Technical Guideline for Drinking Water Distribution Pipes in Kenya

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Foreword

By WASPA

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- Water Services Regulatory Board

Abbreviations

DI - Ductile Iron

ERC - Energy Regulatory Commission

GI - Galvanized iron

HDPE - High Density Polyethylene

KEBS – Kenya Bureau of Standards

NRW – Non Revenue Water

PE – Public Entity

PPOA - Public Procurement Oversight Authority

PP-R - Polypropylene Random

Specs – Specifications

TOR – Terms of Reference

uPVC - Unplasticized Polyvinyl chloride

WASPA – Water Services Providers Association

WASREB – Water Services Regulatory Board

WSP – Water Service Provider

1 Introduction

Non Revenue Water (NRW), as being one of the main performance indicators for water utilities, has been reduced only marginally from *47 %* in 2008/2009 to *44 %* in 2011/12. At this pace, the national target of *30 %* set in the National Water Services Strategy (NWSS 2007-2015) will therewith not be achieved [1]. "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].

While good progress has been made with regard to access to safe and clean drinking water, sanitation and sewerage in Kenya, the goal of reducing NRW to *30 %* is still lagging behind.

Reducing NRW to the sector benchmark of *20 %* should be the number one priority for Water Service Providers (WSPs) to decrease drinking water wastage, increase revenue, extend coverage, and ultimately ensure a more efficient provision of water to consumers.

The Guideline is in line with the National Water Service Strategy (2007-2015), p. 18 [3], which states 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 breakdown times".

Pipe and joint failure (e.g., burst and leak) is one of the major causes of supply water loss in Kenya. The main causes of pipe failure include improper pipe, fittings and joint type; substandard pipe and fittings; poor installation and maintenance of pipes. The water loss due to the pipe and joint failure increases the overall energy consumption of the water distribution system. Minimizing water loss through an active leakage reduction program will reduce the waste of energy embedded in the lost water. Hence, installation of appropriate good quality pipe and fittings is very important to reduce the service downtime and water loss, as well as increase the energy use efficiency.

The Technical Guideline comprises recommendations for the procurement process, the selection of water distribution pipes, the establishment of technical specifications, and the installation and maintenance of drinking water distribution pipes.

The Guideline is based on an investigation of the current situation through questionnaires (filled in 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 envisaged to support and guide the WSPs through each step with regard to procurement, installation and maintenance of different metal and plastic pipes in the provision of water services.

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

2 Recommendations for a Generic Procurement Process

As each WSP has established its own procurement process based on their specific requirements and experience, recommendations for further improvements are given instead of suggesting a 'one fits all solution'. These recommendations are based on the Kenyan Public Procurement and Disposal Act (2005), its subsidiary legislation entitled Public Procurement and Disposal Regulations (2006), and the ISO standard 10845-1:2010 – Construction Procurement – Processes, methods and procedures, which aims at establishing a procurement process being 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 incorporates the procurement of drinking water distribution pipes by WSPs. WSPs are classified as "Class B" PEs. PEs must carry out their procurement and disposal activities in accordance with the Public Procurement Oversight Authority (PPOA), the Regulations, Standard Tendering Documents (available on www.ppoa.go.ke), Manuals and any directions of the PPOA [4].

This includes the basic procurement process, consisting of 17 steps and to be followed by all PEs, shown in Table 1. The main roles and responsibilities are taken over by the 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	User Department, Procurement Unit & Boards/Councils
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	Procurement Unit
Step 7	Approval of Tendering Documents	Tender Committee
Step 8	Advertisement & Invitation for Tender	Procurement Unit
Step 9	Receipt & Opening of Tenders	Tender Opening Committee
Step 10	Evaluation of Tenders (testing of provided samples)	Evaluation Committee and Testing facility (KEBS or Ministry of East Africa Affairs, Commerce and Tourism)
Step 11	Review of Evaluation Report (Approval or Rejection)	Tender Committee
Step 12	Award of Contract	Tender Committee
Step 13	Communicate Award	Accounting Officer
Step 14	Review	PPARB (optional)
Step 15	Sign Contract	Accounting Officer
Step 16	Contract Monitoring	User Department & Procurement Unit
Step 17	Contract Performance Evaluation	User Department & Procurement Unit

Please see the Section 2 of the 'Technical Guideline for Water Meter (Management) in Kenya' for the recommendations addressing the shortcomings for some relevant steps. More detailed information on each of the steps and the main roles & responsibilities can be found in the "User Guide to The Public Procurement and Disposal Act, 2005" [4].

Following Documents Needs to Submitted with Tenders (to be eligible for evaluation)

- Name of the standard(s) used to certify the product(s)
- Certificates of manufacturing quality testing (e.g., methods of manufacturing)
- Certificates of final product quality testing
- KEBS certificates of testing and KEBS marks on the product
- Proof of authenticity of the suppliers as an approved suppliers from the supplier's side
- Proof of authenticity of the suppliers as an approved suppliers from the manufacturers' side (WASP should obtain it directly from the original manufacturer)
- Warranty documents with clear terms and conditions
- Service contract documents with clear terms and conditions (it should be obtained regardless of whether WASP want this in final contract or not. This document will provide confidence on the supplier's authenticity).
- Spare parts availability contract with clear terms and conditions
- Supplier's rating by WASPA's list
- Reference provided by suppliers from previous projects

2.1 Inspection and Acceptance of the Goods

It is manufacturers' responsibility to conduct or arrange to conduct all the quality assurance tests, as well as obtaining the approval certificates from the relevant standardization authorities (e.g., KEBS).

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

Every pipe and fitting should be checked visually for any defect, and/or poor workmanship. If any defect is detected the product should be rejected.

- Check the uniformity of the pipe surface visually (e.g., dent, pit, extruded parts, color, and surface finish/smoothness).
- Both end sections of the pipe should have a clean cut and also should be perpendicular to the axis of the pipe
- *Wall Thickness:* The agreement of the pipe wall thickness with the requirements shall be demonstrated by the manufacturer/supplier. Any of the following techniques can be used- direct wall thickness measurement, mechanical measurement or by means of ultrasound. The pipe wall thickness must be measured by instruments, which have a margin of error of ± 0.1 mm.
- *Outer diameter*: Socket pipes must be measured at spigot with Circometer.
- *Roundness*: Check the roundness of the pipe cross-section visually at spigot. In case of doubt, the largest and smallest axis must be measured with suitable equipment.
- *Inner diameter:* The internal diameter of the lined pipes must be determined. Best practices is to measure the diameter at 200 mm or more from the pipe end, must be carried out two perpendicular measurements, the average of these two measurements can be used to compare with the specification.
- *Protective lining*: The surface of the cement mortar lining shall be uniform and smooth. Footprints of the trowel isolated protruding sand grains and associated with the

manufacturing process surface textures are permissible. However, local defects exist that reduce the layer thickness to the extent that it falls below the minimum specified in Table B1 in Annex B shall be rejected.

3 Selection of Drinking Water Distribution Pipes

Pipe used in the water distribution system mainly classified based on the pipe diameter, such as, large diameter main pipes, which supply entire towns; medium diameter sub-main pipes, which supply a zone; smaller branch lines that supply a street or group of buildings, or small diameter pipes located within individual buildings.

3.1 Introduction to Pipes Widely Used in Kenya

Pipes used in the Kenyan drinking water distribution system can be broadly categorized in 2 main categories based on materials of the pipes; plastic pipes and metal pipes. Both plastic pipes and metals pipes again can be categorized based on the specific properties of the pipes. Plastic pipes and metal pipes widely used in Kenya are described in more detail in Table 2 and Table 3, respectively.

Table 2: Description of Plastic Pipes used in Kenya

Pipe Type	Advantages	Concerns/Disadvantages	Applicability
HDPE (High Density Polyethylene) **(KS ISO 4427 Part 1, 2, 3 & 5)**	○ Lower Costs/relatively cheap and lighter weight than Iron pipes ○ High corrosion resistance- does not rust or corrode, good resistance to acids and alkaline soils. ○ Not rough- low friction head loss. ○ Can be produced in longer length (up to 100m)- Less joining needed, lower chances of joint leak ○ Due to HDPE's flexibility and relatively joint-less construction, installation costs are lower compared to other types of pipe. ○ Does not leak easily, which reduces repairs and maintenance costs. ○ Difficult to make an unauthorized connection by tapping on the pipe ○ Excellent in shifting soils & performs will in earthquake-prone areas. ○ The pipe's flexibility solves many unique problems that cannot be fixed with rigid concrete, PVC or ductile iron pipe.	○ Pipe itself is relatively expensive compared to uPVC ○ Special welding equipments, and worker skilled with HDPE fusion are needed ○ High coefficient of thermal expansion ○ Sensible against sharp stones or damages on surface ○ Protection against UV during storage is necessary ○ Contaminant can diffused through the pipe if installed in contaminated soils.	○ Large to small diameter applications ○ Distribution main, sub-main and branch ○ Settlement-sensitive grounds ○ Pipe made with 'HDPE 100' can reach up to 100 years lifetime
uPVC (Unplasticized Polyvinyl chloride) **(KS ISO 1452 Part 1, 2, 3, 4 & 5)**	○ uPVC has high chemical resistance across its operating temperature range, with a broad band of operating pressures. ○ Due to its long-term strength characteristics, high stiffness and cost effectiveness, uPVC systems account for a large proportion of plastic piping installations. ○ PVC pipe has extremely smooth bore due to which frictional losses and bacterial and fungal formation are at minimum. ○ PVC pipe is only about 1/5 the weight of an equivalent cast iron pipe and a 1/3 to 1/4 of the weight of a cement pipe. As a result, the cost of transportation and installation is cut down immensely.	○ Susceptible to UV damage ○ Pipe produced in short lengths (e.g., 6 m)- Significant joining needed ○ Joints are prone to leak due to poor workmanship, water pressure and other external factors ○ Relatively less flexible	○ Very large to small diameter applications ○ Distribution main, sub-main and branch ○ High corrosive soils but little expected mechanical movement
PP-R (Polypropylene Random) **(KS ISO 15874 Part 1, 2, 3 & 5)**	○ PP-R (Polypropylene Random) has become a key material for hot and cold drinking water piping systems for its high resistance to pressure and temperature. ○ Cheaper than commonly used GI pipes for plumbing	○ Susceptible to UV damage ○ Only for small diameter applications	○ Small diameter applications ○ From water meter to tap

Table 3: Description of Metal Pipes used in Kenya

Pipe Type	Advantages	Concerns/Disadvantages	Applicability
GI (Galvanized iron) **(EN 10255;** **ISO 65)**	○ High pressure rating - Pipes are much more durable than any kind of plastic pipes ○ Widely use for many years - technicians are familiar with the material	○ Pipe is relatively expensive than the plastic pipes ○ Heavy to Handle ○ Rusting/erosion occurs (Galvanization layer does not last forever). - The average life span is generally around 40 years - Bad quality pipe will have significantly lower life span ○ Rough surface - Higher head loss - Possibility of bacteria growth ○ Blockages potential - Minerals can start to build up inside the pipes ○ Difficult to Repair - Galvanized pipes are generally replaced rather than repaired. - If these pipes get damaged, the zinc layer of the galvanization will also get weaker and the pipe will start to corrode in a short period of time.	○ Small diameter applications ○ From water meter to tap
DI (Ductile Iron) **(ISO 2531)**	○ High pressure rating - Pipes are much more durable than any kind of plastic pipes ○ Widely use for many years - technicians are familiar with the material	○ Needs corrosion protection in (cement mortar coating) and outside (galvanized Zink, Zink-Alu, and Epoxy or PE cover in aggressive soils) ○ Pipe is relatively expensive than the plastic pipes ○ Heavy to Handle ○ Installation needs careful axial restraints	○ Very large to medium diameter applications ○ Distribution main, sub-main and branch ○ High corrosive soils but little expected mechanical movement ○ Special demands- high external load areas, and high pressure inside ○ in settlement sensitive grounds where some mechanical movement is expected

3.2 Recommendation for Selection

3.2.1 General Considerations

Of most importance is to only purchase new pipes and fittings. No reused or recycled pipes or fittings shall be bought.

The following aspects are of particular relevance:

- the maximum water pressure in the pipe section
- the maximum external pressure on the pipe section (e.g., traffic load)
- the expected flow rates
- the acceptable pressure loss along the pipe
- the minimum and maximum velocity permitted according to the relevant standards
- the physical and chemical characteristics of the water, including water temperature and water quality
- the suitability of the pipe, fitting and joint type for the intended mechanical, climatic, and hydraulic conditions, including ambient relative humidity, sunlight exposure, vibrations
- the available space and joining work to install the pipe and the fittings
- the possibility of deposition of substances from water inside the pipe

3.2.2 Material

Choice of material depends on the application of the pipes, ground/soil conditions, bedding, pressure, diameter and price.

Transport and main distribution pipes:

- In general, HDPE pipes are recommended by WASPA. HDPE 100 is recommended (can reach 100 years lifetime).
- If enough budget is not available for HDPE pipe, uPVC can be considered.
- Ductile iron (with corrosion protection) should be considered for the following conditions:
    - For very high pressure applications where HDPE and uPVC pipes' allowable operating pressure of the pipes are lower than the required design pressure
    - When required diameter is too large that the installation of HDPE pipe or uPVC pipe become impractical
    - Where the ground has many sharp stones

Distribution branches and house connections pipes:

- In general, HDPE pipes are recommended by WASPA. HDPE 100 is recommended (can reach 100 years lifetime).
- If enough budget is not available for HDPE pipe, uPVC can be considered.

Small diameter applications (e.g., from water meter to tap):

- PP-R pipes (relevant standard - ISO 15874), and/or galvanized iron (relevant standard - BS EN 10255:2004) can be considered

<u>Protective coatings for metal pipes</u>

The metal (e.g., ductile iron) pipes for water systems are coated and/or lined with different materials for corrosion protection. Following are the important aspects of ccorrosion protection coatings.

- Coating materials should be drinking water grade coating
- Environmental friendly coating
- Type and thickness of coating should be adequate for the application
- Outer coating:
  - Zinc dust colour painting with a mass of at least 220 g/m^2, with finishing layer
  - Polyethylene film (as an addition to zinc coating with finishing layer)
  - Zinc-aluminium alloy with or without other metals, with a mass of at least 400 g/m^2, with finishing layer
  - Extruded polyethylene coating according to EN 14628
  - Polyurethane coating to EN 15189
  - Cement mortar coating to EN 15542
  - Guard bands.
- Inner envelopes (liners):
  - Thicker cement mortar lining (cement mortar based on blast furnace cement)
  - Cement mortar lining with top coat
  - Polyurethane lining to EN 15655
- Coating the bonding surface:
  - Epoxy coating
  - Polyurethane coating
- An additional coating is necessary for soils:
  - With a low ground resistance of less than 1500 Ω·cm when installed above the ground water level or less 2 500 Ω·cm when installed below the ground water level
  - Mixed soils, i.e., with two or more different types of soils
  - With a pH below 6, and a high capacity base;
  - Soil containing or contaminated by industrial waste, ash, slag, or industrial wastewater.

3.2.3 Pressure Rating

Allowable operating pressure (PFA) of the selected pipe should be equal to or higher than the maximum design pressure of that pipe section.

3.2.4 Size

Internal diameter of the pipe depends on both peak flow and off-peak flow rates. Size the pipe based on the designed velocity of water inside the pipe. Following listed the recommended velocity inside the different pipes in a water distribution system [5].

- House connection: ≤2 m/s
- Main pipes distribution network ≤1 m/s
- Pressure pipe from pump: 1 -2 m/s
- Pump vacuum pipe: 0.5 - 1 m/s
- Inlet 0.2 - 0.5 m/s

Design should make sure that pipe sizes are selected carefully to avoid ‘stagnant’ water in the distribution system.

3.2.5 Considerations for Source Selection

Currently pipes sold in Kenya are mainly manufactured in Kenya. However some pipes and most of the fittings are imported from foreign manufacturers. Following points need to take into account to ensure quality pipe purchase.

- WASPA should make a list of the reliable manufactures, agents, distributors, suppliers and contractors of the pipes and fittings based on the experiences of the previous projects in Kenya and/or overseas.
- Purchaser (e.g., WSP) should consult with the WASPA list to choose a pipe and fittings manufacturer, model and supplier.
- Purchaser (e.g., WSP) should consult with other WSP(s), who has used the same pipe(s) and fittings, to learn from their experience.

3.2.6 Recommendation

- Important principle is ***Material Loyalty*** (e.g., use pipes made with same material as much as possible). Each pipe material type needs its fittings, tools and knowledge. Specific knowledge developed by using the same pipe types will improve the distribution system quality.
- It is recommended that the WSPs should make a list mentioning pipe types (i.e., materials) for different applications as describe in Section 3.2.2. It is recommended to reduce to only few different types of material to avoid big storage of fittings and repair materials.
- WASPA should make a list of the reliable manufactures, agents, distributors, suppliers and contractors of the pipes and fittings.
- The manufacturing process quality, and the pipe and fitting samples should be tested once in a while.
- Only after detailed provisioning, testing of samples etc a manufacturer shall be included in the list. This is an important factor to reach quality, and encourage the manufacturers to improve their products. If the lobby of water suppliers and users is joined they have the opportunity to influence the quality on the market.

4 Technical Specifications of Tender Document

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

4.1 Certificates

The manufacturer of the pipes 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 pipes and fittings as listed in Table 2 & 3. Please see Annex C for additional examples of the standards applicable to the pipes and fittings used in the drinking water distribution system.

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

It is important to ensure that the specific batch of pipes purchased is the one which had been certified.

4.2 Statement of Material, Pressure and Size of Pipe and Fittings

The selected pipes and fittings material, nominal pressure, and size as described in Chapter 3.2 should be stated in the technical specifications of the tender document.

4.3 Additional Technical Specifications

The following technical specifications should be incorporated additionally:

- In addition to the minimum marking requirement on pipes as stated in international standards (e.g., Table 10 of ISO 1452-2 standard), the manufacturer trademark, material, pressure rating, nominal outside diameter, OD, intended use and other relevant information (e.g., wall thickness) is required to be marked on pipes in every 1 meter length. For plastic pipes batch number, date of production etc needs to be embossed.
- In addition to the minimum marking requirement on pipes as stated in international standards (e.g., Table 24 of ISO 1452-3 standard), the manufacturer trademark, material, pressure rating, nominal outside diameter, OD, intended use and other relevant information (e.g., wall thickness) is required to be marked on every pipe fittings. For plastic fittings, batch number, date of production etc needs to be embossed.
- Similar marking standards applied for DI and GI pipes.
- The pipe and fittings should be stored and delivered according to ISO standards.

4.4 Additional Non-Technical Specifications

Spare *parts/aft*er sales service:

- Availability of fittings (e.g., connectors, socket, gasket, rubber lining) has to be proven. The manufacturer should provide a completee list of available fittings (in English), their specific costs (at the time of purchase) and delivery time. The manufacturer should guarantee the supply of fittings for at least two years after the expiry of warranty.
- The name, address, and contact details of the local agent responsible for providing fittings and maintenance shall be indicated.
- For the case of fusion (e.g., butt, electro and heat) and heat welded type pipes, manufacturer should provide a complete list of available equipment for pipe joining (in English), their specific costs (at the time of purchase) and delivery time; opportunity of equipment rental and rental cost (at the time of purchase). The manufacturer should guarantee the supply of pipe joining equipment for at least two years after the expiry of warranty.

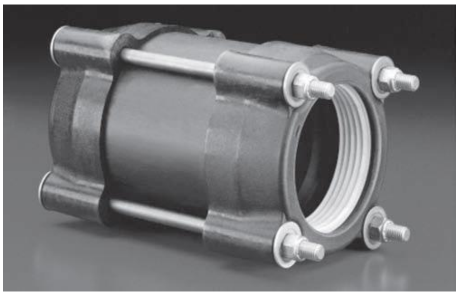
Installation manuals: Installation manuals (in English) shall be provided.
Warranty: The minimum warranty period shall be two years after installation.

5 Installation of Pipes

5.1 Associated Fittings

Additional to the quality pipe purchased, the following fittings and instructions should be applied and followed additionally, in order to ensure the correct functioning of water pipes. A summary of the widely used fittings for different pipe types are summarized in Table 4.

Table 4: Recommended fittings for different pipe joining

Pipe Types	General Connections and Fittings
HDPE to HDPE	○ For small diameter pipe: Mechanical compression couplings, stab type mechanical fittings ○ For medium to large diameter pipe: Different types of fusions (e.g., butt, electro, saddle, socket), flange, mechanical bolt type couplings
uPVC to uPVC	○ Non end load bearing joints: Elastomeric ring seal joints, mechanical joint assemblies ○ End load bearing joints: pipe sockets with solvent cement, flange, unions, end load bearing double socket and elastomeric ring seal
PP-R to PP-R	○ Socket welded joints (Heat fusion), electro fusion, mechanical joints assemblies
HDPE to uPVC	 ○ Transition fitting/ PVC - HDPE Adapters ○ http://www.polycam.com/html/735_1Specs.html ○ Standard SDR sizes 7,9,11 ○ Also, different mechanical Couplings
HDPE to PP-R & HDPE to GI & HDPE to Ductile Iron	  ○ Mechanical Bolt Type Couplings - There are many styles and varieties of “Bolt Type” couplings available to join PE to PE or other types of pipe such as PVC, steel and cast iron in sizes from 1¼” IPS and larger. ○ Other method for PP-R: Transition fitting/ PP-R to HDPE Adapters
uPVC to PP-R	○ Transition fitting/ PP-R to HDPE Adapters

Pipe Types	General Connections and Fittings
GI to GI	 ○ Threaded GI fitting
Ductile Iron to Ductile Iron	 ○ Flange and Flange adapter
GI to Ductile Iron	○ It is very uncommon to connect these two pipes
uPVC to GI	○ flange or a metal adaptor
uPVC to Ductile Iron	○ flange or a metal adaptor
PP-R to GI	○ Flange or a metal adaptor. (BS 6920)

5.2 Installation Instructions

5.2.1 General Recommendations

Installation of pipes and fittings shall be carried out professionally according to the installation instructions provided by the pipes and fittings manufacturers. Additionally, the following recommendations should be followed:

- Measures shall be employed to avoid contamination.
- The pipe shall not be subjected to undue stresses caused by external loading (e.g., traffic loading). Most of the pipe (>95%) installed underground and use trench technique. Proper measures should be taken for trench preparation and trench filling of the pipes.

- The pipe shall be protected from the risk of damage by shock or vibration, from extremes of temperature, of water or ambient air, and due to external environmental corrosion.
- The pipe shall not be subjected to undue stresses caused by pumps, valves and fittings. If necessary, it shall be mounted on a plinth or bracket.
- Unfavourable hydraulic conditions, e.g. cavitations, surging and water hammer, should be avoided.

5.2.2 Butt Fusion Connection

In general, butt fusion jointing involves the fusing together two pipe ends in a special machine which prepares the pipe ends, heats them and brings them together under pressure to form a homogeneous weld. The joint is fully end load resistant and is at least as strong as the parent pipe.

Most HDPE pipe manufacturers have detailed written procedures to follow. ISO 21307 specifies butt fusion joining procedures for polyethylene (PE) pipes and fittings used in the water distribution systems.

Basic equipments required for butt fusion are as follows.

- Butt Fusion machine, inclusive of trimmer, heater plate and hydraulic pump.
- Electric Generator, fuel
- Welding Tent/Base board
- Pipe support rollers
- Clean water, lint free cloths
- External de-beading tool
- Bead gauge
- Pipe end covers
- Indelible marker pen
- Pipe cutting tools

Typical heater plate temperature for single low-pressure butt fusion joining procedures is 200 to 245 degree Celsius. Other parameters and values for butt fusion joining are specified in Table 1 of ISO 21307. Typical butt fusion joining cycle is indicated in Figure 1 of ISO 21307.

A general procedure of butt fusion is provided in Appendix E.

5.2.3 Electro Fusion Connection

Electro fusion fittings incorporate an electrical heating element which is energised via an electro fusion control box to heat the elements. When the fitting is energised the material next to it becomes molten causes the pipe surface to melt, resulting in a molten pool of material fusing the materials of fitting and pipe. Once the molten pool cooled this produces a fully fused and leak free joint.

Basic equipments required for electro fusion are as follows.

- E/F control unit
- Electric generator (e.g., 110 V)
- 3 - 3.5 KVA for 39.5 volt fittings
- 6 - 7 KVA for 80 volt fittings
- Jointing shelter

- Pipe scraping tool, including mechanical
- scrapers for pipe end preparation
- and hand scrapers for saddle
- joints
- Pipe cutting tool
- Marker pen, solvent wipes, lint free
- cloths/paper towels

A number of manufacturers produce electro fusion control boxes and the required additional tools. The correct tools must be used to ensure reliable joints. The equipments may be either purchased or rented from the tool manufacturer or their agents. The site equipment should include:

A general procedure of electro-fusion is provided in Annex D.

5.2.4 Saddle/ Conventional Fusion

The conventional technique used to join a saddle to the side of a pipe. It consists of simultaneously heating both the external surface of the pipe and the matching surface of the “saddle” type fitting with concave and convex shaped heating tools until both surfaces reach proper fusion temperature. This may be accomplished by using a saddle fusion machine that has been designed for this purpose.

A general procedure of saddle fusion is provided in Annex D.

5.2.5 Socket (heat) Connection

This technique consists of simultaneously heating both the external surface of the pipe end and the internal surface of the socket fitting until the material reaches the recommended fusion temperature, inspecting the melt pattern, inserting the pipe end into the socket, and holding it in place until the joint cools.

Mechanical equipment is available to hold both the pipe and the fitting, and should be used for sizes larger than 2” CTS (Copper Tube Size) to help attain the increased force required and to assist in alignment.

Most pipe manufacturers have detailed written procedures to follow. The majority refer to ASTM F 2620. A general procedure of socket-fusion is provided in Annex D.

5.2.6 Socket (Solvent Cement) Connection

Socked solvent cement joints are one of the most widely used connection for water distribution pipe, especially for uPVC pipes. All WSP have technicians who are familiar with socked solvent cement joints. However, proper professional care and attention should be provided to ensure the high quality joints. Only the highest quality solvent cements from reputed manufacturers should be used. If necessary, technicians should get additional training on this type of jointing method.

Most pipe manufacturers have detailed written procedures to follow. There are many solvent cementing techniques published covering step by step procedures on how to make solvent cemented joints. A good source of references is Technical Manuals published by George Fischer Piping Systems.

5.2.7 Threaded Connection

Threaded connection joints are one of the most widely used connection for water distribution pipe, both for plastic and metal pipes. All WSP have technicians who are familiar with threaded connections. However, proper professional care and attention should be provided to ensure the high quality joints. Only the highest quality thread sealant (or "pipe dope") approved for use with the type of pipe or PTFE tape from reputed manufacturers should be used. If necessary, technicians should get additional training on this type of jointing method.

Most pipe manufacturers have detailed written procedures to follow. There are many threaded connection techniques published. A good source of references is Technical Manuals published by George Fischer Piping Systems.

5.2.8 Flange Connection

Flange connection is usually used for medium to large diameter pipes. Following are some important aspects of flange connection.

- For the flange connected pipe and fittings, use gaskets that properly match the diameter of the pipe. Flow interruption may occur when gaskets are projecting inwards.
- Gasket should be made of recommended compatible material e.g. EPDM, Teflon, PTFE (EN 12560-1 Gaskets for class-designated flanges) etc.
- Torque wrench should be used for bolt tightening
- Tightening torque value depends on type of gasket, amount and diameter of bolts
- Appropriate torque values and tightening procedure should be used to ensure proper connection.

Most pipe manufacturers have detailed written procedures to follow. There are many flanged connection techniques published. A good source of references is Technical Manuals published by George Fischer Piping Systems.

Some important points of flange connection are provided in Annex D.

5.2.9 Recommendations for Installation to Prevent Joint Failure

See table 4 to choose the right type of connectors. See sec 5.2.1 to 5.2.8 to choose the right type of joining method and the best practices. Following are the important aspects to avoid a joint failure.

- Fitting certified under ISO standards shall be purchased.
- Proper type of fittings should be used (see Section 5.1)
- Proper joining technique should be used (**no innovative techniques shall be allowed** e.g., super glue)
- Proper equipment should be used
- Skilled technician should be used
- Pipe and fitting should be properly cleaned before joining according to the guideline
- Proper setting time should be allowed before commissioning

5.2.10 Depth of Soil Cover

The minimum recommended depth of cover for underground installation of pipe depends on the location of the pipe installation, as stated in Table 6. Note that the minimum allowable depth of cover for all sizes of pipes is 76 cm in US.

A good source of references for underground pipe installation is Technical Manuals published by George Fischer Piping Systems.

Table 6. Minimum recommended depth for buried pipelines in United States [6]

Location		**Type of pipeline**	**Class Location**	**Minimum cover for buried operating pipelines (cm)**
General (other than as indicated below)		Any	Any	**76**
Below travelled surface	Highway	Any	Any	**122**
	Highway ditch	Any	Any	**91**
Below travelled surface	Road	Any	Any	**122**
	Road ditch	Any	Any	**91**
Below base of rail	Cased	Any	Any	**157**
	Uncased	Any	Any	**25**
Rail ditch	Cased	Any	Any	**91**
	Uncased	Any	Any	**91**
Water crossing		Any	Any	**122**
Water crossing (in rock)		Any	Any	**46**
Drainage or irrigation ditch invert		Any	Any	**76**

5.2.11 Step-by-Step Installation

In general, major pipes 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 Simplified Step-by-Step Installation procedure for Underground Installation of PE Piping is presented in Annex D.

5.3 First Operation of New or Repaired/Serviced Pipe Sections

The following points shall be considered before water pipes are used for the first time [7].

- Care shall be taken to prevent the ingress of debris into the supply lines.
- After installation, water shall be let into the mains slowly, and with trapped air bled so that build up of excess pressure situations can be avoided.

If requested in the specification, pressure tests for the installed pipe sections shall be undertaken by the supplier/installer with the required documentation, engineers from the WSP can also participate during these tests.

6 Management of Pipes

Pipe data should be entered into the system at the time the pipe is purchased or first installed. These data can be entered directly into the system by the person receiving the pipe. Nevertheless, it is recommended to choose one person responsible for updating the registry.

Pipe should be always be stored with cover, and ends of the pipes should be closed by using proper caps.

7 Maintenance of Pipes

Carefully planned pipe maintenance and cleaning programmes should be in place to maintain the internal cleanliness of distribution network pipes, to prevent flow conditions that may allow system contamination.

Water pipes should be inspected regularly to ensure the following.

- Search ability and accessibility of the assets and pipe routes
- Leak tightness (e.g., Pressure drop, wet soil)
- Operability and operating condition of the system components as well as the pipeline network belonging components and instruments
- Quality of potable water

The required maintenance measures and strategies are defined and influenced by.

- Function and importance of the specific asset
- Percent of water losses
- Local operation conditions
- Type and condition of the pipe surrounding earth (e.g., wet soil, erode away cover etc.)
- Damaged through traffic and soil movement
- Material of pipes, valves and type of fittings

A simplified pipe maintenance schedule is presented in Table 7.

Table 7. Pipe maintenance schedule

Application	Inspection of	Maintenance Measures	Frequency
Main and submain distribution Pipes and fittings	○ Waterlosses (NRW) ○ Leak check by sight ○ Soil cover erosion ○ Overbuilding (e.g., construction of new road/infrastructures), safeguard of pipe route	○ Repair ○ Rehabilitation ○ Replace	Once per month
House connection pipes until meter	○ Leak check by sight ○ Use of correct fittings for connections ○ Bypass or unofficial connections ○ Soil cover erosion	○ Repair ○ Rehabilitation ○ Replace	During meter reading collection

7.1.1 Selection of the Sections of the Pipe Need Urgent Maintenance

A general approach to target pipes to be cleaned requires analysis of available water-quality information and maintenance records, and integration with other maintenance activities within the distribution system.

Monitoring of water-quality changes in the network can be used to identify baseline conditions and to locate the points where deposits have accumulated. The following parameters can be employed for this purpose:

- Heterotrophic bacteria counts and total coliforms
- Residual disinfectant concentrations
- Turbidity, colour, odour
- Iron, aluminium and manganese concentrations
- Consumer complaints

The colour of filter-papers used to filter set volumes of water can indicate the internal condition of pipe. The method has been used to distinguish problems caused by corrosion, deposition of treatment chemicals and deposition of manganese.

7.2 Maintenance Types

A range of activities and solutions are available for pipe maintenance, such as simple pipe cleaning, relining pipes with linings and pipes renewal. The costs and complexity of these are obviously different and dictate that problems are investigated in a systematic way based on performance data.

7.2.1 Pipe Cleaning Programs

Pipe-cleaning programmes require careful planning to be effective. The basic principle is that water must enter the length of main being cleaned from a length of main that has been previously cleaned or is known to be clean.

The most commonly used methods to clean pipes are flushing, air scouring and swabbing with compressible foam swabs. Other, more abrasive methods (e.g., are high pressure water jetting, power boring with metal flails, and abrasive pigging devices (AWWA, 2001)) are generally recommended for cleaning of pipes before the renovation of pipes by protective coating or lining.

Following items need to be considered for the planning of a pipe cleaning activity.

- Where cleaning is required and which method needs to be used.
- Plans of the area(s) to be cleaned.
- Assess potential contamination hazards (low pressures, pipe environment, air valves, etc) and which preventative measures to adopt.
- Timing of works and labour; determine plant and material requirements including those for good hygienic practice
- Assess on-site traffic problems, access and condition of mains and valves.
- Review and, if necessary, modify the estimated time and cost.
- Brief operators, notify consumers, and arrange system modifications (e.g. tappings) if required.
- Consumers, especially critical ones such as hospitals and other utilities, need to be informed of maintenance activities via a suitable communication strategy
- Monitor progress and effectiveness of the work.
- The environmental impacts of an extensive pipe-cleaning programme should always be assessed beforehand.

7.2.2 Pipe Renovation

Pipe renovation/replacement decision needs to be taken based on careful investigation of the pipe deterioration type and extents to identify the appropriate engineering solution. This process is usually called rehabilitation planning (Evins et al., 1989; AWWA, 2001), and it incorporates more complex and costly methods than those used for planned maintenance and survey. Detail rehabilitation planning is not within the scope of this guideline. However, every WSP should establish a detail rehabilitation planning for the water distribution network. Following are the general scenarios which warrant pipe renewal.

- Where the pipes are deteriorated to such an extent that targeted renovation and replacement is necessary to maintain operability.
- As an example, iron pipes have corroded internally to produce hard encrustations that prevent the maintenance of water pressure and disinfectant residuals,
- Where external corrosion and ground movement have created excessive leakage.

7.2.3 Hygiene

Any maintenance task in water distribution systems shall comply with the cleanliness requirements related to the drinking water quality. This obligation to cleanliness applies equally to any direct access to the water distribution systems (eg. as in use of fire hydrants and for work on water distribution systems).

- Wear protective clothing (e.g., gloves, mouth/nose protection and head cover).
- After completion of the work, properly clean the parts, and disinfect if possible.
- Provide regular instructions to employees to draw attention to the hygienic requirements.
- Employees with diseases which can be spread through water shall not work in commissioning of a part which can come to direct contact with supply water. Employees should have clear instruction for notifying relevant disease to the employer, in particular for stomach/ intestinal diseases.
- An important hygienic requirement is to avoid low or negative pressures in, and adjacent to, those parts of the network being cleaned.
- When using swabs or injected air to clean pipe, the materials and fixtures are potential sources of contamination and therefore good hygienic practices should be followed.

Detailing the specific maintenance procedures would exceed the frame of this Guideline, as every type and brand has its own maintenance procedure. Hence, for more detailed information, the provided maintenance manual from the manufacturer should be consulted.

7.3 Maintenance Procedure and Equipment

The requirement of the equipment depends on the chosen pipe maintenance method.

- Flushing is the simplest of the pipe cleaning techniques.
  - Usually do not involve the use of any additional equipment, rather than opening and closing some valves to generate required water pressure.
  - Involves the discharge of water from pipes, generally through hydrants and washouts, to generate velocities in the pipe capable of removing accumulated material and biofilms inside the pipe and attached to its walls.
- The swabbing process involves driving a cylindrical foam sponge (known as a swab) through pipes using water pressure.
  - The swab has a diameter approximately 25% greater than the pipe it is being forced through.
  - Various grades of swab are available (typically, they come in three grades: soft, hard and scouring).
  - In practice, swabbing will be effective when the velocity of the water in the pipe is between 0.8 and 1.5 m/s.
  - If the swab travels too fast it will remove less material and will suffer from wear and tear.
  - To prevent the swab from tumbling, the ratio of length to diameter should be 2 for small diameters (< 100 mm) and 1.5 for larger diameters.
  - Usually three and six swabs are sent through a pipe to achieve adequate cleaning.
- Air scouring involves the controlled injection of filtered, compressed air into pipes, usually via a hydrant.
  - Given a continuous supply of water and air in the right proportions, discrete "slugs" of water are formed in the main and driven along by the compressed air at high velocity.
  - There is no need to turn the water or air on and off to achieve this effect. Achieving the right conditions whereby high velocity 'slugs' are propelled through the pipe is a skilled task, and normally undertaken by a specialist team.
- Renovation of pipes is generally done by using either non-structural or structural linings.
  - Examples of non-structural linings are coating with spray-on protective linings such as cement mortar or epoxy resin.
  - Examples of structural linings are insertion of pipe liners such as polyethylene.
  - Renovation of pipes by using either non-structural or structural linings needs speciality equipments and procedure, and the lining should be conducted by the lining suppliers/contactors.

7.4 Maintenance Resources and Documentation

A clear organizational structure about the pipe maintenance needs to be established by every WSP.

7.4.1 Operational Unit Which Organize or Perform the Maintenance

The team should be equipped with proper means to ensure the followings-

- Regular (if possible, continuous) monitoring of the systems to ensure the quality and quantity of the water is delivered.
- Take immediate steps to ensure the proper functioning of the systems (e.g., prompt initiation of modifications and repairs)
- Inform customers / users when supply constraints is expected
- Proper customer service, eg. processing of complaints, use of fault hotline, customer contacts
- Control of construction sites of third parties with potential impact on water distribution systems
- Monitoring of water quality in the current operation as well as for relevant changes
- Initiation and monitoring of inspection and maintenance in accordance with prepared maintenance schedule
- Work preparation and coordination of operational and maintenance activities with customers
- Planning, initiating and monitoring the repair measures
- Monitoring of warranties and warranty periods
- Proper training and instruction shall be provided to the employees
    - Technical leadership (result control)
    - Qualified technician (knowledge of network, repair of leakages, knowledge of standard procedures and technical manuals)
    - Defined tasks in job description for responsible staff
    - Regular internal trainings (documented)

7.4.2 Documentation

Following documents should to be easily accessible to facilitate effective maintenance

- Site plans , as built drawings, functional schemes, site position plans with indication of pressure zones, hydrants plans
- Proper maintenance work plan
- Access to technical data of valves, piping fittings, manholes and house connections (Network Information System)
- Data management rights, ownership of land, contracts with carriers of traffic routes
- Access to customer addresses, usage data and information on the pipe network loads.
- Workflow-System for planning, work preparation, follow up and develop repair measures and costs

An applicable template for operation and maintenance schedule for pipes is shown in Table E1 in Annex E.

Applicable templates for inspection report and maintenance activity report are shown in Table E2 and Table E3, respectively in Annex E.

7.5 Disposal of Pipes

Pipes should be disposed according to ISO 14001. According to ISO 14001 the organization shall consistent with a life cycle perspective of their products. They have to consider the need to provide information about potential significant environmental impacts associated with the end-of-life treatment and final disposal of its products. The organization shall maintain documented information to the extent necessary to have confidence that the processes have been carried out as planned.

References

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

[2] WASREB, “IMPACT - A Performance Review of Kenya's Water Services Sector 2012 - 2013 - Issue No. 7,” Nairobi, 2014.

[3] “National Water Service Strategy 2007-2015”.

[4] P. P. O. Authority, “User Guide to the Public Procurement and Disposal Act, 2005, and the Public Procurement and Disposal Regulations, 2006,” August 2009.

[5] Hamburg Wasser

[6] http://www.edptoolbox.org/documents/Pipeline-Depth-of-Cover.pdf

Annex A: WASPA Pipe Management Survey Findings

As is highlighted in the introduction, Chapter 1, this Guideline incorporates the findings of a pipe management survey that was conducted by WASPA with bfz-SWAP support. The questionnaire was disseminated to all 55+ member WSPs. We would like to appreciate 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. The bullets below summarize the major findings[1].

- For metallic pipe: most common material is galvanized iron connected through flange, VJ coupling and welding. Majority (>95%) of it is installed underground and faces problem of corrosion/rust.
- For non-metallic (plastic) pipes: most common material are uPVC, HDPE and PP-R connected through glue (solvent cement), fusion and flange. Majority (>95%) of it is installed underground and faces problem with burst and crack. Table B1 summarizes the survey findings of the non-metallic (plastic) pipes.
- Joints failure due to poor joining practices was identified as the major sources of leaks.

Table A1. Survey findings about non-metallic (plastic) pipes used in Kenya

No.	Parameters	Data
1.1	Estimated known pipe network length, km	5160
1.2	Pipe material currently used	HDPE, uPVC, PP-R
1.3	Pipe above ground & underground	>95% are underground
1.4	Pipe connection type	Coupling, Glue (solvent cement, Butt Fusion, Flange, Welding
1.5	Typical diameter, DN	12 – 450
1.6	Typical pressure rating, PN	10 – 16
1.7	Typical failure/problem	Burst, Crack, Leak

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

Annex B: Thickness of Cement Mortar lining (DIN EN 545) for DI pipes

Table B1. Minimum thickness and tolerance of cement mortar lining

DN	Layer thickness	
	Nominal value	Deviation limit
400 to 300	4	-1.5
350 to 600	5	-2.0
700 to 1200	6	-2.5
1400 to 2000	9	-3.0

Note: Maximum crack width and maximum radial offset can be found in DIN EN 545.

Source: Hamburg Wasser

Annex C: List of relevant standards for pipe systems

ISO 161-1 Thermoplastic pipes for the transport of fluids
ISO 1183 Polyethylene - measurement of density
ISO 3607 PE pipes - tolerances on o. d. and wall thicknesses
ISO 3663 PE pressure pipes and fittings - dimensions of flange
ISO 4427 Buried PE pipes for the supply of potable water
ISO 4437 Buried PE pipes for the supply of gaseous fuels
ISO 4440 PE pipes and fittings - determination of melt flow rate
ISO 6447 Rubber seals-joint rings used for gas supply pipes and fittings
ISO 8085 PE fittings for the supply of gaseous fuels
EN 1555 Plastic piping systems for gas supply - Polyethylene (PE)
EN 12201 Plastic piping systems for water supply - Polyethylene
EN 13244 Plastic pipe systems for buried and above-ground pressure systems for water for general purpose, drainage end sewerage
EN 1295-1 Structural design of burried pipelines under various conditions of loading
DIN 3535 Gaskets for gas supply
DIN 3543 Valves in PE HD for PE-HD-Mass pipes
DIN 3544 Valves in polyethylene of high density (PE-HD) Requirements and test of tapping valves
DIN 8074 Pipes in polyethylene of high density (PE-HD)-Mass
DIN 8075 Pipes in polyethylene of high density (PE-HD) General quality requirements - Test
DIN 16963 Pipe joints and piping components for pressure pipelines in high density polyethylene (PE-HD)
DIN 19533 Pipes in PE-HD and PE-MD for drinking water supply; pipes, pipe joints, piping components
DS 2131.2 Pipes, fittings and joints of PE type PEM and PEH for buried gas pipelines
UNI 8849 Raccorcdi di polietilene (PE5O), saldabili per fusione mediante elementi riscaldanti, per condotte per convogliamento
di gas combustibili. Tipi, dimensioni e requisiti
UNI 8850 Raccordi di polietilene (PE50), saldabili per elettrofusione per condotte interrate per convogliamento di gas combustibili.
Tipi, dimensioni e requisiti
O Norm B 5192 Pipes, pipe joints and piping components in PE for buried gas pipelines
DSV 2207 Fusion of thermoplastic plastics, (PE) pipes and Part I piping components for gas and water pipelines
DVGW G 477 Manufacture, quality assurance and testing of pipes in rigid PVC and PE-HD for gas pipelines
DVGW VP 302 Butterfly valves in PE-HD
DVGW VP 304 Gas and tapping valves for PE-HD piping systems
DVGW VP 607 PE-HD fittings for gas and water pipelines
DVGW VP 608 Polyethylene pipes (PE80 and PE100) for gas and drinking water lines; requirements and tests
DVGW VP 609 Plastic clamp joints for connecting PE pipes in the water supply
DVGW VP 610 Temporary test basis for water tapping valve, requirements and tests
DVGW VP 302 PE-HD butterfly valves
DVGW VP 304 Gas butterfly valves for PE-HD piping systems
DVGW VP 610 Temporary test basis for water tapping valve, requirements and tests
DVGW G 472 Laying gas lines
DVGW G 459 Laying gas domestic connections
DVGW G 477 Pipes and piping components for rigid PVC and HDPE gas lines
DVGW W 320 Rigid PVC, HDPE and LDPE water supply pipelines
O Norm B 5192 Pipes, pipe joints and piping components in PE for buried gas lines
EN 681 Seals (water)
UNI 8849 Raccorcdi di polietilene (PE50), saldabili per fusione mediante elementi riscaldanti, per condotte per convogliamento
di gas combustibili. Tipi, dimensioni e requisiti
UNI 8850 Raccordi di polietilene (PE50), saldabili per elettrofusione per condotte interrate per convogliamento di gas combustibili. Tipi, dimensioni e requisiti.

List of relevant standards PVC-U pressure pipe systems
ISO 2045 Minimum insertion depth for push-fit sockets
ISO 2536 Flange dimensions
ISO 3460 PVC adapter for backing flange
ISO 3603 Leak test under internal pressure
ISO/DIN 4422 PVC pipes and fittings for water supply
EN 1452 Plastic pipelines for water supply (PVC-U)
ISO 1452 Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U):
– Part 1: General
– Part 2: Pipes
– Part 3: Fittings
– Part 4: Valves
– Part 5: Fitness for purpose of the system
EN 1456 Buried pressure drainage and sewage pressure lines (PVC-U)
EN 1295-1 Structural design of burried pipelines undervarious conditions of loading
DIN 2501 Part 1 Flange, connection dimensions
DIN 3441 Part 1 PVC valves; requirements and testing
DIN 3543 PVC tapping valves, dimensions
DIN 4279 Part 7 Internal pressure test of PVC pressure pipelines for water
DIN 8061 Part I PVC pipes; general quality requirements
DIN 8062 PVC pipes; dimensions
DIN 8063 Part 4 Pipe joints and piping components for PVC pressure pipelines; adapters, flanges, seals,
dimensions
DIN 8063 Part 5 Pipe joints and piping components for PVC pressure pipes; general quality requirements, tests
DIN 16450 Fittings for PVC pressure pipes; designations, symbols
DIN 16929 Chemical resistance of PVC
DIN 19532 PVC pipelines for drinking water supply
KRV A 1.1.2 Push-fit joints on PVC pressure pipes and fittings, dimensions, requirements, test
KIWA BRL K 603 Plastic gate valves of nominal sizes from 25 mm through 150 mm
KIWA Quality Specification No. 53 Couplings and fittings of unplasticized polyvinylchlorid for water pipes
KIWA Criteria Nr. 23 Injection moulded PVC-fittings with flange connections
KIWA BRLK 2013 Rubber rings and flange gaskets for potable and foul water pipe connections
EN 681 Seals (water)
WIS 4-31-07 Specification for emplasticized PVC pressure fittings and assemblies for cold potable water (underground use)

List of relevant standards PP pressure pipe systems
ISO 15874 Plastics piping systems for hot and cold water installations — Polypropylene (PP)
— Part 1: General
— Part 2: Pipes
— Part 3: Fittings
— Part 5: Fitness for purpose of the system
— Part 7: Guidance for the assessment of conformity (published as CEN ISO/TS 15874-7).

List of relevant standards PE pressure pipe systems
ISO 4427 consists of the following parts, under the general title Plastics piping systems — Polyethylene (PE) pipes and fittings for water supply:
— Part 1: General
— Part 2: Pipes
— Part 3: Fittings
— Part 5: Fitness for purpose of the system

List of relevant standards metal pipe systems

EN 14628 Ductile iron pipes, fittings and accessories. External polythene coating for pipes: Requirements and test methods
EN 15189 Ductile iron pipes, fittings and accessories. External polyurethane coating for pipes: Requirements and test methods
EN 15542 Ductile iron pipes, fittings and accessories. External cement mortar coating for pipes: Requirements and test methods
EN 15655 Ductile iron pipes, fittings and accessories. Internal polyurethane lining for pipes and fittings: Requirements and test methods
ISO 2531 Ductile iron pipes, fittings, accessories and their joints for water applications
EN 10255 Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions.
ISO 65 Carbon steel tubes suitable for screwing in accordance with ISO 7-1

Annex D: General procedure for different pipe connection methods

i. Butt fusion

Follow these general steps when performing butt fusion:

1. Clean, clamp and align the pipe ends to be joined
2. Face the pipe ends to establish clean, parallel surfaces, perpendicular to the center line
3. Align the pipe ends
4. Melt the pipe interfaces
5. Join the two pipe ends together by applying the proper fusion force
6. Hold under pressure until the joint is cool

ii. Electrofusion

Follow these general steps when performing EF fusion:

1. Prepare the pipe (scrape, clean)
2. Mark the pipe
3. Align and restrain pipe and fitting per manufacturer's recommendations
4. Apply the electric current
5. Cool and remove the clamps
6. Document the fusion process

iii. Socket Fusion

Follow these general steps when performing socket fusion:

1. Thoroughly clean the end of the pipe and the matching inside surface of the fitting
2. Square and prepare the pipe end
3. Heat the parts
4. Join the parts
5. Allow to cool

iv. Saddle/Conventional Fusion

Follow these general steps when performing saddle fusion:

1. Clean the pipe surface area where the saddle fitting is to be located
2. Install the appropriate size heater saddle adapters
3. Install the saddle fusion machine on the pipe
4. Prepare the surfaces of the pipe and fitting in accordance with the recommended procedures
5. Align the parts
6. Heat both the pipe and the saddle fitting
7. Press and hold the parts together
8. Cool the joint and remove the fusion machine

v. Flange Connections

Follow these general steps when performing flange connections:

1. Ensure all flanges, gaskets, bolts, studs and nuts are free of dirt, mud, grit, etc.

2. Bring flanges together ensuring there is sufficient gap to install the gasket.

3. Ensure that the bolts, studs and nuts have been lubricated.

4. Install two or three bolts near the bottom of the flange to receive and cradle the gasket. Then install gasket between the flanges and the remainder of the bolts and studs.

5. Tighten all nuts to finger tightness. Center the studs between the nuts so that an equal number of threads extend past the nut on each side of the connection.

6. Tighten bolts or studs in the in sequence of 12, 6, 3 and 9 o'clock positions; progressively tighten all bolts as follows using a torque wrench. Number of steps and % of tightening can varies; however, 100% torques never shall be applied at once.

   - 5% of final torque
   - 20% of final torque
   - 50% of final torque
   - 75% of final torque
   - 100% of final torque

Annex D1: Selection tool ‘Lengths of bolts and tightening torques’

For example, please see the following for the ‘Lengths of bolts and tightening torques’ selection tool developed by George Fischer.

How it works:

1. Select pipe material
2. Select diameter d or DN
3. Select type of flange (PVC, PP-V or PP-steel flange)
4. Select combination loose-loose flange L or loose-fixed flange F
5. Read out length of bolt b
6. Table => Tightening torques depending on type of gasket, amount and diameter of bolts

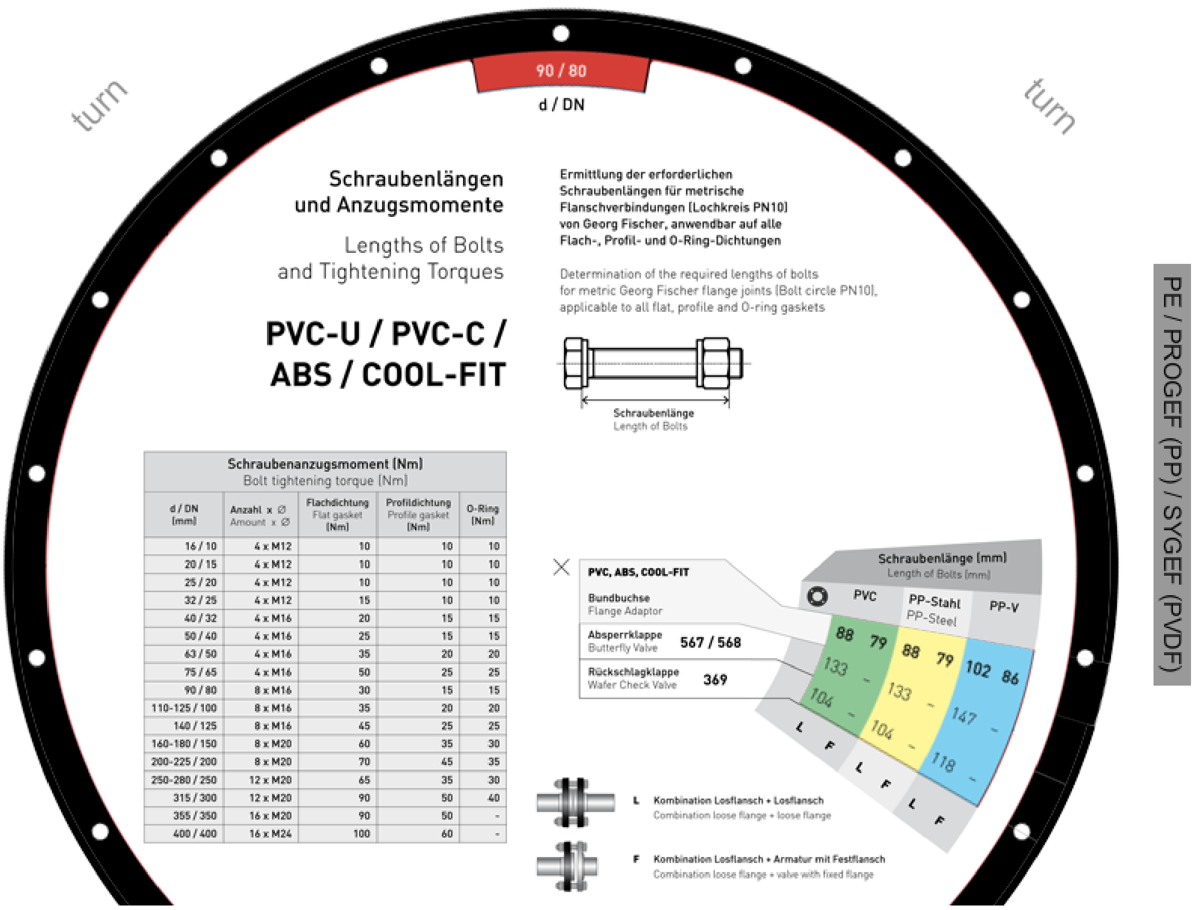


Figure E2. Sample of ‘Lengths of bolts and tightening torques’ selection tool output.

http://www.gfps.com/com/en/support_and_services/online_tools/lengths_of_bolts_and_tightening_torques.html

Annex D2: Bolts and tightening technique for flanged connections

To ensure even distribution of stresses in the fully installed flange, bolts should be tightening in a diametrically staggered pattern as described in ANSI B16.5.

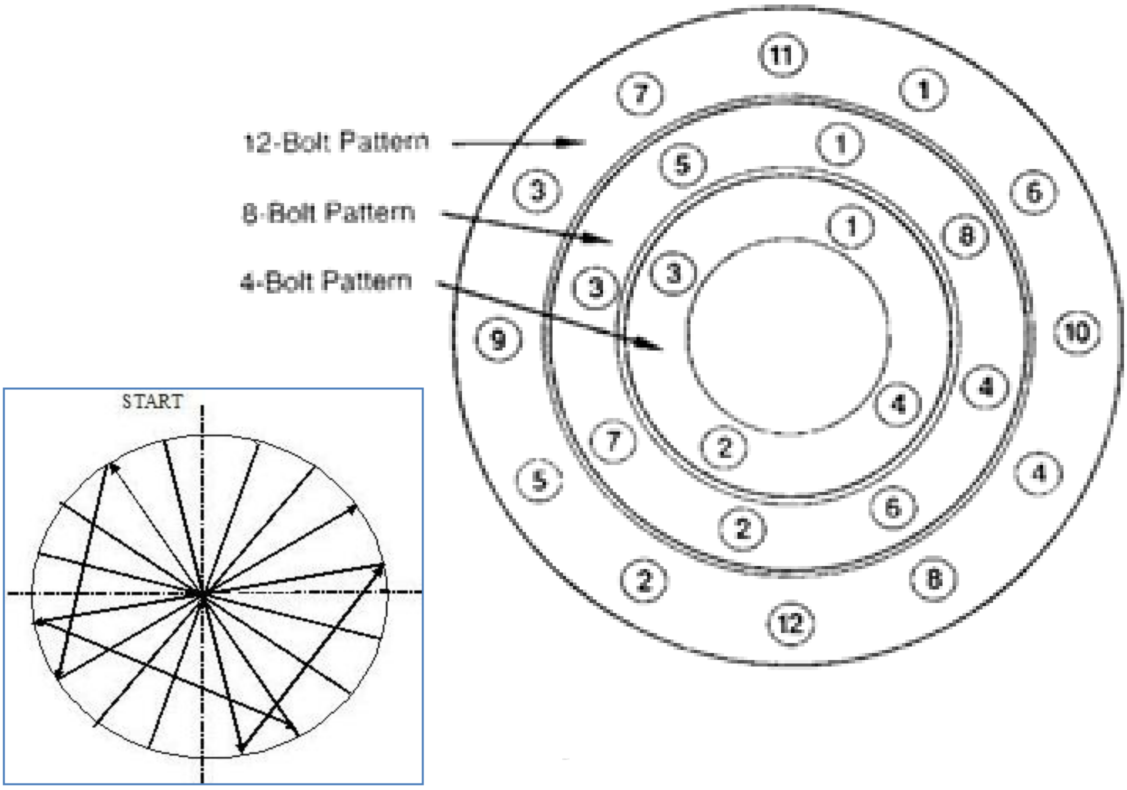


Figure E2. Diametrically staggered pattern for bolt tightening

Annex E: Operation and Maintenance Schedule, and Reports for Pipes (templates with samples)

Table E1. Maintenance Schedule for 'name of WSP' WSP

S/N	Assess	Quantity	Type of maintenance	Activities	Requirement	Cost (KES)	By Who	Time Frame
1	PVC Pipes 3"	46	Preventive and Emergence	-Remove an old Pipes and replace new Pipes	-New PVC Pipes -Hoe -Hack saw -Lubricants[oil]	120,000	Plumbers	02/02/2016-13/02/2016
2	PVC Pipe 1.5''	150m	Preventive	Connecting pipes of 1.5'' in existing line to distribution line	Coupling 1.5'' ,Pipe ranges, Get valve 1.5'',connecter 1.5 Nipple 1.5'' ,coupling Tee 1.5'',tred sill, hoe, hack saw	95,000	Plumbers	04/03/2016-10/03/2016
3	Gs pipe 2.5"	20	Preventive	-New pipe replacement to Shiuki B/holl -Flashing out water to shiuk B/holl.	-Gs pipe 2.5" -Chain block -pipe ranges -socket	1,300,000	Pump mechanical	27/03/2016-30/03/2016

Table E2. February-March 2016 Inspection Report

Inspection	Observation	Date
Remove an old Pipes and replace new Pipes	6 Pipes 3'',was replaced	7/02/2016
Construction and repairing of Water Points.	3 water points namely ABC, DEF, and IJK were repaired	17-20/2/2016
Connecting pipes of 1.5'' in existing line to distribution line	Pipe laying, Fitting connections and back filling of excavated soil.	09/03/2016
- New pipe replacement to MNO B/hole - Flashing out water to MNO B/hole	- 2 Gs pipe were replaced to the B/hole - Flashing was accomplished	30/3/2016

Table E3. February-March 2016 Maintenance Activity Report

Activity Performed	Location	Date
6 Pipes 3'',was replaced	4 pipes ABC and 2 pipes DEF	7/02/2016
3 water points namely were repaired	ABC, DEF, and IJK Water points	17-20/2/2016
Pipe laying, Fitting connections and back filling of excavated soil.	DEF	09/03/2016
- 2 Gs pipe were replaced to the B/hole - Flashing was accomplished	XYZ at MNO B/Hole	30/3/2016