

Manufacturers and suppliers are responsible for conducting or arranging for the carrying out of all quality assurance tests, and for obtaining the necessary documentation (e.g., approval certificates) from the relevant standardization authorities (e.g., KEBS).

Manufacturers and suppliers should submit all relevant certificates and documents for each order.

Upon receipt of goods, WSPs should visually inspect each valve and associated fitting for any defect or poor workmanship. If any defect is detected, the product should be rejected. WSPs should check for:

- Visual uniformity of the surface (e.g., absence of dents, pits, extruded parts, uneven coloring, and uneven surface finish/smoothness).
- Evidence of poor workmanship in the appearance of the product or the interaction of its moving parts.

3 Selection of Valves Used in the Drinking Water Distribution Network

According to the standard EN 1074, valves used in the water distribution system can be classified into the following categories based on their function:

- Isolation valves (e.g., gate/sluice, butterfly, float/ball cock);
- Control valves (e.g., butterfly, ball, glove, pressure reducing);
- Check valves (e.g., check, foot); and
- Air valves (e.g., air release, air/vacuum release, combination air).

3.1 Introduction to Valves Widely Used in Kenya

Valves used in the Kenyan drinking water distribution system are primarily categorized according to their construction and function. Table 2 describes the types of valves widely used in Kenya, their general application, and key considerations in their use.

Table 2: Valves used in Kenya – Description, application, and key considerations

Valve type (function)	General application	Key considerations
Gate / sluice valve **(isolation)**	○ Gate valves are designed only to start or stop flow ○ Widely used ○ Rising stem type (outside screw and yoke) - Exposed screw extending above the valve bonnet - In pump stations (easy to see whether the valve is open or closed) - Cannot be used where dirt might get into the screw ○ Non-rising stem type - No exposed screw extending above the valve bonnet - Screw thread down to the gate mechanism and the operating shaft is sealed at the top of the valve bonnet. - Must use for buried valves	○ Should not be used for throttling flow for prolonged periods because vibration of flow will eventually wear and damage the valve (Ref: Water Distribution Operator Training Handbook Third Ed [5])
Butterfly valves **(isolation and control)**	○ Primarily design as On/Off valve ○ Can be used for occasional flow throttling	○ Advantage of operating more easily and quickly than gate valve (due to equal pressure on both sides) ○ Less expensive than gate valve, particularly in the larger size ○ Creates greater pressure loss than gate valve. In general, pressure loss is not significant in comparison to other line losses ○ Can create severe water hammer if closed too quickly ○ If used for prolonged high pressure throttling, the disk will vibrate and will eventually wear and damage the valve
Check valve **(check/non**	○ Designed to allow flow in only one direction. ○ Most common use is in discharge side of pump to	○ Depending on how and where check valve is installed, there could be a problem with valve slamming shut, potentially creating a serious water hammer

Valve type (function)	General application	Key considerations
-return)	prevent backflow	○ To prevent the water hammer, some valves are equipped with various devices to dampen the closing (e.g., spring, external weight)
Foot valve **(check/non -return)**	○ Special type of check valve ○ Placed at the bottom of suction pipe of pump to prevent backflow so that the pump will not lose its prime when power is turned off	○ Depending on how and where the foot valve is installed, there could be a problem with valve slamming shut, potentially creating a serious water hammer ○ To prevent the water hammer, some valves are equipped with various devices to dampen the closing including, spring, external weight etc.
Float valve / ball cock **(isolation)**	○ Used in tanks and cisterns to maintain water level and prevent overflow ○ Activated via lever and float (ball); rise and fall of ball controls water flow ○ Made for high, medium and low pressure. (Ref: "Types of Valves Used in Water Supply Pipelines," [6])	
Air release valve **(Air)**	○ Automatically releases small pockets of accumulated air while the pipeline operates under pressure ○ Should be installed at the highest points of the distribution lines	○ Installation is not very common in Kenya. However, these valves are widely used around the world to reduce energy required for pumping ○ If not installed, accumulated air can restrict flow within a pipe, eventually increasing pumping cost
Air/Vacuum release valve **(Air)**	○ Automatically releases large quantities of air during pipeline filling ○ Automatically admits large amounts of air when the internal pressure drops below atmospheric pressure	○ Installation is not very common in Kenya. However, these valves are widely used around the world to avoid pressure surges in pipelines
Combination air valves **(air)**	○ Contains both a small air release orifice and a large air/vacuum port in one assembly ○ Combines the functions of both the Air/Vacuum release and Air release valves	○ Excellent choice for high points in the distribution line ○ Installation is not very common in Kenya. However, these valves are widely used around the world to avoid pressure surges in pipelines
Pressure reducing valve **(control)**	○ Operate automatically to throttle flow and maintain lower pressure in lower distribution system zones ○ Water systems in hilly country must establish several system pressure zones by using PRV	○ Can increase water system performance, reduce operating costs, and extend life of other fixtures ○ Proper sizing is critical, particularly under low flow conditions; sizing corresponds to flow and pressure ranges, not pipe size ○ Only one regulator required for most applications; however, some configurations require additional units (Ref: "Water Pressure Reducing Valves," [7])

Valve type (function)	General application	Key considerations
Pressure relief valve	○ Installed at a point on the water system to release high-pressure water created by water hammer ○ Essentially a globe valve with adjustable spring to maintain pressure on valve seat and keep valve closed under normal operating conditions	

3.2 Recommendation for Selection

3.2.1 General Considerations

3.2.1.1 New valves

The most important consideration is to purchase only new valves. No reused or recycled valves nor spare parts shall be purchased.

3.2.1.2 Standards

3.2.1.3 Valves certified under ISO standards (e.g., KS ISO 1452-4 for uPVC valves) or comparable national standards shall be purchased.Fit for purpose

To ensure effective function, aspects of the section and system must be considered in addition to features of potential valves. Prior to selection, determine the following information:

a) Maximum water pressure in the section where valve will be installed;
b) Expected flow rates;
c) Acceptable pressure loss along the valve;
d) Minimum and maximum velocity permitted according to the relevant standards;
e) Physical and chemical characteristics of the water, including water temperature and water quality;
f) Suitability of the valve type for the intended mechanical, climatic, and hydraulic conditions, including ambient relative humidity, sunlight exposure, and vibrations;
g) Available space and joining work to install the valve and fittings;
h) Possibility of deposition of substances from water inside the valve;
i) Connection types and interchangeability;
j) Internal and external corrosion and aging resistance;
k) Valve material (e.g., uPVC (ISO 1452-4), lubricants)
l) Performance requirements:
    a. Mechanical strength;
    b. Leak-tightness;
    c. Hydraulic airflow characteristic;
    d. Resistance to disinfection products; and
    e. Endurance;

3.2.1.4 Markings for opening and closing

Direction of the opening and closing of a valve shall be clearly marked on the valve body. This provision is necessary due to the common practice in Kenya of removing hand-wheels of valves in order to prevent manipulation of the valve settings by unauthorized persons.

The number of turns needed to fully open/close a valve shall be clearly marked on the valve body. In Kenya, flow meters are rarely installed with a modulating valve, therefore counting the number of turns is a common method to modulate flow.

3.2.2 Type

The selection of valves should be based on intended their intended function. See Table 2, Section 3.1, for descriptions of valves, general application, and key considerations.

3.2.3 Pressure Rating

Allowable operating pressure (PFA) of the selected valve should be equal to or higher than the maximum design pressure of the valve installation location in the distribution system.

3.2.4 Size

Sizing criteria differ according the valve type.

Gate/sluice, butterfly, check, foot, and pressure reducing valve types: valve connection diameter and the pipe diameter at which the valve will be installed should be of the same size.

Float/ball cock, air release, vacuum release, parallel installed secondary pressure reducing, and pressure release valve types: the selection of the valve depends on the design parameters, which will be site-specific and determined in consultation with the distribution system designers.

3.2.5 Material

Regarding the material and construction of valves, the following general requirements should be followed. Additionally, the buyer (WSP) shall ensure that the selected valve meets the Kenyan laws and regulations regarding material requirements, with certificates provided as documentary evidence.

A key principle is **material loyalty**: materials shall be used as consistently as possible (i.e., use valves made with the same material). Each valve material type requires corresponding fittings, tools and knowledge. Specific knowledge developed by using consistent materials will improve the distribution system quality.

To support this goal of material loyalty, WASPA should make list of different valve types and their materials and how they can be used for different applications, similar to Table 2. Limiting the number of different materials used will reduce the need for a large inventory of different types of replacement and repair materials.

The material used shall be of adequate strength and durability. In particular:

a) Brass should be avoided as a material for the active components (e.g., stem, gland) of a valve.
b) Bronze is recommended for active components.
c) For gate valves, flat-bottom valves (i.e., without grooves) should be chosen. (See Annex B.)
d) In general, metallic valves can be exceedingly heavy, requiring lifting equipment for installation. If high-quality valves made predominately of non-metallic materials are available, these valves should be given priority in selection. This recommendation is especially applicable to air release valves.

e) The material used shall not be adversely affected by water temperature variations within the working temperature range. In Kenya, valves must endure a water temperature of 50ºC.
f) Valves should be made of non-toxic, non-contaminating, and biologically inert materials. Attention is drawn to national regulations.
g) The material used shall be resistant to internal and external corrosion, or protected by a suitable surface treatment.

3.2.6 Considerations for Source Selection

Currently all the valves sold in Kenya are imported from foreign manufacturers. The following actions are recommended for WASPA and WPSs to ensure the purchase of high-quality valves.

1. WASPA should create a master list of reliable manufactures, agents, distributors, suppliers, contractors, and models of valves, based on previous experience gained from projects in Kenya and/or overseas. Organizations and models should be included only after rigorous evaluation of performance of their services and goods. Bringing water suppliers and users together to maintain these benchmarks will ensure high quality valves in the water distribution network and encourage manufacturers to improve their products.
2. The purchaser (WSP) should consult the WASPA list to choose a recommended valve manufacturer, model, and supplier.
3. The purchaser (WSP) should consult with other WSP(s), who have used the same valve(s) to learn from their experience.

4 Technical Specifications of Tender Document

Technical specifications of a tender document for the procurement of valves should incorporate the following information.

4.1 Certificates

The manufacturer of the valves must hold the Quality System Certificate for the standard ISO 9001.

Additionally, the purchased product shall be certified according to the standards applicable to the valves and fittings. Please see Annex C for examples of the standards applicable to the valves and fittings used in the drinking water distribution system.

The supplier should provide the specific manufacturer's authorization for selling its product, and the relevant certificate issued by KEBS.

The purchaser (WSP) must ensure that the specific model purchased is the model for which the certificate was issued.

4.2 Statement of Type, Pressure, Size and Material of Valves

The selected valve type, nominal pressure, size, and material as described in Section 3.2 should be stated in the technical specifications of the tender document.

4.3 Additional Technical Specifications

The following additional technical specifications should be incorporated in the tender document:

a) Marking requirements:
   i. Name (or trademark) of the manufacturer, year of manufacture, and number of the relevant part of the standard used to certify the valve (e.g., for isolating valve: EN 1074-2) shall be marked in a durable and clearly visible manner.
   ii. Material, nominal pressure rating (PN), nominal diameter of flange (DN), nominal diameter, manufacturer information, and intended use shall be marked on the valve (following Table 2 of ISO 1452-4).
   iii. The direction of the flow shall be indicated by a durable and clearly visible arrow (if applicable).
b) Threaded valves shall be supplied with a complete set of connectors that are made of copper alloy or equivalent material resistant to corrosion, rust, and damage due to shock or vibration. The connectors shall be threaded to the correct male size, comprising cap nuts, linings, and fibber sealing washers.
c) Valves should be stored and delivered according to EN 1074 or equivalent standards.

4.4 Additional Non-technical Specifications

The following additional non-technical specifications should be incorporated in the tender document:

a) Spare parts/after sales service:
   i. Availability of connecting parts must be proven. The manufacturer should provide a complete list of available connecting parts (in English), their specific costs (at the time of purchase), and delivery time. The manufacturer should guarantee the supply of connecting parts for at least two years after the expiry of warranty.
   ii. The name, address, and contact details of the local agent responsible for providing connecting parts and maintenance shall be indicated.
b) Installation manuals (in English) shall be provided.
c) The minimum warranty period shall be 5 years. However, 10 years is preferred.

5 Installation of Valves

5.1 Associated Fittings

Proper fittings should be used in order to ensure the correct functioning of valves. A summary of the widely used fittings for different pipe types is presented in Table 4 of the “Technical Guideline for Drinking Water Distribution Pipes in Kenya.”

5.2 Installation Instructions

5.2.1 General Recommendations

Installation of valves shall be carried out professionally according to the installation instructions provided by the specific manufacturer. Additionally, the following recommendations should be followed:

a) Install valves horizontally at the designated location, with the arrow (typically shown on the body of the valve) facing towards the direction of the flow of valve (if available).
b) Valves shall be easily accessible for installation, for maintenance, for removal and for in situ dismantling of the mechanism, if required.
c) Measures shall be employed to avoid contamination, especially when the valve is installed in a pit, by mounting the valves and the fittings at a sufficient height above the floor. If necessary, the pit shall be provided with a sump or drain for water removal.
d) The valve shall be protected from the risk of damage by shock or vibration, extreme temperatures, water or ambient air, and external environmental corrosion.
e) The valve shall not be subjected to undue stresses caused by pipes and fittings. If necessary, it shall be mounted on a plinth or bracket.
f) Unfavorable hydraulic conditions (e.g. cavitations, surging, water hammer) should be avoided.
g) Valves should be installed inside a ground box or vault to protect them from settling earth or other hazards, and to reduce the chance of theft. The casings should be lockable and can be made out of concrete or metal.

5.2.2 Step-by-Step Installation

In general, major valves and fittings suppliers provide step-by-step installation guidelines for their products, which should be followed. Furthermore, WSP can establish their own step-by-step guidelines based on their experience.

A summary of the widely used connection methods are presented in Section 5.3 of the "Technical Guideline for Drinking Water Distribution Pipes in Kenya."

5.3 First Operation of New or Repaired/Serviced Valves

The following points shall be considered before valves are used for the first time.

1. Before installation, the water mains shall be flushed. Care shall be taken to prevent the ingress of debris into the supply lines.
2. After installation, water shall be let into the mains slowly and with trapped air bled so that the trapped air does not cause a pressure surge and resulting damage.

If requested in the specification, pressure tests for the installed valves shall be undertaken by the supplier/installer with the required documentation. Engineers from the WSP can also participate in conducting these tests.

6 Management of valves

6.1 Valve Registry

A valve registry provides complete information for each valve used in the water distribution network. If possible, the valve registry should be integrated or linked with a Geographic Information System (GIS), as with Kenya's water meter registry. A simplified option is to create the valve registry as a separate Excel file.

We recommend the inclusion of the following valve attributes in the registry:

a) GPS coordinates;
b) (Administrative) zone code;
c) Serial number;

d) Brand;
e) Length (in mm);
f) Type;
g) Diameter;
h) Pressure rating;
i) Valve material;
j) Manufacturing date;
k) Installation mode (above ground, underground);
l) First installation date (can be used to establish the age of the valve in combination with the manufacturing data, if known);
m) Last installation (or servicing) date (can be used to estimate the age of the valve if the first installation date is unknown);
n) Operational status: functional, non-functional, damaged (but functional), or testing requested;
o) Visible defects; and
p) Remarks of the registrant.

6.2 Training of Valve Management Team

WSPs should establish a valve management team within the utility. Depending on the capacity of the utility, the team can range from 2 or 3 people (including staff responsible for maintenance) up to 10-20 people. This team will manage all required activities addressing all aspects of valve management: valve selection/sizing, procurement, installation, maintenance and replacement. As a starting point, the team should consist of one or more:

a) **Supervisors:** responsible for customizing this Guideline to the WSP-specific context and overseeing the implementation of a valve management strategy; and
b) **Valve installation/servicing technicians**: one or more (subject to the number of valves) staff members responsible for new installations, (regular) valve servicing, and replacement.

The team should be trained sufficiently in valve management (in house by the supervisors), and re-trained regularly through vocational training to keep abreast with technological advancements. Valve manufacturers/suppliers can offer specialized/customized training courses as well.

7 Maintenance of Valves

Valves can become clogged or damaged as a result of wear and tear. To ensure each valve is functioning properly, the utility should establish a valve maintenance program. Maintenance of valves includes checking for proper performance of the valve's function (e.g., sealing), cleaning, and, if required, replacement of valves.

7.1 Maintenance Schedule

A preventive maintenance schedule for maintenance and servicing of valves should include the following items:

a) Set priorities, including regularly scheduled tests of function;
b) Issue work orders for tasks to be performed;
c) Maintain list of scheduled tasks not completed and record of completed tasks; and
d) Maintain record of tools, materials, labor, and costs required to complete each task.

The longevity of valves with respect to retaining their functional accuracy depends on many factors including the quality of water and how the valves are used. Adherence to a maintenance schedule will extend the life of valves and prevent costly damage resulting from valve failure.

A simplified valve maintenance schedule is presented in Table 3. WSPs should consider this schedule as a starting point on which to build.

Table 3. General valve maintenance tasks and schedule

Application	**Inspection of**	**Maintenance Measures**	**Frequency**
Open/Close/Modulating valves (Gate/Sluice valve, Butterfly valve, Float valve) *Note: Washout valves also should be considered under this category*	○ Mobility of the drive ○ Any outside leak (visual inspection) ○ Operation status (tightness in closed position; , and ab to operate in fully open position) ○ Corrosion development ○ Electric function (if applicable)	○ Complete open and close, at least five turns ○ Repetition if sticking ○ Documentation of rotations ○ Parallel flushing if possible through hydrant ○ Position marking	Depends on importance of valve's function within the network ○ Critical to network: monthly ○ Non-critical: annually
Unidirectional flow (Check valves, Foot valve, Float valve/ball cock)	○ Any outside leak (visual inspection of check valve) ○ Operation status (tightness in closed position; able to operate in fully open position) ○ Corrosion development	○ Complete open and close, at least five turns ○ Repetition if sticking ○ Clean any accumulated debris	Annually
Air release valves	○ Any outside leak (visual inspection) ○ Operation status ○ Corrosion development ○ Function during opening /closing (simulation)	○ Cleaning ○ Opening (check for color, clear air passage) ○ Improve corrosion protection	Monthly Annually (for function simulation)
Pressure reducing valves	○ Mobility of the drive ○ Any outside leak (visual inspection) ○ Operation status ○ Corrosion development ○ Electric function (if applicable)	○ Complete moving and testing different positions and simulation ○ Cleaning ○ Check position/pressure (pressure gauge)	Quarterly
House connections valves	○ Mobility of the drive ○ Any outside leak (visual inspection) ○ Operation status (tightness in closed position; able to operate in fully open position) ○ Corrosion development	○ Close valve and check water supply ○ Cleaning	Semi-annually

An sample preventive maintenance schedule for valves is provided in Table D1 of Annex D.

Sample inspection reports and maintenance activity reports are provided in Table D2 and Table D3, respectively.

7.2 Maintenance Procedure

Details of specific valve maintenance procedures are outside the scope of this Guideline, as every type and brand of valve requires its own specific maintenance procedure. Hence, for more detailed guidance, the maintenance manual provided by the manufacturer should be consulted. However, the following generic maintenance measures shall be taken:

a) Lubrication of the spindles shall be performed regularly.
b) Leaking spindles shall be repacked.
c) Rust and sediment in the valve shall be removed by shutting the disc firmly in the seat, then opening approximately 25% and closing tightly several times. (The increased velocity usually flushes out obstructions.)
d) Valve chambers/boxes also require maintenance to ensure that the interiors of chambers are free of silt and covers remain intact and properly positioned.
e) Valve chambers shall not become water logged.

8 Disposal of Valves

Valves should be disposed according to ISO 14001. This International Standard requires organizations to consider the full life cycle of their products and the need to provide information about potentially significant environmental impacts associated with products' end-of-life treatment and final disposal. The WSP shall maintain documentation that end-of-life and disposal processes have been carried out in accordance with ISO 14001.

Annex A: WASPA Valve Use Survey Findings

As is highlighted in the introduction to this document, this Guideline incorporates the findings of a valve management survey that was conducted by WASPA with bfz-SWAP support. The questionnaire was disseminated to all member WSPs. We would like to acknowledge and thank the following 11 WSPs for directly contributing to the Guideline by submitting their questionnaires: Eldoret, Isiolo, Kewasco, Kisumu, Mathira, Mawasco, Murang'a, Nakuru Rural (NARUWASCO), Nawasco, Nyeri, South West Kenya.

Table A1 summarizes the major findings of the survey[1]. The most common types of valves currently used in Kenya are gate/sluice and butterfly, with problems of spindle fatigue and leaks reported.

Table A1. Survey findings about valves used in Kenya

No.	Parameters	Data
2.1	Common type for isolation	Gate/Sluice
2.2	Common type for diversion	Gate/Sluice
2.3	Common type for flow control	Butterfly Gate/Sluice
2.4	Typical pressure rating, PN	16
2.5	Typical failure/problem	Gate gets stuck Spindle shaft/thread wear off Leaks

[1] More detailed information is available from WASPA on request.

Annex B: Best engineering practices for the selection of different types of valves.

B.1 Sluice/Gate Valves

According to Kenyan WSPs' experience, **rubber resilient seated gate valves** performed better than the metal seated gate valves. This superior performance is due to the resilient seated gate valves' flat valve base, which allows free passage for sand and pebbles in the valve. Therefore, foreign material does not settle in the valve. Normally, pipe systems will not be completely free from impurities regardless of how thoroughly the pipe is flushed upon installation or repair. The metal seated gate valves usually has a grooved base, which allows foreign material to settle in the depression, thus affecting the function of the valve.

Malindi Water & Sewerage Co. Ltd informed us that they have had a positive experience with the type of rubber resilient seated gate valves shown in Figure B1.

Figure B1: Rubber resilient seated gate valves produced by AVK Valves (Photo courtesy: Priscillah Oluoch, Deputy Technical Manager, Malindi Water & Sewerage Co. Ltd)**.**

B.2 Float Valve / Ball Cock

(Note: Information in this section is drawn from "Trouble-Free Operation for Float Valve Selection and Installation." [11])

Ensure proposer stem length, float ball size, and ratings for pressure and flow rate.

If adjustments are needed to reduce the length of the stem or size of the float to fit a particular application, the best option is to select two smaller sized valves instead of one large valve in order to maintain pressure and flow rate. If a single, smaller-sized standard assembly or orifice is used, it can maintain reliable shut-off at high pressure, but may still reduce flow rate. If a non-standard assembly is used, reductions in both water flow and inlet pressure may result, which will require the use of a pressure regulator. .

B.3 Air Release Valve

In most cases, the size of the air release valve is a judgment decision based on experience. The following steps can be taken to select an appropriate air release valve:

1. Convert pipeline flow rate to Cubic Feet per Minute (CFM).
2. Multiply CFM by 0.02 (2% air content) to estimate dissolved air in water.
3. Determine the working pressure at the valve.
4. Refer to the Orifice Air Capacity Table in the AWWA manual [5] or the relevant table provided by the manufacturer.

The percent of air content can be varied depending on the potential for entrained air. The air release valve inlet connection should be as large as possible to maximize the exchange of air and water in the valve.

B.4 Air/Vacuum Release Valve

The accepted rule of thumb indicates that air/vacuum valves should be 25 mm per 0.3 m pipe diameter [8]. For example 1.2 m diameter line would have a 100 mm diameter valve.

B.5 Pressure Reducing Valve

(Note: Information in this section is drawn from "Correct Sizing of a Pressure Reducing Valve." [12])

The pressure reducing valve should be selected based on a velocity of 1-2 m/s and an intended pressure reduction of 2:1, not to exceed 4:1. For example, if the supply pressure is 600kPa, the static downstream pressure should be 300kPa. Multiple sequential valves may be used to achieve larger pressure drops (e.g., for tall buildings).

Low flow situations must be taken into consideration when sizing the pressure reducing valve, as a valve sized only for maximum flow will remain partially closed during low flow periods, causing excessive wear and noise. Installing a second, smaller bypass valve parallel to the main valve can prevent these problems.

Annex C: List of relevant standards for valves

Standards applicable to the valves used in drinking water distribution systems are listed below.

- KS ISO 1452-4: Plastic piping system for water supply and buried and above-ground drainage and sewerage under pressure – Unplasticized poly(vinyl chloride) (PVC-U) – Part 4: valves.
- EN 1074-1: Valves for water supply. Fitness for purpose requirements and appropriate verification tests. Part 1 - General requirement
- 1074-2: Valves for water supply. Fitness for purpose requirements and appropriate verification tests. Part 2 – Isolating valves
- 1074-3: Valves for water supply. Fitness for purpose requirements and appropriate verification tests. Part 3 – Check valves
- 1074-4: Valves for water supply. Fitness for purpose requirements and appropriate verification tests. Part 4 – Air valves
- 1074-3: Valves for water supply. Fitness for purpose requirements and appropriate verification tests. Part 5 – Control valves

Annex D: Sample Preventive Maintenance Schedule and Reports

Table D1. Sample Preventive Maintenance Schedule for WSP

S/N	Assets	Quantity	Activities	Required materials	Cost (KSi)	By whom	Time Frame
1	Security boxes	7	-Installation of security boxes for water meter and main valves	-Security boxes -Hoe -Spade -Pipe wrenches -Padlock	4,500	Meter Reader	23/02/2016-25/02/2016
2	Non return valves 2”	2	-Replacement of non-return valve to the main line -Chamber construction	-Non-return valves -Pipe wrenches -Thread seal -Connector -Nipple -Socket	56,000	Plumbers	25/02/2016-28/02/2016
3	Non-return valves 3”	2	-Installation of 2 non return valves in the main line -Chamber construction	-Non-return valves -Pipe wrenches -Thread seal -Connector -Nipples -Socket -Flanges -Gasket maker	43,000	Plumbers	12/03/2016-18/03/2016
4	Air Valve 1.5’’	1	-Installation of air valve -Chamber construction to protect air valve	-Air valve -Saddle clamp -Pipe wrenches -Hack saw -Nipple	217,00	Plumber and mason	21/03/2016-25/03/2016

Table D2. Sample Inspection Report

Inspection	Observation	Date
-Installation of security boxes for water meter and main valves	1 Security box installed in water meter at ABC water Kiosk	25/2/2016
-Replacement of non-return valve to the main line -Chamber construction	1 Non-return Valve Replaced in the main line -Chamber constructed to protect Non-return valve Serial Number1234 installed in main line	28/2/2016
-Installation of 2 non-return valves in the main line -Chamber construction	-2 non-return valves were installed to the main line	14/03/2016

Table D3. Sample Maintenance Activity Report

Activity Performed	Location	Date
1 security box installed in water meter and main valves at ABC water Kiosk	ABC	25/2/2016
1 Non-return Valve Replaced in the main line -Chamber constructed to protect Non-return valve Serial Number1234 installed in main line	DEF	28/2/2016
-2 Non-return valves were installed to the main line.	IJK- XYZ	14/03/2015

References and Additional Resources

[1] State department of water, Standards for non-revenue water management in Kenya, nairobi: Ministry of envrionment, water and natural resoures, 2014.

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[5] "Water Distribution Operator Training Handbook, Third Ed," American Water Works Association 2005.

[6] "Types of Valves Used in Water Supply Pipelines," http://www.gharexpert.com/tips/articles/Construction/1815/Plumbing-1815-Types-Valves-Used-In-Water-Supply-Pipe-Lines_0, 2016

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[8] "Theory, Application, and Sizing of Air Valves," VAL-MATIC Valve and Manufacturing Corp.

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[10] "Specification for the Laying of Water Mains and Drinking Water Supply," Water Services and Development Department Water Section, South Dublin Country Council

[11] "Trouble-Free Operation for Float Valve Selection and Installation," http://www.cdivalve.com/products/float-valves-trouble-free-operation, 2016.

[12] "Correct Sizing of a Pressure Reducing Valve," http://allvalve.com.au/plumbing/news/newsPRVsize.htm, 2015.

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