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EAST AFRICAN STANDARD

Water supply — Requirements for systems and components outside buildings

EAST AFRICAN COMMUNITY

First Edition 2010

Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in East Africa. It is envisaged that through harmonized standardization, trade barriers which are encountered when goods and services are exchanged within the Community will be removed.

In order to meet the above objectives, the EAC Partner States have enacted an East African Standardization, Quality Assurance, Metrology and Test Act, 2006 (EAC SQMT Act, 2006) to make provisions for ensuring standardization, quality assurance, metrology and testing of products produced or originating in a third country and traded in the Community in order to facilitate industrial development and trade as well as helping to protect the health and safety of society and the environment in the Community.

East African Standards are formulated in accordance with the procedures established by the East African Standards Committee. The East African Standards Committee is established under the provisions of Article 4 of the EAC SQMT Act, 2006. The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

Article 15(1) of the EAC SQMT Act, 2006 provides that "Within six months of the declaration of an East African Standard, the Partner States shall adopt, without deviation from the approved text of the standard, the East African Standard as a national standard and withdraw any existing national standard with similar scope and purpose".

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

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Introduction

In specifying the requirements of this standard due regard has been taken of the importance of a reliable and safe supply of water for human consumption as well as for the purpose of trade, industry, agriculture and fire-fighting.

The widely varying water supply legislative requirements, populations, social and climatic conditions across the region have also been taken into account.

This standard does not make any implication with regard to ownership of or responsibility for pipes or other apparatus in the supply system.

In the preparation of this East African Standard, the following source was consulted extensively:

EN 805:1999, *Water supply — Requirements for systems and components outside buildings*

Assistance derived from this source and others inadvertently not mentioned is hereby acknowledged.

Water supply — Requirements for systems and components outside buildings

1 Scope

This East African Standard specifies:

— general requirements for water supply systems outside buildings (see Figure 1), including potable water mains and service pipes, service reservoirs, other facilities and raw water mains but excluding treatment works and water resources development;

— general requirements for components;

— general requirements for inclusion in product standards which may include specifications which are more stringent;

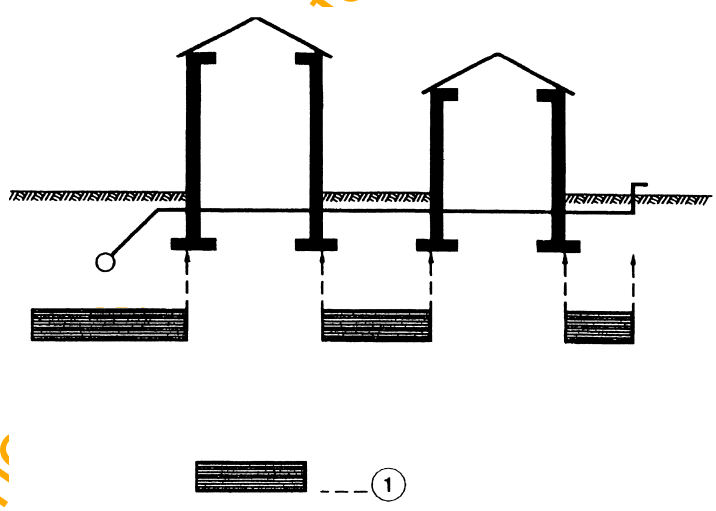
— requirements for installation, site testing and commissioning. The requirements of this standard apply to.

— the design and construction of new water supply systems;

— the extension of significant areas forming a coherent part of an existing water supply system;

— significant modification and/or rehabilitation of existing water supply systems.

NOTE It is not intended that existing water supply systems are to be altered to comply with this standard, provided that there are no significant detrimental effects on water quantity, security, reliability and adequacy of the supply.



Key
1 Field of application of this standard

Figure 1 — Field of application of this standard

2 Normative references

This East African Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to the East African Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 1295-1, *Structural design of buried pipelines under various conditions of loading — Part 1: General requirements*

EN 1508, *Water supply — Requirements for systems and components for the storage of water*

EN 45011, *General criteria for certification bodies operating product certification*

EN 45012, *General criteria for certification bodies operating quality system certification*

ISO/IEC Guide 65, *General requirements for bodies operating product certification systems*

ISO/IEC 17021, *Conformity assessment — Requirements for bodies providing audit and certification of management systems*

ISO 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10IRHD and 100 IRHD)*

ISO 9001, *Quality management systems — Requirements*

3 Definitions

For the purposes of this standard, the following definitions apply.

3.1 Pressures

For the designation of pressures in see Table 1 and annex A.2.

Table 1 — Designation of pressures

Abbreviation [a]	**English**	
DP	design pressure	System related
MDP	maximum design pressure	
STP	system test pressure	
PFA	allowable operating pressure	Component related
PMA	allowable maximum operating pressure	
PEA	allowable site test pressure	
OP	operating pressure	System related
SP	service pressure	
a Valid for all language versions.		

3.1.1
allowable maximum operating pressure (PMA)
maximum pressure occurring from time to time, including surge, that a component is capable of withstanding in service

3.1.2
allowable operating pressure (PFA)
maximum hydrostatic pressure that a component is capable of withstanding continuously in service

3.1.3
allowable site test pressure (PEA)
maximum hydrostatic pressure that a newly installed component is capable of withstanding for a relatively short duration, in order to ensure the integrity and tightness of the pipeline

3.1.4
design pressure (DP)

maximum operating pressure of the system or of the pressure zone fixed by the designer considering future developments but excluding surge

3.1.5
maximum design pressure (MDP)
maximum operating pressure of the system or of the pressure zone fixed by the designer considering future developments and including surge, where:

— MDP is designated MDPa, when there is a fixed allowance for surge;

— MDP is designated MDPc, when the surge is calculated

3.1.6
operating pressure (OP)
internal pressure which occurs at a particular time and at a particular point in the water supply system

3.1.7
pressure zones
areas of pressure ranges within a water supply system

3.1.8
service pressure (SP)
internal pressure delivered at the point of connection to the consumer's installation at zero flow in the service pipe

3.1.9
surge
rapid fluctuations of pressure caused by flow alterations over short periods of time

3.1.10
system test pressure (STP)
hydrostatic pressure applied to a newly laid pipeline in order to ensure its integrity and tightness

3.2 System

3.2.1
gravity system
system where flow and/or pressure are caused by the force of gravity. There are two kinds of such systems:

— pressurized gravity system, where the pipeline operates full;

— non-pressurized gravity system, where the pipeline operates partially full.

3.2.2
local main
water main which connects principal main(s) with service pipes

3.2.3
potable water
water intended for human consumption as defined by the relevant national authorities

3.2.4
principal main
water main serving as a principal distributor within the supply area, normally without direct consumer connections

3.2.5
pumped and gravity system

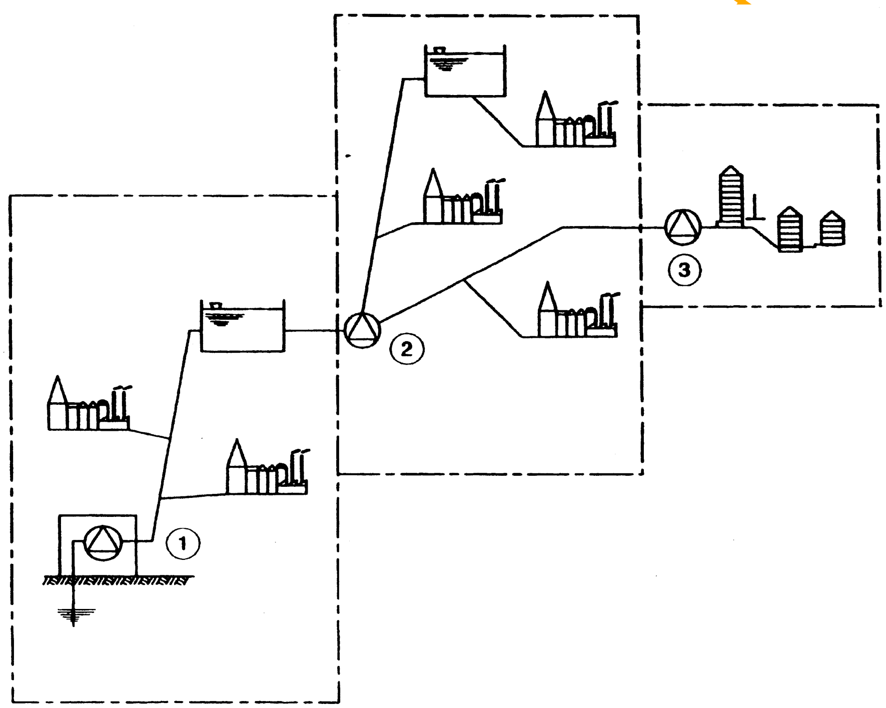
system where the gravity system and the pumped system are used, either separately or in combination, to provide the flow and/or pressure

3.2.6
pumping station
pumping installation designed to provide adequate pressure and flow within the distribution system. Three types can be distinguished (see Figure 2):

— main lift, normally at the outlet of the treatment works, or source if there is no treatment, to provide flow to the service reservoir;

— intermediate to deliver flow on the way to a service reservoir or supply area;

— booster to pump directly from and to the area without storage.



Key
1 Main lift
2 Intermediate
3 Booster

Figure 2 — Example of different types of pumping stations

3.2.7
pumped system
system where flow and/or pressure are provided by means of one or more pumps and where the pipeline operates full

3.2.8
reservoir
storage facility for water

3.2.9
service pipe
water pipe which supplies water from the local main to the consumer

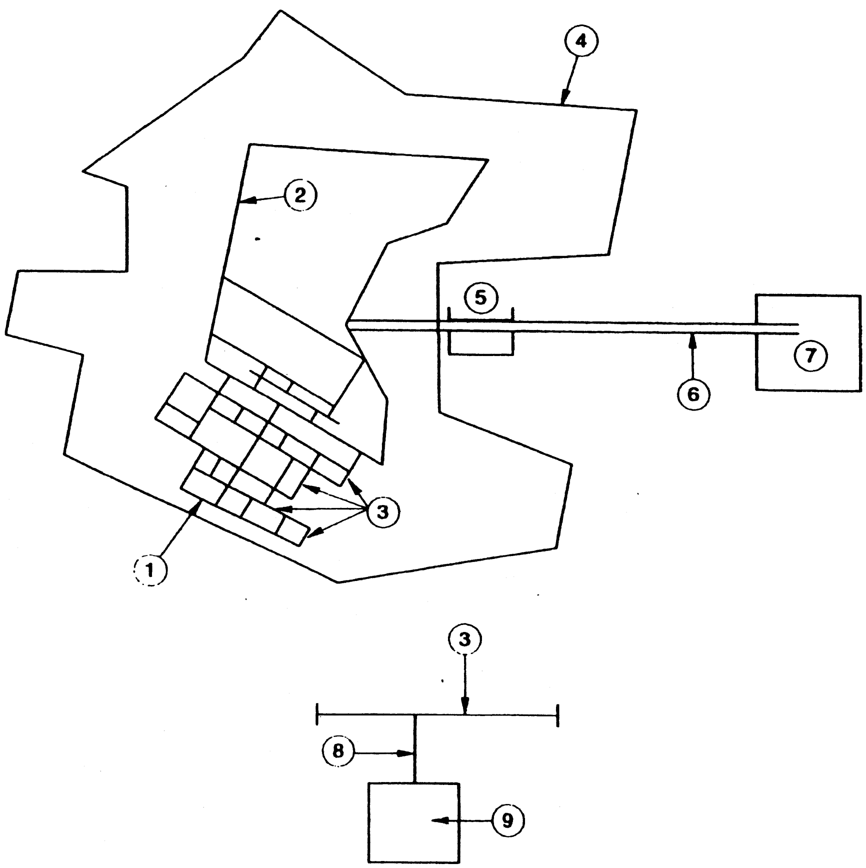
3.2.10

service reservoir
covered reservoir for potable water which includes water compartment(s), control building, operation equipment and access arrangement providing reserve supplies, pressure stability and balancing demand fluctuations

3.2.11
standby plant
plant or system, such as additional pumps or duplicate mains, installed to provide secondary means for the supply of services in the event of failure or malfunction of the normal operating unit

3.2.12
trunk main
water main which interconnects source(s), treatment works, reservoir(s) and/or supply areas, normally without direct consumer connection(s)

3.2.13
water distribution system
part of the water supply system comprising pipelines, service reservoirs, pumping stations and other assets by which water is distributed to the consumers. It begins at the outlet from the water treatment works (or source, if there is no treatment) and ends at the point of connection to the consumer's installation (see Figure 3).



Key

1	Network	2	Principal main
3	Local main	4	Supply area
5	Service reservoir (may be present)	6	Trunk main
7	Source or treatment works	8	Service pipe
9	Consumer		

Figure 3 — Example of a water distribution system

3.3 Components

3.3.1
accessories
components, other than pipes, fittings or valves, which are used in a pipeline, e.g. glands, bolts, locking rings for joints, ferrules

3.3.2
adjustable joint
joint which permits significant angular deflection at the time of installation but not thereafter

3.3.3
coating
additional material applied to the external surface of a component to protect it from corrosion, mechanical damage or chemical attack

3.3.4
ferrule
component used to connect a service pipe to a main, usually capable of shutting off the flow of water to the service pipe

3.3.5
fitting
component, other than a pipe, which allows pipeline deviation, change of direction or bore. In addition, flanged-socket pieces, flanged-spigot pieces and collars/couplings are defined as fittings

3.3.6
flexible joint
joint which permits significant angular deflection, both during and after installation and which can accept a slight Q offset of the centre line

3.3.7
flexible pipe
pipe whose load carrying capacity is limited by deformation (diametral deflection and/or strain) under load to the ultimate design criteria without breaking or overstressing (flexible behaviour)

3.3.8
joint
connection between the ends of two components including the means of sealing

3.3.9
lining
additional material applied to the internal surface of a component to protect it from corrosion, mechanical damage or chemical attack

3.3.10
pipe
component of uniform bore, normally straight in axis, having e.g. socket, spigot or flanged ends

3.3.11
pipe barrel
cylindrical part of the pipe with a uniform cross-section excluding socket and spigot where appropriate

3.3.12
rigid joint
joint that does not permit significant angular deflection, either during or after installation

3.3.13
rigid pipe

pipe whose load carrying capacity is limited by breaking without significant deformation of its cross-section (rigid behaviour)

3.3.14
semi-rigid pipe
pipe whose load carrying capacity is limited either by deformation/overstressing (flexible behaviour) or by breaking (rigid behaviour) depending on its ring stiffness and/or the conditions of installation

3.3.15
valve
component isolating or controlling flow and pressure, e.g. isolating valve, control valve, pressure reducing valve, air valve, non-return valve, hydrant

3.4 Diameters

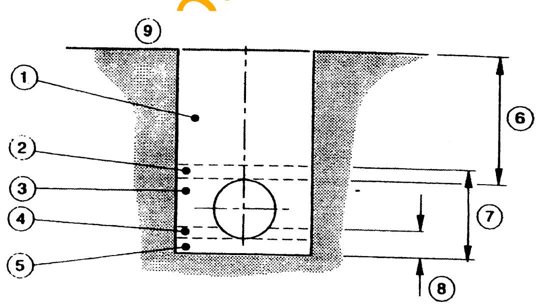
3.4.1
external diameter (OD)
mean external diameter of the pipe barrel at any cross-section. For pipes with externally profiled barrels, the external diameter is taken as the maximum diameter when viewed in cross-section.

3.4.2
internal diameter (ID)
mean internal diameter of the pipe barrel at any cross-section

3.4.3
nominal size (DN/ID or DN/OD)
numerical designation of the size of a component, which is a whole number approximately equal to the actual dimension in millimetres. This applies to either the internal diameter (DN/ID) or the external diameter (DN/OD).

3.5 Installation

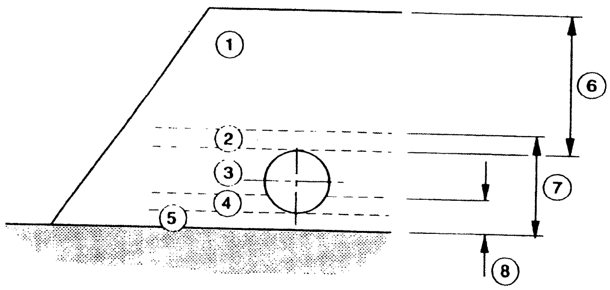
Installation terms are shown in Figure 4.



Key

1	Main backfill including road construction, if any	2	Initial backfill
3	Side fill	4	Upper bedding
5	Lower bedding	6	Depth of cover
7	Embedment	8	Bedding
9	Ground surface		

a) Example of pipe laying in trenches



Key

1	Main backfill including road construction, if any	2	Initial backfill
3	Side fill	4	Upper bedding
5	Lower bedding	6	Depth of cover
7	Embedment	8	Bedding

b) Example of pipe laying in embankments

Figure 4 — Illustration of terms used in pipe installation

3.5.1
aggressive soil
soil which could have a corrosive or other adverse effect on a component and which requires special consideration with respect to protective measures

3.5.2
cathodic protection
method of protecting metal components against corrosion in which the metal to be protected is maintained in a cathodic state relative to its surroundings

3.5.3
contaminated soil
soil which has been affected by previous land use or by direct or indirect infiltration of chemicals or other substances, such that it requires special consideration

3.5.4
depth of cover
distance from the crown of the pipe barrel or fitting to the existing or future surface of the terrain

3.6 Hydraulic design

3.6.1
back flow
flow of water from outside the system in a direction contrary to the intended one

3.6.2
equivalent length
addition to the real length of a pipeline to simplify the allowance for local head losses at fittings, valves, etc., used for calculating the total head loss of a pipeline

3.6.3
peak flow factor
ratio between peak flow and average flow in the same period of time

3.6.4
water demand
estimated quantity of water required per unit of time

3.7 Structural design

3.7.1
bedding reaction angle
angle used for calculation purposes, corresponding to the arc of soil bearing reaction applied at the underside of the component

3.7.2
ring stiffness
resistance of a pipe to diametral deflection in response to external loading applied along one longitudinal diametric plane. The ring stiffness is defined by the following formula:

$$S = \frac{E \cdot I}{D_m^3}$$

where

S is the ring stiffness of the pipe in pascals (1 Pa = 1 N/m^2);

E is the modulus of elasticity in flexure in the circumferential direction in pascals (1 Pa = 1 N/m^2);

I is the second moment of area of the pipe wall in the longitudinal direction, per unit length in metres to the fourth power per metre;

D_m is the mean diameter of the neutral axis of the pipe wall in metres.

NOTE This definition applies to both short and long term values.

3.7.2
ultimate load
load which causes failure as defined in the product standards

4 Application of standards and regulations

In all aspects, including health and safety, the national standards, transposing East African Standards as available, shall apply as well as the regulations valid at the place where the system is being constructed and/or operated.

5 Requirements for water supply systems

5.1 Water quality

5.1.1 General

The water quality in the potable water supply system shall satisfy the requirements of EAS 12.

5.1.2 Materials

All parts of water supply systems in contact with potable water shall be designed and constructed using components and materials which meet the appropriate requirements such that there is no unacceptable deterioration of water quality.

5.1.3 Prevention of back flow

Potable water supply systems shall be designed, equipped and installed to ensure the prevention of back flow. The location and operation of air valves and washouts shall avoid water entering the system (see A.3). Any equipment installed for this purpose shall meet the requirements of applicable standards.

Potable water supply systems shall be designed, installed and operated to minimize water stagnation which would lead to unacceptable deterioration of water quality.

The following arrangements leading to stagnation shall be carefully considered:

— mains with dead ends;

— spurs serving hydrants;

— unisolated pipes laid in advance of development,

— sections with permanently low flow rates;

— enhanced pipe diameters required for fire-fighting or other non-permanent purposes. Where necessary, facilities shall be provided for mains flushing.

5.1.5 Cross-connections with other systems

The interconnection of potable water supply systems shall only be permitted if the chemical and physical properties are compatible for blending and there is no unacceptable deterioration of water quality.

Except when water is intended for blending in the distribution system to produce a potable supply, there shall be no direct connection between potable water supply systems and systems containing non-potable water, any other liquid or gas, except where suitable arrangements are made to incorporate a physical air gap or an appropriate anti-pollution device conforming to national standards, transposing EAS as available. Closed valves or non-return valves, except for air valves, washouts and hydrants, do not constitute an effective means of separation for the purpose of this clause.

5.2 Design life

Systems shall be designed for a life of at least 50 years. Some components such as pumps and certain metering and control equipment may require earlier renovation or replacement.

NOTE This does not necessarily apply to temporary parts of a system.

5.3 Demand for water

5.3.1 Water demand estimates

Estimates of present and future demands shall be made (see A.4).

5.3.2 Water for fire-fighting

The requirements for water for fire-fighting purposes shall be determined in accordance with national legislation or local regulations (see A.5).

5.4 System security

Due regard shall be paid to security of water supply systems with respect to acts of terrorism, vandalism and other unlawful activity.

In general, the underground system will be secure but particular attention shall be given to above-ground pipework.

Pumping stations, service reservoirs and other above-ground structures are vulnerable and shall be designed to deter unauthorized entry or interference with the operation of the system. In particular, the possibility of contamination of the water shall be minimized.

Where risks are high the provision of security fencing and monitoring systems shall be considered.

6 Service objectives

The water supplier shall define the levels of service to be achieved at the point of connection to the consumer's installation. The definitions shall include service pressures, flow rates and continuity of supply (see A.6).

7 Rehabilitation

For works of repair, renovation or replacement, the relevant requirements of this standard shall be followed. In case of repair or renovation the design life extension may be less than 50 years.

8 Design

8.1 Design objectives

The objectives of the design process are to determine the characteristics of the water supply system in order to meet the requirements outlined in this standard and the defined levels of service over the range of operating conditions, having regard to all relevant economic considerations.

8.2 Peak flow factors

Where water use is estimated on an average day basis, suitable factors shall be applied to give estimates of the expected demand in the peak week, peak day and peak hour (see A.7).

NOTE Other peak factors may be relevant.

8.3 Hydraulic design

8.3.1 Sizing

Mains and service pipes shall be sized to meet the maximum specified flow rate having regard to the defined levels of service (see A.8).

In determining the required capacity of a service reservoir the balance between supply and demand shall be taken into account. In addition, other aspects shall be considered including, but not limited to, the following:

- estimated time to repair burst main upstream;
- effect of pump/power failure;
- existence of alternative sources of supply;
- single or duplicate supply mains to storage;
- degree of telemetry monitoring;
- ratio of peak hour to average flow rate;
- requirements with respect to water for industrial supplies, fire-fighting or other special circumstances.

8.3.2 Mains

8.3.2.1 General

Hydraulic calculation shall be carried out in order to demonstrate that the system will:

— satisfy the estimated demand;

— operate at acceptable velocities;

— operate within the required pressure range.

In addition, the design pressure and the maximum design pressure shall be established at appropriate points in the system.

The required diameters to satisfy the flow requirements for the hydraulic gradient available shall be verified by using the following formulae:

$$H_r = \lambda \cdot \frac{L}{D} \cdot \frac{v^2}{2g}$$

$$\Delta p = \lambda . \frac{L}{D} \frac{\rho}{2} . v^2$$

$$\frac{I}{\sqrt{\lambda}} = -2 \log_{10} \left(\frac{2.51}{Re.\sqrt{\lambda}} + \frac{k}{3.71.D} \right)$$

$$Re = \frac{v.D}{v}$$

Where

Δp is the pressure loss in pascals[1)]';

H_r is the total head loss in metres;

λ is the coefficient of head loss;

L is the length of pipeline in metres;

g is the gravity acceleration in metres per square second;

D is the internal diameter of pipeline in metres;

ρ is the unit mass of water in kilograms per cubic metre;

Re is the Reynolds number;

υ is the kinematic viscosity in square metres per second;

k is the hydraulic roughness value in metres;

v is the flow velocity in metres per second.

8.3.2.2 Hydraulic roughness value

The hydraulic roughness value k to be considered in the calculation shall be either:

— design roughness value k_1 including influences of pipes and joints; or

[1)] 100 kPa = 1 bar.

— design roughness value k_2 including influences of pipes, joints, fittings and valves, (see A.9).

If k_1 is used, secondary head losses shall be considered (see A.10).

Possible long term increases of roughness shall be considered in establishing the design roughness value.

Other components, such as meters, pumps etc., shall be considered separately as specific head losses.

8.3.2.3 Flow velocities

Aspects to be considered in determining acceptable flow velocities shall at least include the following (see A.11):

— stagnation;

— turbidity;

— pressure;

— surge;

— pumping facilities.

8.3.2.4 Local mains

Local mains shall be designed to meet estimated peak flow rates. The capacity of local mains shall be adequate to convey additional flows for fire-fighting in accordance with national or local requirements (see A.12).

8.3.3 Network analysis

Network analysis shall be considered as a means of investigating the complex relationship between the system configuration, demands, pressures and flows in a network (see A.13).

8.3.4 Service pipes

8.3.4.1 Domestic consumers

The diameter of service pipes for domestic purposes shall be determined on the basis of the levels of service requirements' including service pressure and flow rate. Head losses through all components including fittings and meters shall be taken into consideration.

8.3.4.2 Non domestic consumers

The service pipe diameter shall be determined on the basis of the requirements of the consumer as agreed with the water supplier.

8.3.4.3 Fire-fighting

Reference shall be made to local regulations.

8.4 Structural design

8.4.1 Internal forces

Pipelines shall be designed for maximum flow, no-flow and transient conditions. In the case of transient conditions the amplitude and frequency shall be estimated.

Pipelines shall be designed to withstand a transient pressure of 80 kPa below atmospheric pressure (approximately 20 kPa absolute pressure).

The design pressure and the maximum design pressure shall be determined (see A.2). Test pressure shall be taken into consideration (see 11.3.2).

8.4.2 External forces

The external forces to be taken into account shall include:

- backfill loads (vertical and horizontal forces due to earth load);
- surcharge;
- groundwater;
- transient loads;
- self-weight of the pipe and weight of the water at least for DN ≥ 1 000;
- any other forces arising from installation or the consequences thereof including pipes on local supports.

8.4.3 Temperature range

Pipelines shall be designed for continuous operation over the anticipated temperature range of the water to be supplied. Loads arising from any temperature difference between installation and operation shall be taken into account. Attention shall be paid to the effects from external temperature conditions.

8.4.4 Unbalanced thrust

Forces are exerted at valves, changes in direction and diameter, branches and blank ends. These forces shall be compensated by an adequate number of restrained joints, thrust blocks or other anchorages.

Where thrust blocks are to bear against the soil the safe bearing pressure shall be determined. The possibility of shear failure, sliding and potential disturbance of the thrust block by subsequent excavation shall be considered.

8.4.5 Design requirements

The designer shall state the assumptions related to the forces mentioned in 8.4.1, 8.4.2, 8.4.3 and 8.4.4 and additionally all the assumptions relevant to the structural design of the pipeline which shall at least include:

- geometric dimensions of the trench or embankment (width, depth, etc.);
- embedment and backfill conditions;
- trench support conditions;
- characteristics of native soil and embedment material.

The designer shall specify for the system the design pressure(s) (DP), maximum design pressure(s) (MDP) and system test pressure(s) (STP) considering all relevant flow conditions.

The designer shall specify components which meet the conditions in Table 2.

Table 2 — Pressure conditions for specifying components

Components		System
PFA	≥	DP
PMA	≥	MDP
PEA	≥	STP
≥ 80 kPa below atmospheric pressure		≤ 80 kPa below atmospheric pressure

8.4.6 Unforeseen ground conditions

In the event of unforeseen ground conditions arising during installation, the design shall be reconsidered.

8.5 System layout

8.5.1 Mains

The required layout of all mains will depend very much on local circumstances (see A.14), but in all cases consideration shall be given to the following:

— reliability of supply;

— good access for maintenance;

— provision and location of line valves, air valves, washouts and hydrants;

— adverse ground conditions and difficult terrain;

— risk of damage to and from trees and tree roots;

— pipe materials and corrosion protection systems in aggressive or contaminated soils;

— minimum gradient;

— crossing of roads, rivers and railways;

— adoption of shortest practical route;

— location of other services, buildings and structures

— telemetry, control and metering;

— all design pressures;

— earth loads;

— traffic loads;

— ease of operation;

— national and local planning, environmental protection;

— depth of frost penetration;

— risk of damage to and from other utilities, works and apparatus; where practicable a minimum distance of 0.40 m shall be provided between parallel services with 0.20 m vertical clearance at crossings;

— for buried pipes the minimum depth of cover;

— the maximum depth of cover for ease of repair.

The exact location and depth shall be a matter for detailed consideration following, whenever possible, accepted arrangements for utility services.

8.5.2 Types of system configurations

Systems may have different degrees of interconnection. Guidance is given in A.15.

8.5.3 Service pipes

The location and depth of service pipes shall follow the same requirements as for mains (see 8.5.1 and A.16).

The service pipes shall be planned to be as straight as possible following the shortest route from the local main to the building.

Service pipes shall include a valve and/or ferrule for shut-off purposes.

8.5.4 Valves

8.5.4.1 Entry and release of air

Mains shall be provided with facilities to release air at high flow rates when the pipeline is being filled and to permit the entry of air at higher flow rates during draining. Large orifice air valves and sometimes hydrants can be used for this purpose.

Provision shall also be made for the release of accumulations of air during normal operation. Small orifice air release valves are usually adequate for this purpose (see A.17).

The size and type of the air valve required shall be determined by the designer depending on the predicted flowrate of air and the configuration of the system. All points where the gradient of the pipeline changes shall be considered (see A.17). Reference shall be made to the appropriate product standards for valve selection.

The arrangement of valves and chambers shall be designed to avoid the inflow of external water.

8.5.4.2 Draining

Appropriate washout facilities, depending upon local conditions, shall be provided according to operational requirements e.g. for draining or flushing.

The size of washouts shall be related to the volume of water to be drained, the time available and the capacity of the receiving watercourse or area (see A.18).

The design shall ensure that the kinetic energy of the discharge is safely dissipated; a washout manhole may be provided for this purpose. Consideration shall also be given at the design stage to the environmental impact of the discharge and, where appropriate, facilities for setting and/or neutralization of disinfectant shall be included.

Washouts shall be designed to avoid any unacceptable deterioration of water quality by appropriate physical arrangements.

8.5.4.3 Isolation

The location of isolating valves shall be planned to facilitate shut-off in an emergency. Consideration shall be given to the number of properties likely to be affected in relation to the required level of service. Local circumstances involving housing density and the location of hospitals, schools, apartment buildings and industrial premises shall be taken into account (see A.19).

8.5.4 Hydrants

Hydrants are required for fire-fighting. They may also be used for operational purposes, e.g. filling, draining, venting and flushing of the main. The location and type of hydrants shall therefore be determined by local circumstances and regulations as appropriate (see A.20).

8.5.5 Surge limiting equipment

Surges can be generated following power failures, pump starting or stopping and valve operation. Consideration shall be given to the need for surge limiting equipment as part of a pumped or gravity system.

8.6 Protection against aggressive environment

The designer shall assess potential damage due to contact with soils and various pollutants (see A.21).

The designer shall consider, with reference to product standards, appropriate measures to protect pipelines against undesired effects due to aggressive environments and the conveyed water.

The designer shall specify the method for the repair of coatings, linings and for any additional protection of joints.

8.7 Reservoirs

Reservoirs including water towers, shall be designed in accordance with relevant East African Standards. They shall be constructed and tested to provide the required security to supplies and shall not permit any unacceptable deterioration in the quality of the stored water.

8.8 Pumping stations

Determination of plant arrangements and pump duties for complex systems may require detailed studies using network simulation and optimization techniques. Control systems, actuated by pressure, flow, level or time, will depend on local conditions and may be manual or fully automatic with telemetry monitoring. Safeguards shall be incorporated in pump controls to stop units in the event of loss of suction pressure, or unacceptable flow conditions. Control systems shall ensure that unnecessary repeated stopping/starting or speed changes are prevented.

Pumping units shall be selected to prevent the following conditions:

— cavitation;

— instability (abnormal fluctuation between different rates of flow);

— overloading (abnormal increase in power consumption).

Acoustic emissions caused by the operation of pumping stations shall remain within the permissible limits as defined by the relevant regulations.

See A.22.

8.9 Documentation

A full record of any relevant design data and results shall be made.

9 General requirements for product standards

9.1 General

Water supply components shall be capable of withstanding all conditions for which they have been designed, when used in water supply systems as defined in Clauses 3 to 8.

All components shall conform with the relevant product standards, transposing EAS as available. The components shall be marked accordingly, including where appropriate the marking of conformity with the essential requirements or regulations where applicable.

The product standard and technical approvals shall at least include the requirements specified in Clause 9 and any other requirement necessary to ensure fitness for purpose in the field of water supply. The product standards shall also specify the appropriate test methods (type tests and/or quality tests) to ensure compliance with these requirements.

Product standards shall specify any further relevant information not given in this standard regarding transport, storage, installation and maintenance.

Product standards shall be used for evaluating a product. In the absence of a product standard, this standard shall be used as a reference for the establishment of a specification.

This standard applies equally to components which are factory made and to those constructed in situ. The properties of the materials and components and their durability shall be defined and tested including their time-dependent degradation (see also 9.9).

Product standards shall give sufficient information to enable verification of fitness for purpose of the components.

9.2 Materials

All materials used for components, including linings, coatings and seals, intended for water supply systems shall be suitable for such an application. They shall not cause any unacceptable deterioration of the quality of the water with which they come into contact.

9.3 Dimensions

9.3.1 Nominal sizes

The size of the components shall be designated by the use of DN. Within the size range given below the DN values shall be taken from either of the two following series, which shall be mandatory from December 31, 2003, one relating to the internal diameter (DN/ID), the other to the external diameter (DN/OD). Product standards shall indicate to which series they relate.

DN/ID: 20, 30, 40, 50, 60, 65, 80, 100, 125, 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 800, 900, 1 000, 1 100, 1 200, 1 250, 1 300, 1 400, 1 500, 1 600, 1 800, 2 000, 2 100, 2 200, 2 400, 2 500, 2 600, 2 800, 3 000, 3 200, 3 500, 4 000.

DN/OD: 25, 32, 40, 50, 63, 75, 90, 110, 125, 160, 180, 200, 225, 250, 280, 315, 355, 400, 450, 500, 630, 710, 800, 900, 1 000, 1 100, 1 200, 1 250, 1 300, 1 400, 1 500, 1 600, 1 800, 2 000, 2 100, 2 200, 2 400, 2 500, 2 600, 2 800, 3 000, 3 200, 3 500, 4 000.

9.3.2 Internal diameters

Product standards of components designated with DN/ID shall specify the internal diameter and tolerances which shall not exceed the values given in Table 3.

Product standards of components designated with DN/OD shall specify the external diameter, wall thickness and the relevant tolerances. Minus tolerances on the calculated internal diameter derived from the nominal values given in the product standard shall not exceed the values given in Table 3.

Table 3 — Minus tolerances on the internal diameter

DN	Minus tolerance on mean mm	Minus tolerance on individual value mm
DN < 80	0.05 DN	0.1 DN
80 ≤ DN ≤ 250	5	10
250 < DN ≤ 600	0.02 DN	0.04 DN
DN > 600	15	30

9.3.3 Length and wall thickness

Tolerances of wall thickness and lengths of components shall be specified in the product standards, irrespective of whether the wall thickness and/or length is given. If the wall thickness and/or length is not specified in the product standard, the product standard shall require the manufacturer to declare it.

9.3.4 Geometry of pipes, fittings and valves

Except in the case of pipes delivered in coils, pipes shall be straight, within tolerances specified in product standards. If pipes are delivered in coils, product standards shall specify a minimum radius of the coils.

The plane of the end faces of the pipes, fittings and valves shall be at 90° to the relevant axis with a tolerance such that the function of the pipe joint shall not be impaired.

Preferred angles for bends are 11°15'; 22°30'; 30°; 45° and 90°.

9.3.5 Internal surface

The internal surface of pipes, fittings and valves shall be free from visible defects that may affect their hydraulic performance. The product standard shall specify the acceptable imperfections.

9.3.6 Appearance and soundness

Components shall be of uniform condition. They shall not exhibit any damage or be affected in any way likely to impair their performance.

9.4 Structural design

Product standards shall indicate the relationship between the pressures they specify and PFA, PMA and PEA.

The structural design of components shall take into account all the relevant factors for their safe and reliable operation in water supply systems as described in 5.2 and 8.4, as well as:

— the maximum and minimum operating temperatures, and temperature-induced loads (see A.23);

— the effects of sustained long term loading on the material properties (e.g. creep, static fatigue);

— the effects of dynamic loading on the material properties (e.g. dynamic fatigue);

— the effects of potential hazards such as ground movements and/or earthquakes.

Components shall be designed to withstand, when installed, a transient pressure of 80 kPa below atmospheric pressure (approximately 20 kPa absolute pressure).

The maximum allowable long term deflection shall not exceed 8 %.

Product standards shall give sufficient information to enable structural design. Examples of the type of information to be included in product standards are given in Table A.2. For new products or materials this table shall be used as a checklist to establish their relevant characteristic properties.

For valves including hydrants, the identification of the three relevant pressures (PFA, PMA, and PEA) shall be specified for the valve in the open position and in the closed position so that the valve function and its tightness are assured under all these pressures. The valve shall be capable of operation for the whole range of PMA and PFA on one or both sides as appropriate.

9.5 Mechanical requirements

9.5.1 Circumferential resistance

Product standards shall state methods by which resistance to internal and external loadings is assured (see Table A.2).

9.5.2 Longitudinal resistance

For long rigid or semi-rigid pipes of small diameters, product standards shall state the resistance to bending moment or bending load for a specified span and loading condition.

Alternatively, limiting values of length to diameter ratios shall be given in product standards. This is to help avoid problems when transporting, lifting, handling and installing pipes (see Table A.2).

9.6 Water tightness

All pipeline components, including joints, shall be designed, manufactured and tested to ensure water tightness throughout the design life under the relevant loading conditions indicated in 9.4.

9.7 Joints

9.7.1 General

Product standards shall require that sealing materials comply with the requirements of the relevant East African Standards.

Joints having elastomeric seals shall be designed in such a way as to ensure water tightness throughout the design life, taking into account the long term sealing material properties (e.g. elasticity, strength, relaxation, temperature sensitivity) and, where appropriate, the possibility of joint movements during the lifetime of the system.

If the joint includes parts having significant strength regression, product standards shall state the required performance and shall specify the necessary tests.

The product standards shall specify the types of joints by which the components are to be connected:

— rigid joints;

— adjustable joints;

— flexible joints.

The product standards shall also state if the specified joints are non-restrained or restrained:

— **non restrained joints** shall have adequate axial withdrawal to accommodate any axial spigot movement induced by temperature fluctuations and the Poisson contraction of the pipe under internal pressure in addition to the specified angular deflection;

— **restrained joints** shall be capable of withstanding the end-thrust due to internal pressure and, where applicable, due to temperature fluctuation and the Poisson contraction of the pipe under internal pressure.

9.7.2 Rigid joints

Product standards shall state the required performance of rigid joints and shall specify the necessary tests.

9.7.3 Adjustable joints

Product standards shall state the required performance of adjustable joints and shall specify the necessary tests. The lowest value of the allowable angular deflection shall be as shown in Table 4.

Table 4 — Lowest allowable angular deflection of adjustable joints

DN	Radian	Degree
<300	0.03	1°43'
300 ≤ DN ≤ 600	0.02	1°09'
600 < DN ≤ 1000	0.01	0°34'
DN > 1000	$0.01 \times \frac{1000}{DN}$	$0^{o}\,34' \times \frac{1000}{DN}$

Product standards shall state the values of allowable angular deflection or require the manufacturer to do so. If adjustable joints include elastomeric gaskets they shall comply with 9.7.4 for their allowable angular deflection.

9.7.4 Flexible joints

The lowest values for the allowable angular deflection of flexible joints shall be as shown in Table 5.

Table 5 — Lowest allowable angular deflection of flexible joints

DN	Class A		Class B	
	radian	degree	radian	degree
<300	0.03	1°43'	0.06	3°26'
300 ≤ DN ≤ 600	0.02	1°09'	0.04	2°18'
600 < DN ≤ 1000	0.01	0°34'	0.02	1°09'
DN > 1000	$0.01 \times \frac{1000}{DN}$	$0^{o}\,34' \times \frac{1000}{DN}$	$0.02 \times \frac{1000}{DN}$	$1^{o}\,09' \times \frac{1000}{DN}$

Product standards shall state the values of allowable angular deflection or require the manufacturer to do so.

Where plain-ended pipes are jointed by couplings having a flexible joint at each end, the allowable angular deflection shall be attainable at each end of the coupling.

The water tightness of flexible joints to internal and external pressure shall be demonstrated under the following conditions:

— condition 1: joint deflected to the allowable angular deflection and, where applicable, to its thermal and Poisson's axial withdrawal allowance.

— condition 2: joint subjected to a transverse shear across the joint and, where applicable, to its thermal and Poisson's axial withdrawal allowance.

The product standard shall state whether conditions 1 and 2 are tested separately or in combination.

The product standard shall state the value of the transverse shear across the joint to either a minimum of 10 × DN expressed in newtons (test in combination) or 20 × DN expressed in newtons (separate tests), but, where applicable, the diametric deflection of the spigot shall not exceed the maximum allowable pipe deflection.

The tests shall be carried out as type tests. The product standard shall state the diameter to be tested in order to cover the whole range of diameters.

Type testing shall take into account all relevant unfavourable manufacturing tolerances (e.g. maximum and minimum diameters of socket and spigot, ovality).

The test pressures shall be at least:

— PEA (allowable site test pressure) for all kinds of joints;

— 80 kPa below atmospheric for joints whose tightness or gasket stability is influenced by the pressure.

A cyclic pressure type test shall be carried out under condition 2 or under a combination of conditions 1 and 2 as stated in the product standard. The test pressure shall vary between PMA (allowable maximum operating pressure) and 0.5 PMA or PMA - 500 kPa, whichever is the greater. The test shall comprise at least 24 000 cycles.

Satisfactory service experience of at least 10 years prior to the first date of publication of this standard for a particular joint product combination for water supply shall be accepted as satisfying this cyclic type test requirement. This 10 years allowance is valid only for joints the design of which has not been changed within this period of time.

Restrained joints shall be tested while subjected to the whole end thrust defined in 9.7.1.

Product standards shall state any additional performance requirements of flexible joints and shall specify the necessary tests.

9.8 Protective measures

Where internal and external and other protective measures are specified in the product standards, the limitations on the use of the products shall also be stated.

Where applicable, product standards shall state test methods.

The product standards shall also define the means necessary to ensure that the protective measures will be effective in use.

9.9 Durability

The product standard shall give all requirements and test methods so as to ensure that the components fulfil the functional requirements given in 9.2 to 9.8 for the design life given in 5.2 as appropriate.

9.10 Test methods

9.10.1 General

Product standards shall comply with 9.10.2 to 9.10.8 and shall specify appropriate test methods (type tests and/or quality tests), including those not mentioned in 9.10.

9.10.2 Measurement of diameter and wall thickness

9.10.2.1 Internal diameter

If measurement of internal diameter is a requirement of the product standard, it shall be carried out near all ends of the components and where appropriate. At least two measurements shall be taken at each section of measurement at approximately equal angular spacing in each section and the mean internal diameter calculated.

9.10.2.2 External diameter

If measurement of external diameter is a requirement of the product standard, it shall be carried out in a similar position and manner to that in 9.10.2.1, or by calculation from the circumference at each section of measurement of the component.

9.10.2.3 Wall thickness

If measurement of wall thickness is a requirement of the product standard, it shall be carried out near all ends of the component and where appropriate. At each measurement section, thickness shall be measured at a minimum of four approximately equidistant points. Alternatively, minimum and maximum values shall be determined at each measurement section.

9.10.3 Measurement of deviation from straightness of barrel

If measurement of deviation from straightness is a requirement of the product standard, the method of measurement shall be stated. Deviation shall be measured at the centre point of a line of length not less than two thirds of barrel length.

9.10.4 Measurement of deviation from squareness of component ends

If measurement of deviation from squareness is a requirement of the product standard, the method of measurement shall be stated.

9.10.5 Longitudinal resistance test for pipes

If there is a longitudinal resistance requirement in the product standard, the following bending test criteria shall apply:

— the test shall be carried out on a test machine having recording facility;

— the pipe to be tested shall be supported near each end so that, with the resultant load at the centre, it will break with one circumferential crack (3 or 4 point loading);

— the span shall be not less than 5 × DN, expressed in millimetres;

— the supports shall be designed to produce vertical reactions only.

9.10.6 Crushing test for pipes with rigid behaviour

If a product standard requires a crushing test, it shall state whether it is a proof test and/or an ultimate load test and it shall be carried out on a test machine having:

— a load recording facility;

— a loading beam, the lower face of which is a bearer having an elastomeric bearing strip of thickness between 20 mm and 40 mm and hardness between 45 IRHD and 65 IRHD; [2)] the maximum width of the bearing strip shall be as given in Table 6;

— a bottom bearer on which is located a V shaped support with a minimum included angle of 170°; each face of the support shall either be covered with, or have a bearing strip of, elastomeric material having the same thickness and hardness as that on the loading beam.

2) International rubber hardness degree, in accordance with ISO 48

Table 6 — Maximum width of bearing strip

DN < 400	50 mm
400 < DN ≤ 1200	(0.12 × DN) mm
DN > 1 200	150 mm

The test consists of subjecting a complete pipe or section of pipe to the action of a uniformly distributed load. Bearers may be divided into sections.

The test load shall be applied symmetrically over the entire bearer length. The position of the load may be adjusted to maintain horizontal stability.

During application of at least the final third of the specified load, the rate of increase of load shall be constant and this period of loading shall be at least 30 s.

9.10.7 Ring stiffness test for pipes with flexible behaviour

If a product standard requires a stiffness test and/or a proof deformation test and/or an ultimate deformation test, it shall be carried out on a test machine having load and deformation recording facilities. The product standard shall state whether the bearer and the beam shall be flat steel plates (with no bearing faces or strips) or as described in 9.10.6.

The determination of short term ring stiffness and of long term deformation behaviour shall be carried out according to relevant East African Standards, or, in the absence of these, the appropriate ISO standards.

9.10.8 Pressure tests

The product standards shall state the type and purpose of each test e.g. a proof pressure test (at a pressure specified by the product standard) or an ultimate pressure test (at a pressure leading to failure as specified in the product standard).

9.10.8.1 Tests for pipes

The tests shall be carried out on one or more pipes or sections of pipe under hydrostatic pressure for a certain duration at all conditions to be stated in the product standards.

The test pieces shall be clamped into a suitable apparatus. They shall be filled with water and adequately vented.

9.10.8.2 Tests for joints

The tests shall be carried out on two pipes or sections of pipe, jointed and supported in such a way that, where appropriate, they can move in relation to each other to limits of the requirements stated in product standards.

9.10.8.3 Tests for fittings, accessories, valves and other components

Test methods shall be stated in product standards to demonstrate suitability for use.

9.11 Interconnection of products

Each product standard shall state whether or not components within dimensional series (or tolerances) can be interconnected.

Where such interconnection is not confirmed, the product standard shall specify the means (e.g. adaptor) required to effect interconnection.

9.12 Quality control

Each product standard shall contain requirements for quality assurance to be used. Guidance for good practice in the field of quality control and certification is given in A.24.

9.13 Marking

Product standards shall specify the marking requirements.

Each component or, where this is not possible, each package of components, shall be marked indelibly and in a clearly visible manner.

In order to identify the component with certainty, the following information shall be provided as a minimum:

— identification of product standard number i.e. EAS XXXX;

— identification of manufacturer and site of production;

— identification of year of manufacture;

— identification of certification body, if any;

— identification of classes, where applicable;

— identification for suitability for use with potable water, where applicable.

10 Installation

10.1 General requirements

10.1.1 Qualifications

Competent personnel, capable of assessing the quality of the work within the scope of this standard, shall be employed for the supervision and the execution of the construction project.

Contractors appointed by the employer shall possess the qualifications necessary for the execution of the work. The employer shall make sure that the necessary qualifications are met (see A.25).

10.1.2 Rules for the execution of construction work

Construction work shall be executed in accordance with East African Standards, the requirements of the water supply company and taking into account any specific instruction of the manufacturer of pipeline components.

10.1.3 Transport and storage of pipeline components

The pipeline components shall be protected against damage. Only suitable equipment shall be used for the loading and unloading as well as for transport. Pipeline components shall be transported and stored in such a way that they do not come into contact with hazardous substances, e.g. by capping the openings. The pipeline components shall not be contaminated by earth, mud, sewage or other deleterious substances. If such contamination is unavoidable, the pipeline components shall be cleaned before being installed. The information and instructions provided by the manufacturers of pipeline components, with regard to avoidance of damage, degradation and contamination, shall be strictly observed.

10.1.4 Health and safety

All work shall be carried out in accordance with the Health and Safety Regulations applicable at the place of work.

10.1.4.1 General requirements

Personal protection equipment shall be provided in accordance with the relevant accident prevention regulations. All personnel shall be instructed on the relevant accident prevention regulations.

Sites shall be equipped with appropriate alarm devices and other emergency equipment in order that suitable immediate action can be taken in case of an accident.

The degree of maintenance and the reliability of the emergency equipment provided, including utilities and materials, shall be checked regularly. Defective equipment shall be removed from the site and replaced.

Prior to the commencement of construction, information (e.g. plans) on all apparatus of other operators shall be obtained. Safety precautions shall be taken whenever necessary.

10.1.4.2 Installation requirements

Excavation sites, shall be secured in a manner that prevents any danger to the personnel employed, other persons, properties and traffic (e.g. traffic control, foot bridges, lighting).

The support for excavations, including trenches, shall be installed in a manner to provide for safe working conditions. Access ladders shall be provided where necessary and secured in position when in use.

Construction operations shall not cause damage to existing structures.

The storage and transport of pipes, other components and materials shall be carried out in a manner which presents no danger to the personnel employed, other persons and properties.

When laying pipelines and installing components, relevant health and safety regulations shall be observed (e.g. wearing protective clothing and equipment when cutting, welding or otherwise treating materials). For fibre-cement components containing asbestos, national regulations shall apply.

When using asbestos-cement components special precautions shall be taken when cutting, machining or carrying out other operations likely to create dust.

10.2 Pipe trenches

10.2.1 Construction of pipe trenches; working space

The dimensions of the working space and the construction method shall be such that proper installation of pipeline components and surrounding material is possible. The dimensions of the pipe trench and the construction method assumed in design shall be observed in the execution of the work, unless a variation is agreed with the designer.

Before pipes are laid, the trench shall be checked for correct depth, gradient, width and condition of the trench bottom.

10.2.2 Depth of cover

The pipe trench shall be formed and excavated in such a way that all pipes are finally laid at a frost-free depth. Where it is not possible, alternative frost protection shall be provided. The depth of cover shall be as specified, unless a modification is agreed with the designer.

10.2.3 Bedding

The bedding shall be so constructed that the pipes rest on it throughout their barrel length. If necessary, appropriate holes shall be excavated in the lower bedding to accommodate joints.

If the trench bottom is suitable as bedding for the pipe, it shall form the lower bedding unless otherwise specified by the designer. The bottom of the trench shall be formed to the correct longitudinal profile and compacted if necessary.

If the trench bottom is not suitable as bedding for the pipes (e.g. stones, rock, non-load bearing or loosened soil), the trench shall be excavated to a greater depth, depending on the material of the pipe and its external protection. The extra soil removed shall be replaced by suitable selected material formed to the correct longitudinal profile and compacted (see 10.6.2).

Special bedding measures shall be employed for non-load-bearing soil. Any special requirement specified by the designer shall be complied with.

10.3 Installation of pipeline components

10.3.1 Distances from underground installations

The horizontal distance from foundations and similar underground installations shall be not less than 0.40 m in normal circumstances.

Where there is lateral proximity or where the pipeline runs parallel to other pipelines or cables, the horizontal l distance between them shall be not less than 0.40 m in normal circumstances. At points of congestion, a distance of at least 0.20 m shall be maintained except where this distance cannot be achieved. In all cases suitable measures shall be taken to prevent direct contact. These measures shall be agreed with the respective operators.

Where cables and pipelines cross, a clearance of at least 0.20 m shall be maintained. If this is not possible, measures shall be taken to prevent direct contact. The possibility of transmission of forces through direct contact shall be excluded. These measures shall be agreed with the respective operators.

Care shall be taken not to affect the stability of other installations when carrying out excavations.

Any special requirement specified by the designer shall be complied with.

10.3.2 Protection of pipelines against contamination

Pipelines shall be protected from internal contamination while they are being laid and kept clean internally. When work is interrupted or concluded, all openings shall be closed.

10.3.3 Installation of valves, fittings and other components

Installation work shall not cause unacceptable stresses to the system.

Measures shall be taken to accommodate predicted internal and external forces. Where necessary, unbalanced forces shall be resisted by suitable structures. Any special requirements specified by the designer shall be complied with.

Where components made from a particular material require partial or full concrete encasement, this shall be stated in the product standard. The dimensions and details of the concrete encasement shall be such that it is capable of withstanding any intended loads applied to the pipe. This may require the use of reinforced concrete. Provision shall also be made to resist thrust.

10.3.4 Connection to structures

Connections to structures (shafts, buildings, etc.) shall be made in such a way as to avoid undue stresses being exerted either on the pipes or the structures.

Measures suitable for this purpose include, for example, articulated pipe joints or flexibly mounted wall bushes.

Where pipes enter or pass through structures such as anchor blocks or valve chambers or have a concrete surround consideration shall be given to the need to provide flexibility to the pipeline on either side of the structure. The need shall be met by introducing two flexible joints to the pipeline on each side of the structure or by any other system specified by the designer. Care shall also be taken to ensure thorough compaction of the bedding material beneath the pipe immediately adjacent to the structure, particularly where over-excavation of the trench has occurred. In some circumstances, consideration shall be given to backfilling this over excavation with lean mix concrete (i.e. with low cement content) to the underside of the pipe bedding material.

10.3.5 Precautions against flotation

When necessary, precautions shall be taken to prevent pipe flotation. Such precautions shall not induce unacceptable stresses in the pipes.

10.4 Pipe joints

10.4.1 General requirements

Pipeline components shall be connected in such a way that the pipeline is watertight and withstands static and dynamic stresses. Joints and components shall conform to the relevant East African Standards, and be installed in accordance with the manufacturer's additional instructions,

10.4.2 Unrestrained joints

Pipelines with unrestrained joints shall be securely anchored at blank ends, tees, bends, tapers and valves to resist thrust arising from internal pressure. Anchors and thrust blocks shall be constructed to withstand the forces resulting from the internal pressure, including site test and dynamic forces, taking into account the safe bearing pressure of the actual surrounding soil (see 8.4.4). Concrete anchor blocks shall be of such a shape as to leave joints clear.

10.4.3 Restrained joints

Restrained joints shall be installed in accordance with the manufacturer's instructions.

10.4.4 Welded joints

Welding shall be carried out only by personnel qualified according to relevant East African Standards. If such standards are not available, welding shall be performed by suitably trained personnel, using welding equipment and methods approved by the pipe and fitting manufacturer.

10.4.5 Lubricants for joints

All lubricants which can come into contact with potable water intended for human consumption shall comply with relevant East African Standards.

10.5 Protection against corrosion and contamination

10.5.1 External protection

10.5.1.1 General requirements

Repairs and additions to the pipe coatings at faults and at pipe joints shall be effected as specified by the designer in accordance with the product standard, taking into account the manufacturer's instructions. The materials and method to be employed shall depend on the material originally used and the protection required, e.g. plastics sleeving, bitumen sheathing, protective tape, anticorrosive blankets, shrink-on hoses or shrink-on formed parts. Any exposed pipeline components after being cleansed, derusted and dried, shall be protected e.g. by strips, bitumen strips, by pouring round anticorrosive media or by tapes or shrink-on formed parts.

Where pipes have plastics coatings or loose plastics sleeving, care shall be taken to prevent contact with large sharp-edged stones, shale, flints or any harmful substance. Unacceptable heat effects, such as from district heating pipelines, shall be avoided.

10.5.1.2 Inspection and testing of anticorrosive external coatings

Where the designer specifies testing or when laying pipeline components made of metallic materials with an electrically non-conducting coating to the pipes and a cathodic protection of the system, the coatings shall be tested with an electrical testing apparatus and, if necessary, properly repaired.

After visual inspection, the continuity and resistance of coatings of cathodic protected pipeline systems shall be tested with an electrical spark test device or equivalent before backfilling.

The test voltage shall be specified by the designer depending on the type and the thickness of the coating material.

Any defects disclosed shall be rectified by a procedure compatible with the original coating and the repaired area retested.

10.5.2 Internal protection

Any damage to the internal coating or lining shall be repaired in accordance with the manufacturer's instructions. Where specified by the designer, the internal coating or lining of the joint area shall be effected in accordance with the design specification. Internal coating or lining shall comply with the relevant East African Standards, for materials in contact with potable water.

10.6 Embedment and main backfill

10.6.1 General

The load and stress distribution on the pipe, as well as its deflection, are largely determined by the manner in which the bedding and the remainder of the embedment are carried out. The embedment shall comply with the requirements specified by the designer, taking into account any relevant product standard.

10.6.2 Selected material for the embedment

Any material for the embedment (native soil, or imported soil including recycled and cementitious materials, etc.) shall have the following properties:

— it shall be sufficiently stable, when laid, to support the pipeline in the correct position both during and after laying and to enable the installed pipe to accommodate internal and external loads;

— it shall not cause corrosion, damage or degradation of the pipes, coatings, and components with which it is in contact;

— it shall be chemically stable and not react adversely with the soil or groundwater;

— it shall be capable of being compacted to the required density;

— unless otherwise agreed by the designer, it shall not include debris, organic materials, frozen soil, large stones, rocks, tree roots and similar large objects.

Where the native ground is fine grained, such as clay, silt, sand, and if the embedment is partially or totally below the water table, all material selected for the embedment shall be such that fines will not migrate from the adjacent soil of the trench bottom or walls. Conversely, the possibility of migration of fines from the embedment into the native soil shall be minimized by specifying materials with a suitable grading. In some instances specifying, a filter fabric may be an appropriate solution.

10.6.3 Execution of the embedment

Referring to the Figures 4a) and 4b), embedment shall consist of lower bedding, upper bedding, side fill, initial backfill or part of these when specified by the designer.

In all cases, execution of the embedment shall be carried out by placing layers of suitable material as specified. For any given pipe material, the size, quality and the degree of compaction of the embedment shall provide at least the minimum support required by the structural design calculations, in relation to the nature of the native soil and the allowable settlements. Special attention shall be given to the compaction of the bedding material under the haunches of the pipe.

Care shall be taken to fill appropriately any voids left by the withdrawal of the temporary trench wall support system, unless the effect of voids has been taken into account in the design.

Where specific compaction of embedment materials is specified, the materials shall be compacted across the full width of the trench and the withdrawal of temporary trench wall support shall be as specified by the designer.

10.6.4 Execution of the main backfill

The main backfill and final surface of the trench shall be completed in accordance with the required specification for the reinstatement of the trench.

Where specified, tracer tapes shall be installed in the specified position for detection and/or warning and identification purposes.

10.6.5 Control of the degree of compaction

If the designer specifies a degree of compaction, preliminary tests shall be carried out prior to the installation of the pipeline to verify that the required degree of compaction is obtainable. This will depend on the method of compaction, the soil nature, the equipment, the number of passes per layer and the thickness of the layers.

If the designer specifies a method of checking the degree of compaction in situ, the specified tests shall be carried out. The interpretation of the results of the tests and the acceptance criteria shall be as specified by the designer.

If the results of the tests do not comply with the specifications, the zone concerned shall be uncovered and then the affected layers of the embedment and the main backfill reinstated properly.

10.6.6 Diametral deflection of flexible pipes after installation

When the designer specifies a maximum diametral deflection of a flexible pipe after installation, the diametral deflection of the pipe shall be checked along its length at specified cross-sections after the full height of backfill has been placed over the pipe. Measurement shall be carried out by the methods specified by the designer. At no point shall the deflection exceed the specified value. Unless otherwise specified by the designer, any pipe found to have a deflection exceeding the specified value shall be uncovered, the reason for the over deflection established, the problem corrected and then the embedment and main backfill reinstated.

10.7 Records of tests during installation

The results of tests carried out during the period of installation shall, if specified or subsequently required by the designer, be recorded.

11 Testing of pipelines

11.1 General requirements

Every pipeline which has been constructed shall undergo a water pressure test to ensure the integrity of pipes, joints, fittings and other components such as anchor blocks.

11.2 Safety

11.2.1 Equipment and clothing

Prior to the commencement of operations a check shall be made that the appropriate safety equipment is available and that personnel have the correct protective clothing.

11.2.2 Excavations

After installation and until completion of reinstatement, all excavations shall remain adequately guarded. Work not related to pressure tests shall not be permitted in pipe trenches during pressure tests.

11.2.3 Filling and testing

Care shall be taken to fill pipelines with water slowly whilst all facilities for venting are open and the pipelines adequately vented.

Prior to carrying out a pressure test a check shall be made to ensure that the test equipment is calibrated, is in good working order and correctly fitted to the pipelines.

Pressure tests shall be carried out with all facilities for venting closed and intermediate line valves open.

At all stages of testing, the planned sequence and any variation of operations shall be controlled to avoid danger to personnel. All personnel shall be clearly informed of the intensity of the loading on temporary fittings and supports and the consequences if failure occurs.

Pipelines shall be depressurized slowly and all facilities for venting shall be open when emptying pipelines.

11.3 Pressure test

11.3.1 Preparations

11.3.1.1 Backfilling and anchorage

Prior to the pressure test, the pipes shall, where appropriate, be covered with backfill material such that changes in ground condition, which may lead to leaks, are avoided. Backfilling over joints is optional. Permanent abutments or anchorages shall be constructed to withstand thrust at the test pressure. Concrete anchor blocks shall be allowed to develop adequate strength before testing begins. Care shall be taken to ensure that caps or other temporary blanking fittings are adequately anchored, with the load distributed according to the strength of the supporting ground. Any temporary supports or anchorage at the ends of the test section shall not be removed until the pipeline is depressurized.

11.3.1.2 Selection and filling of the test section

The pipeline shall be tested as a whole or, when necessary, subdivided into several test sections. The test sections shall be selected so that:

— the test pressure can be achieved at the lowest point of each test section;

— a pressure of at least MDP can be achieved at the highest point of each test section unless otherwise specified by the designer;

— the necessary water for testing can be provided and removed without difficulty.

Any debris and foreign matter shall be removed from the pipeline before testing. The test section shall be filled with water. For potable water pipelines, potable water shall be used for the pressure test unless otherwise specified by the designer.

Air shall be exhausted from the pipeline as fully as reasonably possible. Filling shall take place slowly from, if possible, the lowest point in the pipeline and in such a way as to prevent back siphonage and so that air escapes at adequately sized facilities for venting.

11.3.2 Test pressure

For all pipelines the System Test Pressure (STP) shall be calculated from the Maximum Design Pressure (MDP) as follows:

— surge calculated

STP = MDPc + 100 kPa

— surge non calculated

STP = MDPa × 1.5 } whichever is the least

or STP = MDPa + 500 kPa

The fixed allowance for surge pressure included in MDPa shall be not less than 200 kPa.

The calculation of surge shall be carried out by appropriate methods and using the relevant general equations according to the conditions specified by the designer and based on the most unfavourable operating conditions.

Under normal circumstances the installation point for the testing equipment shall be the lowest point of the test section.

If it is not possible to install the testing equipment at the lowest point of the test section, the pressure for the pressure test shall be the system test pressure, calculated for the lowest point of the test section, minus the difference in altitude.

In special cases particularly where short lengths of pipeline are laid and for service pipes of DN < 80 and length not exceeding 100m unless otherwise specified by the designer, it is only necessary to apply the operating pressure of the pipeline as the system test pressure.

11.3.3 Testing procedure

11.3.3.1 General requirements

For all types of pipes and materials different approved testing procedures may be applied. The testing procedure shall be specified by the designer and may be carried out in up to three steps:

— preliminary test;

— pressure drop test;

— main pressure test.

The necessary steps shall be fixed by the designer.

11.3.3.2 Preliminary test

The preliminary test is intended to:

— stabilize the part of the pipeline to be tested by allowing most of the time dependent movements;

— achieve an appropriate saturation with water when using water absorbing materials;

— allow the pressure-dependent increase in volume of flexible pipes to occur prior to the main test.

The pipeline shall be divided into practicable test sections, completely filled with water and vented, and the pressure shall be raised up to at least the operating pressure without exceeding the system test pressure.

If unacceptable changes of the position of any part of the pipeline and/or leaks are apparent, the pipeline shall be depressurized and the faults shall be rectified.

The duration of the preliminary test is dependent upon the materials of the pipeline and shall be specified by the designer taking due account of the appropriate product standards.

11.3.3.3 Pressure drop test

The pressure drop test enables assessment of the remaining volume of air in the pipeline.

Air in the test section of the pipeline will result in erroneous data which could indicate apparent leakage or could in some cases mask a small leak. The presence of air will reduce the accuracy of the pressure loss test and the water loss test.

The designer shall specify if the pressure drop test has to be carried out. A method of carrying out the test and the necessary calculations is described in A.26.

11.3.3.4 Main pressure test

11.3.3.4.1 General

The main pressure test shall not be started until the preliminary test, if specified, and the pressure drop test, if specified, have been successfully completed.

Influences of large temperature changes shall be taken into account.

Two basic test methods are approved:

— water loss method;

— pressure loss method.

The designer shall specify the method to be used. For pipes with visco-elastic behaviour the designer may specify an alternative test procedure such as that described in A.27.

11.3.3.4.2 Water loss method

Two equivalent methods of measurement of water loss can be used, i.e. measurement of volume drawn off or measurement of volume pumped in, as described in the following procedures.

a) Measurement of the volume drawn off

Raise the pressure steadily until the system test pressure (STP) is reached. Maintain STP by pumping, if necessary, for a period of not less than one hour.

Disconnect the pump and do not permit any more water to enter the pipeline for a test period of one hour or a longer period if specified by the designer.

At the end of this test period measure the reduced pressure, then restore the STP by pumping and measure the loss by drawing off water until the reduced pressure reached at the end of the test is reached again.

b) Measurement of the volume pumped in

Raise the pressure steadily until the system test pressure (STP) is reached.
Maintain the STP for a test period of not less than one hour or a longer period if specified by the designer.

During this test period measure, by any suitable device, and record the quantity of water necessary to be pumped in order to maintain STP.

The designer shall specify which method is to be used.

The measured water loss at the end of the first hour of the test period shall not exceed the value calculated using the following formula.

$$\Delta V_{max} = 1.2V.\Delta P\left(\frac{I}{E_w} + \frac{D}{e.E_R}\right)$$

Where

ΔV_{max} is the allowable water loss in litres;

V is the volume of the tested pipeline section in litres;

Δp is the allowable pressure loss as stated in 11.3.3.4.3 in kilopascals;

E_w is the bulk modulus of water in kilopascals;

D is the internal pipe diameter is metres;

e is the wall thickness of the pipe in metres;

E_R is the modulus of elasticity of the pipe wall in the circumferential direction in kilopascals;

1.2 is an allowance factor (e.g. for air content) during the main pressure test.

11.3.3.4.3 Pressure loss method

Raise the pressure steadily until the system test pressure (STP) is reached.

The duration of the pressure loss test shall be 1 h or a longer period if specified by the designer. During the main pressure test the pressure loss Ap shall display a regressive tendency and shall not exceed the following values at the end of the first hour:

— 20 kPa for pipes such as ductile iron pipes with or without cement mortar lining, steel pipes with or without cement mortar lining, steel cylinder concrete pipes, plastics pipes;

— 40 kPa for pipes such as fibre cement pipes and non-cylinder concrete pipes. For fibre cement pipes, where the designer is satisfied that excessive absorption conditions exist, the pressure loss may be increased from 40 kPa to 60 kPa.

Alternatively, for pipes with visco-elastic behaviour (such as polyethylene pipes) for which watertightness cannot be verified in adequate time during this test, it shall be verified separately (see

A.27). In this case, to check structural integrity only, the STP shall be restored at regular intervals during the prescribed time and the pressure loss shall show a regressive tendency.

11.3.3.4.4 Test evaluation

If the loss exceeds that specified, or if faults are identified, the system shall be examined and rectified where necessary. The test shall be repeated until the loss complies with that specified.

Where a length of pipeline has been divided into two or more sections for pressure testing and all the sections have been tested satisfactorily, if specified by the designer, the whole system shall be pressurized at the operating pressure for at least 2 h. Any additional component which is included after the pressure test of the adjacent sections shall be inspected visually for leaks and changes of line and level.

11.3.4 Recording test results

A complete record of the details of the test shall be made and retained.

12 Disinfection

12.1 General

After the construction of a pipeline or the extension of a part of a water distribution system or replacement of a pipeline or a part of a water distribution system, the pipelines and service pipes shall be disinfected by flushing and/or the use of disinfectants.

All water to be used for this purpose shall be potable water. Conditions shall be fulfilled so that the water used for flushing and disinfection can be provided conveniently and disposed of with due care to the environment.

12.2 Preparation for disinfection

12.2.1 General requirements

If necessary divide the pipeline system into sections. Separate the section of the pipeline to be disinfected from operational parts of the water supply system. In special cases particularly where short lengths of pipeline are laid and for service pipes of DN < 80 and length not exceeding 100 m, unless otherwise specified by the designer, it is permissible not to separate the pipeline. In these cases care shall be taken that no migration of water from the disinfected section to the operational system can occur.

12.2.2 Disinfection equipment

All equipment used for disinfection operations shall be suitable for water treatment purposes.

12.3 Selection of disinfectant

The use of disinfectants shall be in accordance with the relevant East African Standards where applicable and national local regulations shall be complied with. (See A.28).

The choice of the disinfectants shall be made according to factors such as shelf life and ease of handling (likelihood or accidents to personnel or to the environment). Moreover the choice shall be made in accordance with the contact time required and water quality considerations e.g. pH values and, in the case of calcium hypochlorite, the hardness of the water.

Any chemicals used for disinfection of water supply systems shall comply with the requirements for chemicals used in water treatment as given in relevant East African Standards.

Recommendations for suitable disinfectants, maximum concentrations, limitations of use and neutralizing agents are given in Table A.3.

12.4 Disinfection procedures

12.4.1 General requirements

The following methods for disinfection are permissible:

— flushing procedure using potable water without additional disinfectant and with or without air injection;

— static procedure using potable water with additional disinfectant;

— dynamic procedure using potable water with additional disinfectant.

The minimum contact time shall be specified by the designer taking into account diameter, length type of material and installation conditions of the section to be disinfected.

Care shall be taken to ensure that no potable water with additional disinfectant enters the operational water supply system.

12.4.2 Flushing procedure

Carry out flushing with potable water. The designer shall specify the velocity, the minimum period of time and whether or not air injection is to be used.

12.4.3 Static procedure

Carry out disinfection by allowing the disinfection solution to reside in the totally filled pipeline section. The designer shall specify the concentration of the disinfection solution and the minimum contact time.

If specified by the designer, disinfection by static procedure shall be carried out in combination with the main pressure test. In that case, physically separate the section being disinfected from the operational water supply system. In exercising this option, the designer shall take due regard of the environmental damage which could occur due to accidental release of disinfection solution.

12.4.4 Dynamic procedure

Carry out disinfection by passing a volume of the disinfection solution through the totally filled pipeline section. The designer shall specify the volume, concentration and velocity of the disinfection solution.

12.5 Microbiological clearance and reporting

Following the disinfection contact period, flush the section as many times as necessary to ensure that the residual disinfectant concentration of the water does not exceed the requirements of relevant East African Standards. Dispose of the disinfection solution without harm to the environment. Where necessary use a neutralizing agent (see Table A.3).

When the section is filled with potable water from the system, take samples at positions and time intervals as specified by the designer in accordance with hygiene regulations where appropriate. Test these samples for microbiological compliance as specified. Unless otherwise specified, the foregoing sampling and testing need not be applied to short lengths of main, to works of repair of all diameters or to service pipes of DN ≤ 80.

If the results of testing are satisfactory, connect the section as soon as possible to the water distribution system I to avoid any risk of recontamination.

If the result of the testing is unsatisfactory, carry out a new disinfection procedure until microbiological clearance is achieved and before operation is commenced.

Make and retain a complete record of the details of the whole procedure and the test results.

13 Additional requirements

The following additional requirements shall be fulfilled:

— record of successful pressure test;

— record and certification of microbiological clearance;

— record of the location of newly constructed systems, with details of all relevant components;

— a check of the satisfactory function of all valves, including hydrants;

— installation of information plates, if specified by the designer, with necessary information about components (e.g. type, diameter, dimensions, distances);

— if specified by the designer, a manual detailing the operating data for the system, e.g.;

a) instructions for operating, servicing and functional checks of components;

b) measures against frost;

c) measures against corrosion or contamination;

d) measures for pipelines which have insufficient flow to avoid stagnation.

14 Operation

14.1 Inspection and monitoring

In order to minimize disruptions of water supply and adverse environmental and public health effects, distribution systems shall be monitored and inspected to identify malfunctions or leakages in pipes and other components.

Monitoring shall include flow and pressure measurements, levels of service and other operational information. Depending on local conditions, manual or automated methods may be employed.

The inspection of water supply systems shall include:

— identification of disturbances and leakages;

— functional and hygienic conditions to ensure the correct operation of valves including hydrants and other apparatus.

The frequency as well as the type of monitoring and inspection will depend very much on local circumstances; but in all cases consideration shall be given to the following:

— function and importance of pipes or other components;

— summation of water losses;

— water quality, pressure, flow;

— traffic loads, bedding conditions, soil quality, external forces;

— material of pipes, joints and other components.

14.2 Maintenance

Routine or preventative maintenance programmes shall be considered for appropriate components such as pumps, valves and electrical equipment.

Plans for the future maintenance, replacement and refurbishment of underground assets shall be drawn up in accordance with European, national or local requirements.

15 Updating of documentation

All records of the location of newly constructed mains, with details of all principal components such as valves and hydrants, shall be made and regularly updated. If required, new service pipes shall also be included.

Annex A
(informative)

Guidance to this standard

A.1 General

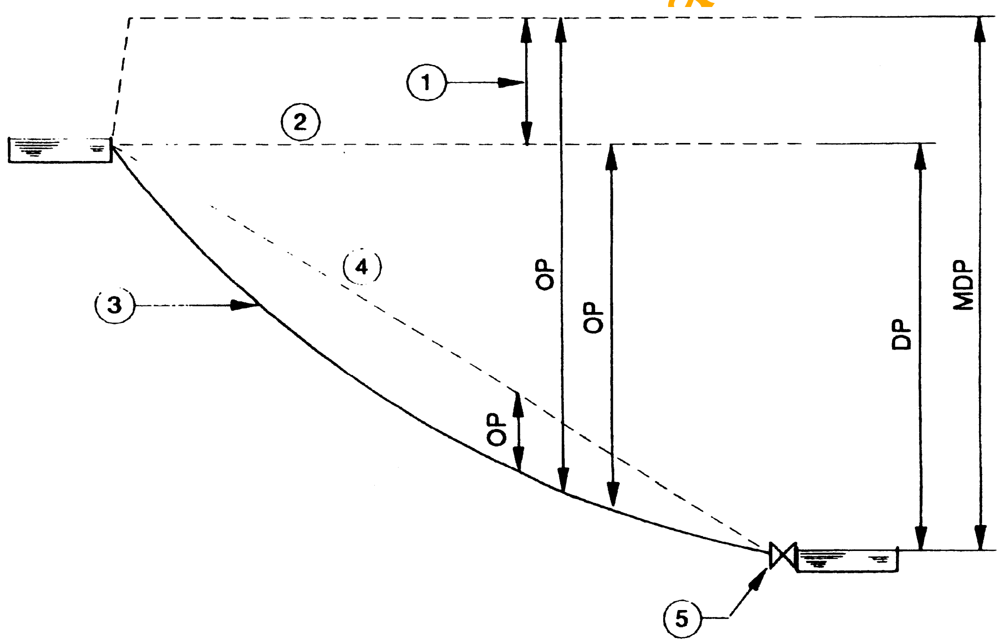
Details given in this annex are intended to give guidance on the criteria to be considered. Alternative techniques may be applied where an improved design will result or where existing procedures are known to give satisfactory results.

The following information refers to the relevant clauses and subclauses of this standard.

For aspects which are not covered by relevant East African Standards, other national standards and/or regulations may be used.

A.2 ad 3.1 Pressures

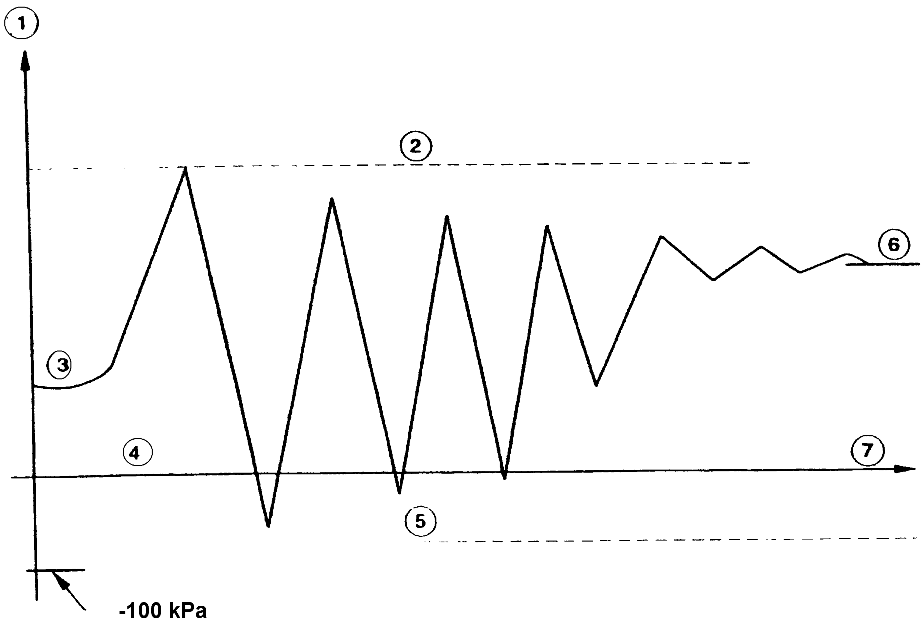
Surge is mainly related to flow velocity and not to internal pressure (see Figures A.1 and A.2).



Key

1 Surge
2 No flow hydraulic gradient
3 Pipeline profile
4 Hydraulic gradient
5 Valve

Figure A.1 — Example of pressurized gravity main



Key

1 Pressure
2 MDP (maximum design pressure)
3 Initial OP
4 Atmospheric pressure
5 Saturated vapour pressure
6 New OP
7 Time

Figure A.2 — Example of surge wave

A.3 ad 5.1.3 Prevention of back siphonage

In circumstances of particularly high risk of unacceptable deterioration of water quality non-return valves should not be considered to constitute an effective means of preventing back flow.

A.4 ad 5.3.1 Water demand estimates

The demand for water will depend very much on local circumstances. Where possible, measurement of consumption should be undertaken.

In the absence of detailed flow measurements or historical data the average daily demand may be obtained by estimating the domestic consumption per person per day (the per capita allowance) and multiplying it by the number of persons to be supplied. Allowances should be made for other uses e.g. street cleaning and supplies to premises such as schools and hospitals which, added to the per capita allowance, give the overall allowance.

Where no better information exists the overall allowance may be taken as being between 150 and 250 l per person per day depending on social and climatic conditions excluding specific industrial demands. In some areas consumption up to 450 l per person per day can occur. Future population increases should be taken into account together with any predicted variations in per capita consumption.

Appropriate allowances should be made for industrial demand and other special features.

A.5 ad 5.3.2 Water for fire-fighting

The potential demand for water for fire-fighting purposes to be provided by the water supply system may be very large in relation to normal requirements. In these circumstances the authorities responsible for fire-fighting should seek alternative sources of emergency supply (beyond the scope of this standard).

A.6 ad 6 Service objectives

Acceptable frequency and duration of interruptions may be achieved by providing adequate trunk main and service reservoir capacity, standby or alternative supplies.

A.7 ad 8.2 Peak flow factors

Where no better information is available the multiplying factor for the peak day can be assumed to vary from 1.5 × the average day demand for populations above 10 000 to over two times the average day demand for population below 2 000.

The peak hour rate in any day may range from twice the average hourly rate in that day for over 10 000 people to more than 5 × the average for less than 2 000. Where consumer storage is provided, the peak hour flow factors may be significantly lower than those suggested above.

Industrial and other special demands will also influence flow factors.

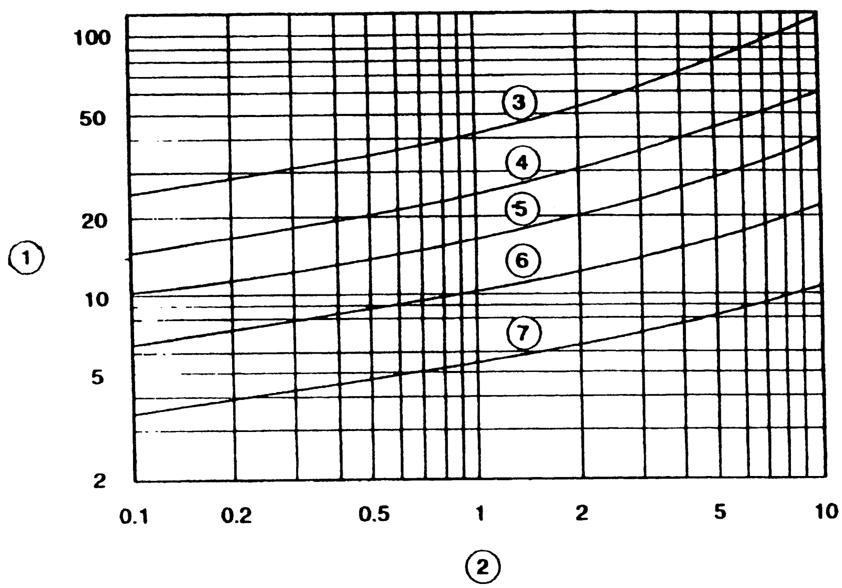
A.8 ad 8.3.1 Sizing

The capacity and flow requirements of the various system components require careful consideration since much depends on the interaction of mains, service reservoirs and pumping installations. In general, local mains and principal mains used for direct supply will need to be capable of sustaining peak flow rates or a subdivision thereof. Mains that supply reservoirs may not be required to meet full peak flow rates.

A.9 ad 8.3.2.2 Hydraulic roughness value

The design roughness value k_2 will normally lie between 0.1×10^{-3}m and 0.4×10^{-3}m for trunk and principal mains and between 0.4×10^{-3} m and 1.0×10^{-3} m for local mains.

The particular design roughness value k^2 will depend upon the pipe or lining material and internal condition, which can be influenced by water quality, as well as on the type and numbers of valves, fittings and joints (see Figure A.3).



Key

1 Pressure loss (kPa)
2 Roughness value (m x 10~3)
3 D=100mm
4 D=150mm
5 D = 200 mm
6 D = 300 mm
7 D = 800 mm

Figure A.3 — Example of relation between roughness value and pressure loss for various internal diameters (D) — (length = 100 m; flow velocity = 1.5 m/s; water temperature = 10 °C)

A.10 ad 8.3.2.2 Hydraulic roughness value

Head losses which occur at fittings and valves can generally be taken into account in two ways:

— the first method uses experimental results which demonstrate that head losses are approximately proportional to the square of flow velocity; coefficients are available for various types of fittings;

— the second method makes use of an "equivalent length" of straight pipe to give the same loss of head as the fittings.

A.11 ad 8.3.2.3 Flow velocities

In practice it will be desirable to avoid unduly high or low velocities. The range from 0.5 m/s to 2.0 m/s may be considered appropriate. However in special circumstances velocities up to 3.5 m/s may be acceptable. For pumping mains a financial appraisal should be undertaken to determine the most economic diameter of pumping main to minimize the capital and discounted pumping cost. The resulting velocity will normally lie in the range of 0.8 m/s to 1.4 m/s.

A.12 ad 8.3.2.4 Local mains

Since the population served will be small there is an increase likelihood of higher peak flow factors arising from simultaneous demands than for trunk and principal mains.

In the absence of better information and special requirements for fire-fighting, the Table A.1 can be used to determine the appropriate size of main for domestic developments serving less than 250 persons. The table is based on the assumption that the main is supplied from one end only.

Table A.1 — Recommended minimum pipe sizes for supplying small residential developments

DN	Suggested number of persons
50 [a]	30
80	100
100	250
[a] Providing the length of main does not exceed approximately 100 m.	

The recommendations given in Table A.1 may be subject to variation according to local practice.

For industrial developments and for residential developments serving more than 250 persons, the sizes of local mains should be determined by calculation.

A.13 ad 8.3.3 Network analysis

The analysis may be a mathematic model of a simplified representation of the network.

The objectives of the analysis should be clearly identified as they will determine the type of model required in terms of the details included and whether a static (snapshot or point in time) or a dynamic (simulation) model is appropriate.

The basic data required for modelling are as follows:

— record drawings of system;

— pumping station and reservoir details;

— locations of installed flow meters;

— current and anticipated water usage;

— pipework materials, class and roughness;

— details of operating and other conditions.

Models should be calibrated over a range of conditions with snapshots representing high, average and low demand conditions. For better results and for the modelling of time dependent parameters calibration should be for a 24 h simulation period.

A.14 ad 8.5.1 Mains

Arrangements for entry onto private land will vary according to local legislation and the policy of the water undertaker. Wherever possible it is recommended that the construction of buildings and other structures or changes in ground level are prohibited within a specified distance of the main for at least the lifetime of the asset.

The recommended minimum gradient is 1/500.
Whenever possible mains should be located to allow easy vehicular access for repair and maintenance. Mains running parallel to or crossing foul of combined sewers should be located at higher levels. If this is not possible adequate precautions should be taken to preclude ingress of contaminated water to the main.

A.15 ad 8.5.2 Types of system configuration

For types of systems see Figure A.4.

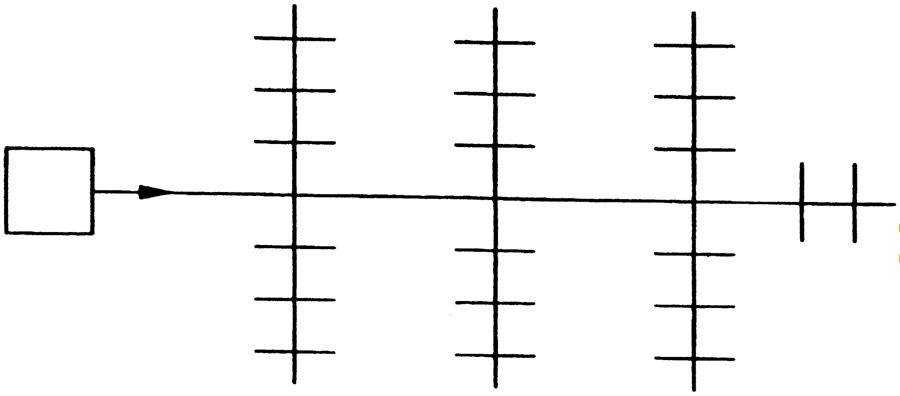


Figure a) — Example of linear main with individual branch mains

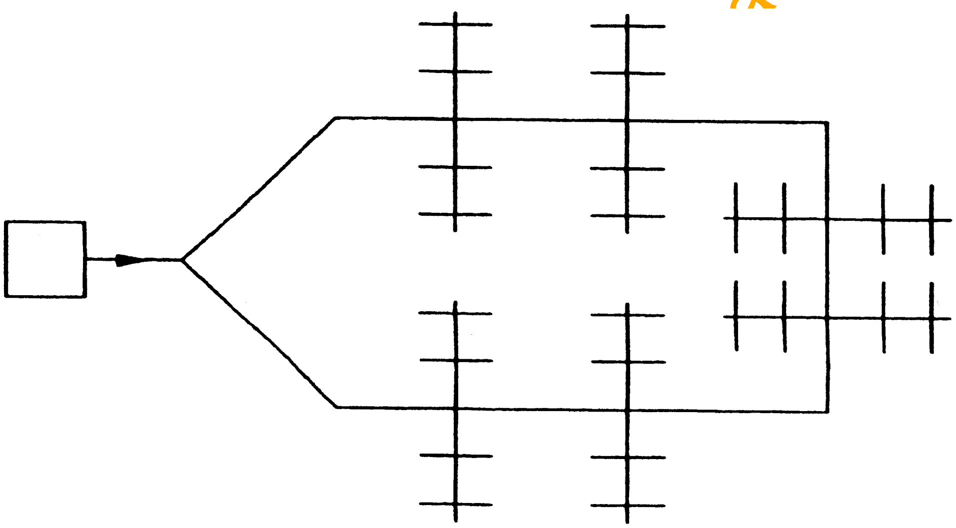


Figure b) — Example of simple networks comprising ring mains with individual branch mains

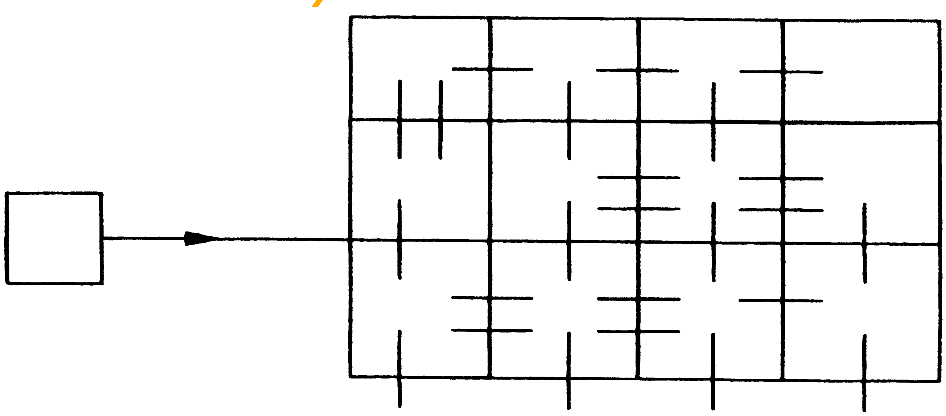


Figure c) — Example of network comprising ring mains with interconnected branch mains

Figure A.4 — Examples of system configuration

Whenever practical and economic, the preferred arrangement of ring systems with interconnected branches should be employed. The use of linear arrangements should be restricted to simple extension or rural distribution systems.

Ring systems have significant advantages:

- head loss reduced and pressures are more uniform;
- the number of properties affected by a shut down can be limited by valve operation with flow in both directions; however, flow reversals may give rise to discoloured water;
- unusual high demands can more easily be met;
- maintenance of supply is improved in the event of fire-fighting.

A.16 ad 8.5.3 Service pipes

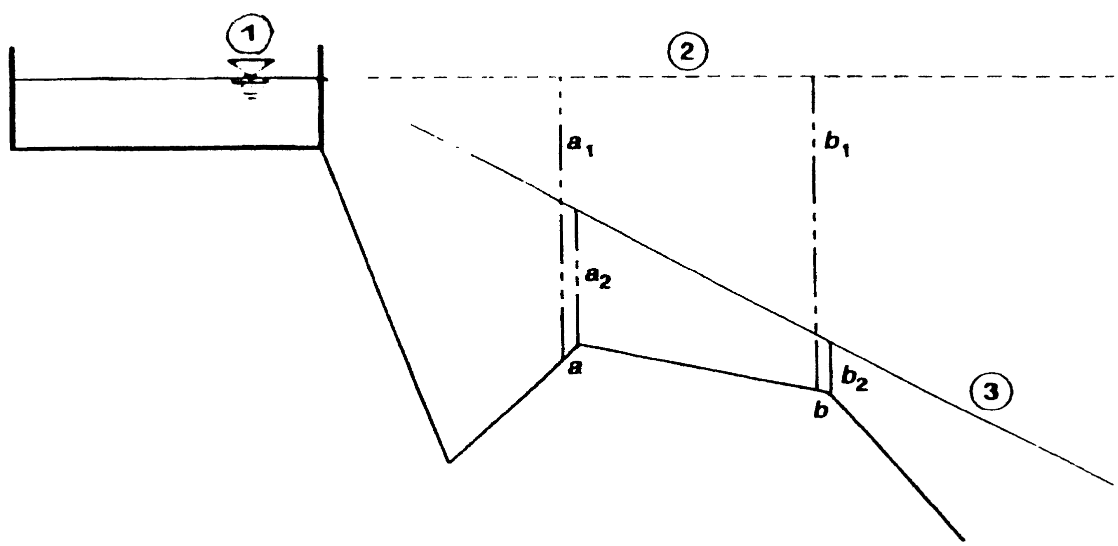
The path taken by the pipe should ensure that pipe installation is unobstructed, that the pipe remains accessible and is easy to monitor.

Where, in exceptional cases, a service pipe runs through hollow areas or beneath parts of buildings (e.g. terraces, stairs), the pipe should be installed in a duct or laid in a protective casing in this area.

Service pipes should not be used as a means of electrical earthing.

A.17 ad 8.5.4.1 Entry and release of air

Air collects at high points, the location of which may change depending on the variation of the hydraulic gradient, see Figure A.5. Air valves incorporating isolating valves should be provided at all possible high points.



Key

1 Water level
2 Hydraulic gradient A
3 Hydraulic gradient B
a = highpoint relative to elevation (hydraulic gradient A)
b = highpoint relative to hydraulic gradient B

Figure A.5 — Examples of high points

A.18 ad 8.5.4.2 Draining

The discharge diameter should not normally exceed DN 200.

A.19 ad 8.5.4.3 Isolation

Isolating valves should be installed on all branches as close as possible to the through main.

Valve location and metering installation should facilitate leak detection procedures.

Between two line valves it may be useful to install facilities for releasing pressure, for venting and draining. For principal and local mains, hydrants may fulfil this purpose.

Risk of extensive damage due to a broken main may be reduced by the use of control valves actuated by flow measurement or telemetered control systems.

The distance and location of shut-off valves should be fixed according to local conditions. In general, the intervals between shut-off valves should not exceed:

— in trunk mains .... 5 km;

— in principal mains .... 2 km;

— in local mains (rural) .... 1 km;

— in local mains (urban)............................. 0.5 km.

A.20 ad 8.5.4.4 Hydrants

Where hydrants are installed on trunk mains or principal mains it is recommended that an isolating valve is provided.

Consideration should be given to avoiding stagnation at hydrants.

A.21 ad 8.6 Protection against aggressive environment

Protective measures may include:

— coatings for some metallic components, suitably designed for various levels of soil corrosivity;

— protective pipes or metallic protection for some plastics components in contaminated soils;

— coatings or suitable mixes for some cement-based components in aggressive soils;

— various types of site arrangements;

— cathodic protection.

Ground contamination by organic substances, such as hydrocarbons and chlorinated hydrocarbons, may have adverse effects upon:

— the quality of potable water (by permeation of organic substances through the pipeline walls);

— the properties of some plastics components;

— the permeability and durability of some elastomeric gaskets;

— the corrosion resistance of some metallic components.

Where a soil survey indicates such ground contamination, measures such as the following should be taken into consideration by the designer.

— change to less vulnerable materials in the affected zones;

- lay pipes subject to permeation in protection ducts;
- use suitable elastomer for joints;
- use suitable corrosion protection for metallic materials;
- exchange the soil;
- re-route the pipeline.

A.22 ad 8.8 Pumping stations

The range of duties required may necessitate installation of a combination of pumps, either operating in series or parallel, or the use of variable speed units. The duplication of pumping units and other equipment should be considered where continuity of supply may be affected by breakdowns and maintenance work. At important sites standby plant should be provided to safeguard supplies in the event of power failure. At other sites the availability of mobile generators may be sufficient.

Valves and pipework should be arranged to minimize head losses while providing facilities for isolation and removal of pump units.

Delivery main valves may be arranged to close before pumps are stopped, and to open after they have reached full speed, both at controlled rates to minimize surge pressure in the pumping mains. Where axial flow pumps have large head and power increase in the low flow range, such isolation valves may not be appropriate. Automatically closing or non-return valves may be used, but consideration should be given to the effects of rapid closure.

A.23 ad 9.4 Structural design

Temperature induced loads are caused by restraints due to temperature difference between installation and working conditions.

Table A.2 identifies examples of the information given in product standards for various material. Equivalent; information can be substituted where appropriate.

Table A.2 — Examples of information on characteristics/requirements/test methods to be included in product standards

Properties	Fibre cement		Reinforced/ Prestressed concrete		Thermoplastics		Thermosets		Ductile iron		Steel	
	S	L	S	L	S	L	S	L	S	L	S	L
Ring bending strength	RT	C	RT[b]	C[b]	C	C	C	C	C	C	C	C
Ring stiffness	-	-	-		C	C	RT	RT	-	-	-	-
Modulus of elasticity (circumferential)	C	C	-		C	C	C	C	C	C	C	C
Deflection %	-	-	-		-	-	RT[e] or [d]	RT[e] or [e]	C[e]	C[e]	C[e]	C[e]
Strain chemical resistance	-	-	-		-	-	-	RT	-	-	-	-
Compressive strength	-	-	RT[c]	C[c]	-	-	-	-	-	-	-	-
Ring tensile strength	RT	C	-	-	C	C	T	T	C	C	C	C
Longitudinal bending strength	RT[a]	C[a]	-	-	C	C[a]	-	-	C	C	-	-
Longitudinal tensile strength	-	-	-	-	-	-	RT	-	RT	C	RT	C
Coefficient of thermal expansion	C	-	-	-	C	-	C	-	C	-	C	-
Poisson's Ratio	C	-	-	-	C	-	C	-	C	-	C	-
Modulus of elasticity (longitudinal)	C	C	-	-	C	C	C	-	C	C	C	C
Raw materials	-	-	SR[f]	-	-	-	-	-	-	-	-	-

[a] depending on diameters
[b] sometimes
[c] for concrete depending on process
[d] ultimate
[e] allowable
[f] cement admixtures, aggregates, steel, water additives

S short term value
L long term value
C characteristics only to be given
T test method to be indicated
RT requirement and test method to be given
SR Standard Reference to be given
\- no information necessary

A.24 ad 9.12 Quality control

The quality control system of the manufacturer should comply with the requirements of ISO 9001.

A.25 ad 10.1.1 Qualification, selection and award

Co-ordinating the procurement procedures of entities operating in the water, energy, transport and telecommunications sectors:

"(1) Contracting entities which so wish may establish and operate a system of qualification of suppliers, contractors or service providers.

(2) The system, which may involve different qualification stages, shall operate on the basis of objective criteria and rules to be established by the contracting entity. The contracting entity shall use European Standards as a reference where they are appropriate. The rules and criteria may be updated as required.

(3) The criteria and rules for qualification shall be made available on request to interested suppliers, contractors or service providers. The updating of these criteria and rules shall be communicated to the interested suppliers, contractors and service providers. Where a contracting entity considers that the qualification system of certain third entities or bodies meet its requirements, it shall communicate to interested suppliers, contractors and service providers the names of such third entities or bodies.

(4) Contracting entities shall inform applicants of their decision as to qualification within a reasonable period. If the decision will take longer than six months from the presentation of an application, the contracting entity shall inform the applicant, within two months of the application, of the reasons justifying a longer period and of the date by which its application will be accepted or refused.

(5) In reaching their decision as to qualification or when the criteria and rules are being updated, contracting entities may not:

— impose conditions of an administrative, technical or financial nature on some suppliers, contractors or service providers that are not imposed on others;

— require tests or proof that duplicate objective evidence already available.

(6) Applicants whose qualification is refused shall be informed to this decision and the reasons for refusal. The reasons shall be based on the criteria for qualification referred to in paragraph 2.

(7) A written record of qualified suppliers, contractors or service providers shall be kept, and it may be divided into categories according to the type of contract for which the qualification is valid.

(8) Contracting entities may bring the qualification of a supplier, contractor or service provider to an end only for reasons based on the criteria referred to in paragraph 2. The intention to bring qualification to an end must be notified in writing to the supplier, contractor or service provider beforehand, together with the reason or reasons justifying the proposed action.

(9) The qualification system shall be the subject of a notice drawn up, indicating the purpose of the qualification system and the availability of the rules concerning its operation. Where the system is of a duration greater than three years, the notice shall be published annually. Where the system is of a shorter duration, an initial notice shall suffice."

A.26 ad 11.3.3.3 Pressure drop test

Method of carrying out the pressure drop test and calculation of allowable water loss.

Raise the pressure of the pipeline to the test pressure, taking care that complete venting of the test equipment takes place. Remove a measurable volume of water ΔV from the pipeline and measure the resultant pressure drop Δp. Compare the removed volume of water AF with the allowable water loss $\Delta V_{\max}$ corresponding to the measured pressure drop Δp. Calculate the allowable water loss using the following formula:

$$\Delta V_{\max} = 1.5 \cdot V \cdot \Delta P \cdot \left(\frac{I}{E_w} + \frac{D}{e \cdot E_R} \right)$$

where

$\Delta V_{\max}$ is the allowable water loss in litres;

V is the volume of the tested pipeline section in litres;

Δp is the measured pressure loss as stated in 11.3.3.4.3 in kilopascals;

E_w is the bulk modulus of water in kilopascals;

D is the internal pipe diameter in metres;

e is the wall thickness of the pipe in metres;

E_R is the modulus of elasticity of the pipe wall in the circumferential direction in kilopascals;

1.5 is the allowable factor for permissible air content prior to the main pressure test.

A.27 ad 11.3.3.4 Main pressure test

A.27.1 General

This alternative method for pipelines with visco-elastic behaviour (such as polyethylene and polypropylene pipelines) is based on the fact that the characteristic creeping of the material is not sufficiently considered within the main pressure test under 11.3.3.4. A special procedure is therefore described below.

A.27.2 Test procedure

The whole test procedure comprises necessarily a preliminary phase including a relaxation period, an integrated pressure drop test and a main test phase.

A.27.3 Preliminary phase

The completion of the preliminary phase is a precondition to carry out the main test phase.

The intention of the preliminary phase is to set up the prerequisities for volume alterations dependent on the pressure, time and temperature.

Set up the preliminary phase as follows to avoid misleading results of the main test phase:

— after flushing and venting depressurize the pipeline to the atmospheric pressure and allow a relaxation period of at least 60 min in order to release any pressure related stress; take care to avoid air entering into the test section;

— after this relaxation period, raise the pressure continuously and quickly (in less than 10 min) to the System Test Pressure (STP). Maintain STP for a period of 30 min by pumping continuously or at short intervals. During this time carry out an inspection to identify any obvious leaks;

— allow a further period of 1 h without pumping during which the pipeline may stretch by visco-elastic creep;

— measure the remaining pressure at the end of this period.

In the event of a successful preliminary phase, continue the test procedure. If the pressure has decreased by more than 30 % of STP, interrupt the preliminary phase and depressurize the test section. Consider and adjust the test conditions (e.g. influence of temperature, indication of leakage). Only resume the test procedure after a relaxation period of at least 60 min.

A.27.4 Integrated pressure drop test

The results of the main test phase can only be judged if the remaining volume of air in the test section is adequately low. The following steps are necessary.

— reduce rapidly the remaining actual pressure measured at the end of the preliminary phase by bleeding water from the system to produce zip of 10 % to 15 % of STP;

— measure precisely the removed volume ΔV ;

— calculate the allowable water loss $\Delta V_{\max}$; using the following formula and check that the removed volume ΔV does not exceed $\Delta V_{\max}$.

$$\Delta V_{\max} = 1.2 \cdot V \cdot \Delta P \cdot \left(\frac{I}{E_w} + \frac{D}{e \cdot E_R} \right)$$

Where

$\Delta V_{\max}$ is the allowable water loss in litres;

V is the volume of the tested pipeline section in litres;

Δp is the measured pressure loss as stated in 11.3.3.4.3 in kilopascals;

E_w is the bulk modulus of water in kilopascals;

D is the internal pipe diameter in metres;

e is the wall thickness of the pipe in metres;

E_R is the modulus of elasticity of the pipe wall in the circumferential direction in kilopascals;

1.2 is the allowable factor for permissible air content prior to the main pressure test.

For the interpretation of the result it is important to use the exact value of E_R considering the temperature and the duration of the test. Especially for smaller diameters and shorter test sections Δp and ΔV should be measured as accurately as possible.

If ΔV is more than $\Delta V_{\max}$, interrupt the test procedure and vent again after the pipeline has been depressurized.

A.27.5 Main test phase

The visco-elastic creep due to the stress caused by STP is interrupted by the integrated pressure drop test. The rapid decrease of the pressure leads to a contraction of the pipeline. Observe and record for a period of 30 min (main test phase) the increase of pressure resulting from the contraction. The main test phase is considered to be successful if the pressure curve shows an increasing tendency and does not decrease at any time of this 30 min period, which is normally long enough to get a good indication (see Figure A.6). If during that period the pressure curve shows a falling tendency, it indicates a leak within the system.

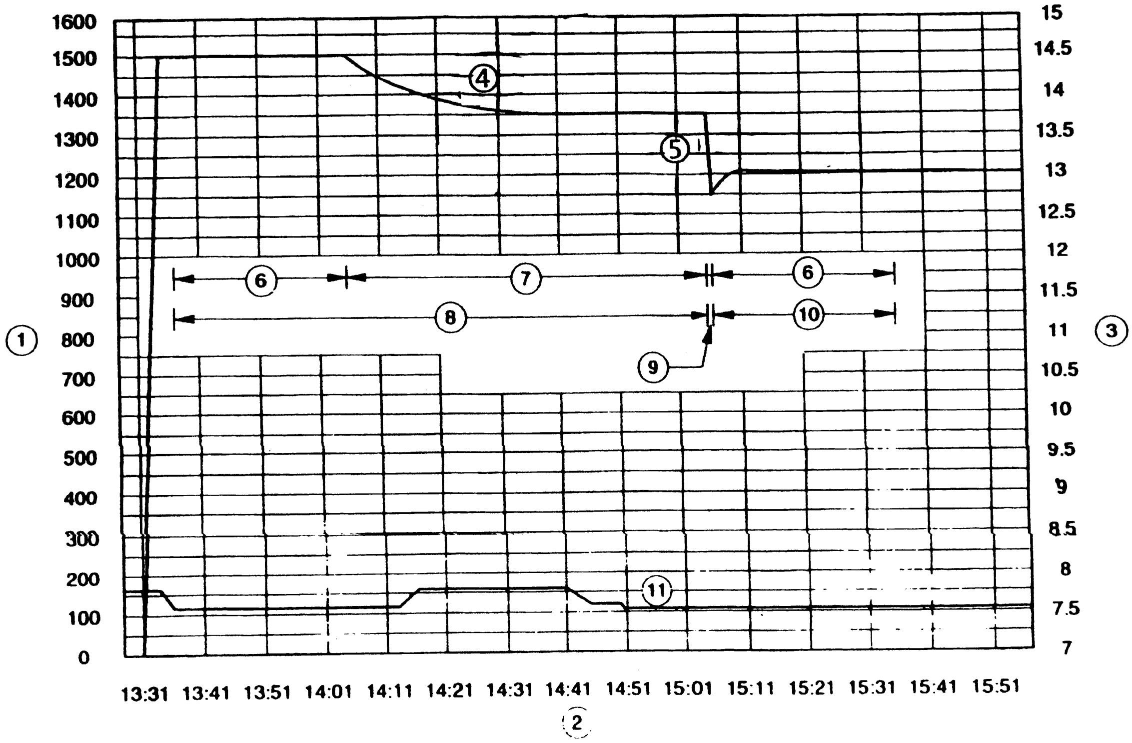
In case of doubt extend the main test phase to 90 min. In that case the pressure loss is limited to 25 kPa from the maximum value occurring within the contraction phase.

If the pressure drops by more than 25 kPa the test fails.

It is advisable to check all mechanical fittings before visually inspecting the welded joints.

Rectify any defect in the installation revealed by the test and repeat the test.

The repetition of the main test phase may only be done by carrying out the whole test procedure including the relaxation period of 60 min in the preliminary phase.



Key

1	Pressure (kPa)	2	Time
3	Temperature (°C)	4	Pressure
5	Δp = 200 kPa	6	30 min
7	60 min	8	Preliminary phase
9	Pressure drop test	10	Main test phase
11	Temperature		

Figure A.6 — Example of pressure test for pipelines with visco-elastic behaviour

A.28 ad 12.3 Selection of disinfectants

The following disinfectants are recommended:

— chlorine gas (Cl_2);

— sodium hypochlorite (NaClO);

— calcium hypochlorite ($Ca(ClO)_2$);

— potassium permanganate ($KMnO_4$);

— hydrogen peroxide (H_2O_2);

— chlorine dioxide (ClO_2).

Storage, handling and use of all these disinfectants can be hazardous. Manufacturer's instructions should be followed.

For details see table A.3.

Table A.3 — Details of chemicals recommended for disinfection of water distribution systems

Disinfectant (in solution)	Recommended maximum concentration mg/l	Neutralizing agents
Chlorine gas (Cl_2)	50 (as Cl)	Sulfur dioxide (SO_2) Sodium thiosulfate ($Na_2S_2O_3$)
Sodium hypochlorite NaClO	50 (as Cl)	Sulfur dioxide (SO_2) Sodium thiosulfate ($Na_2S_2O_3$)
Calcium hypochlorite $Ca(ClO)_2$	50 (as Cl)	Sulfur dioxide (SO_2) Sodium thiosulfate ($Na_2S_2O_3$)
Potassium permanganate $KMnO_4$	50 (as $KMnO_4$)	Sulfur dioxide (SO_2) Sodium thiosulfate ($Na_2S_2O_3$) Iron sulfate ($FeSO_4$)
Hydrogen peroxide H_2O_2	150 (as H_2O_2)	Sodium thiosulfate ($Na_2S_2O_3$) Sodium sulfite (Na_2SO_3) Calcium sulfite ($CaSO_3$)
Chlorine dioxide ClO_2	50 (as Cl)	Sodium thiosulfate ($Na_2S_2O_3$)

Annex B
(informative)

A-deviations

A-Deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the EASC member.

Partner States should indicate the national regulations which might be violated if this standard is applied in its entirety and the respective modifications that may have to b complied with.

Annex C
(informative)

Bibliography

ISO 9001, *Quality management systems — Requirements*