

English Version

## Water supply - Requirements for systems and components outside buildings

Alimentation en eau - Exigences pour les réseaux  
extérieurs aux bâtiments et leurs composants

Wasserversorgung - Anforderungen an  
Wasserversorgungssysteme und deren Bauteile  
außerhalb von Gebäuden

This European Standard was approved by CEN on 29 December 2024.

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

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## European foreword

This document (EN 805:2025) has been prepared by Technical Committee CEN/TC 164 “Water supply”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2025, and conflicting national standards shall be withdrawn at the latest by August 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 805:2000.

The main changes compared to the previous edition EN 805:2000 are listed below:

- addressing climate change and circular economy to enable improvements of water supply systems;
- addressing innovation in new products, processes and solutions for water supply systems;
- improvements related to the long-term safety, planning horizons and the resilience of the water supply systems;
- new subclause A.23 “Testing of non-viscoelastic pipelines (metals, concrete, GRP)” added;
- subclause A.24 “Testing of viscoelastic pipelines (PE, PVC-U, PVC-O)”: improved procedures.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

## **Introduction**

In specifying the requirements of this document, due regard has been taken of the importance of a reliable and safe supply of water for human consumption without excluding other uses of the water from the supply system.

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

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

This document takes into account the EU Strategy on Standardization setting global standards in support of a sustainable, resilient, green and digital EU single market.

Technical experts have reviewed and refreshed all the clauses of the EN 805:2000 revision to bring this document up to date in particular the implications of climate change and adapting the water supply systems, security, pressure testing, record keeping, resilience of water supply and updates as a result of many constructive comments from active users of this document across Europe.

It is presupposed that the users of this document take into account any applicable laws, regulations, directives and standards, including those on health and safety.

## 1 Scope

This document specifies:

- general requirements for water supply systems outside buildings 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 can include specifications which are more stringent;
- general requirements for installation, site testing and commissioning.

The requirements of this document 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;
- interconnections between water supply systems;
- significant modification and/or rehabilitation of existing water supply systems.

**NOTE** It is not intended that existing water supply systems are altered to comply with this document, provided that there are no significant detrimental effects on water quantity, security, reliability and adequacy of the supply. However, this document is intended to cover all water infrastructure systems mentioned above since they are key to meet the sustainable goals of the cities and to show the urgent need to invest in them in order to consider fundamental aspects, such as resilience or mitigation/adaptation to climate change.

## 2 Normative references

The following documents are referenced in the text in such a way that some parts of these or their entire contents constitute requirements of this document. With dated references, only the referenced issue is applicable. With undated references, the last issue of the referenced document is applicable (including all changes).

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*

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

### 3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.1 General

##### 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

##### 3.1.5.1

##### **MDPa**

designation of MDP when there is a fixed allowance for surge

##### 3.1.5.2

##### **MDPc**

designation of MDP 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

Note 1 to entry: 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

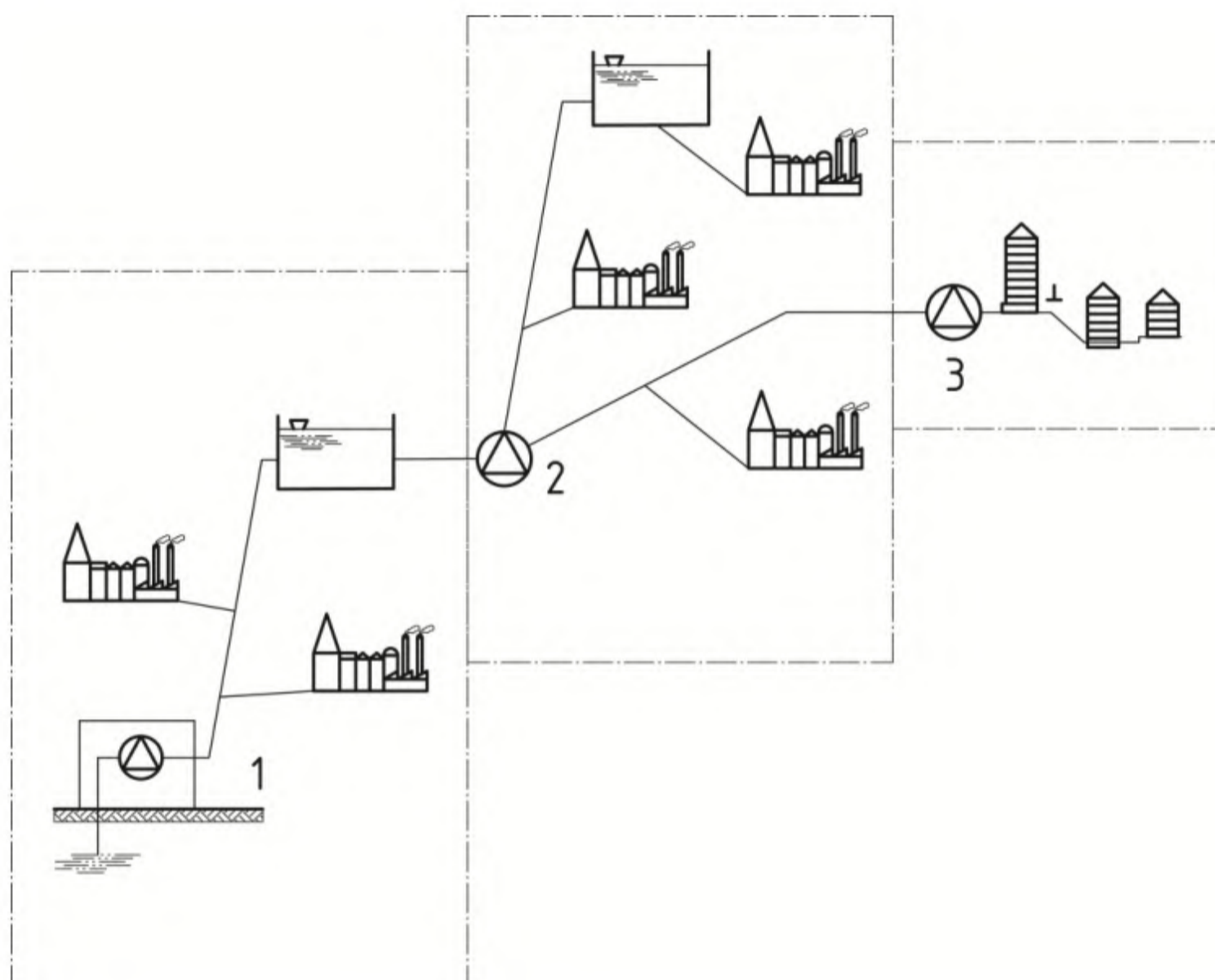
### 3.2.6

#### pumping station

pumping installation designed to provide pressure and flow within the distribution system

Note 1 to entry: Three types can be distinguished (see Figure 1):

- 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 1 — Example of different types of pumping stations**

### 3.2.7

#### pumped system

system where flow and 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 capacity**

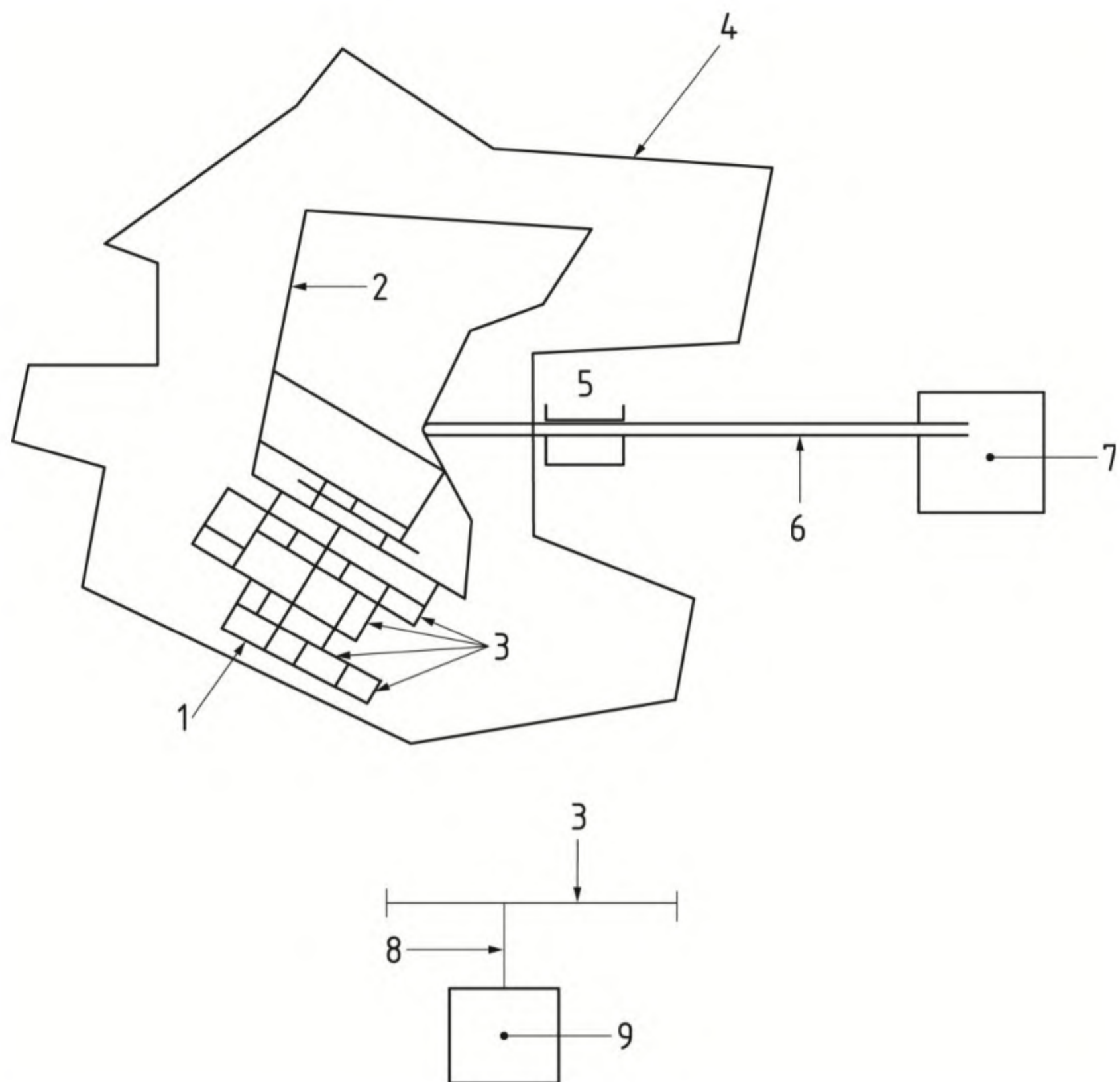
plant or system, such as additional pumps or duplicate mains, installed to provide secondary means for the supply of services in the event of failure or malfunction of the normal operating unit

**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 which 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 2)



<b>Key</b>	
1	network
2	principal main
3	local main
4	supply area
5	service reservoir (optional)
6	trunk main
7	source or treatment works
8	service pipe
9	consumer

Figure 2 — 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, for example 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 where, 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 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, for example 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, for example 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**

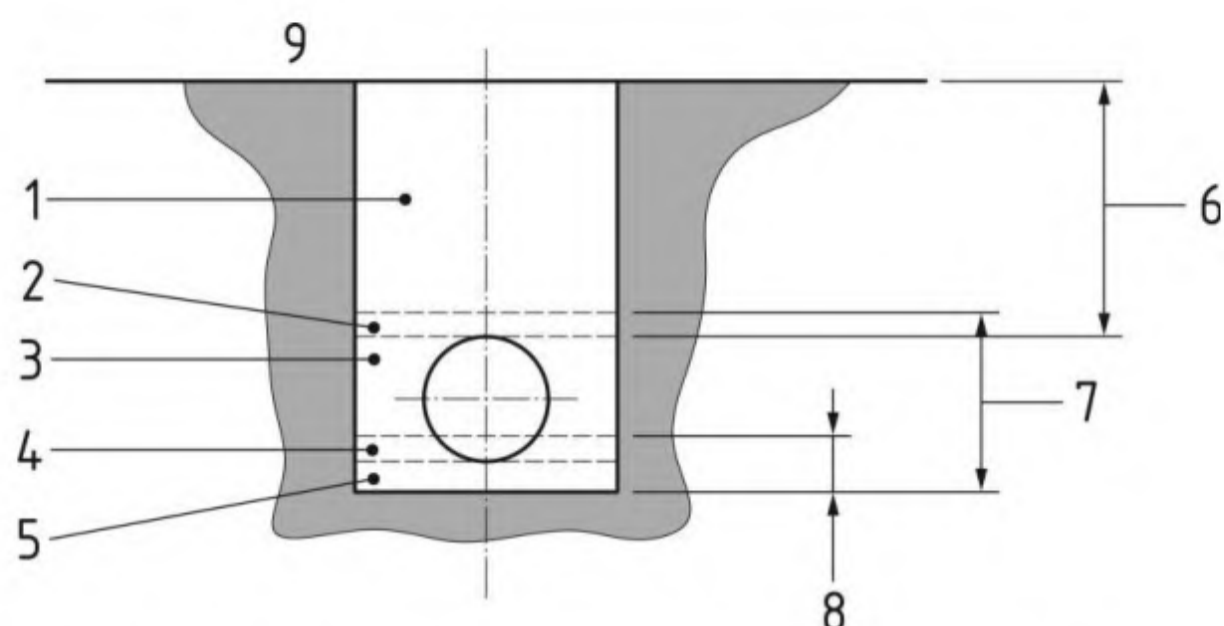
##### **DN/ID**

##### **DN/OD**

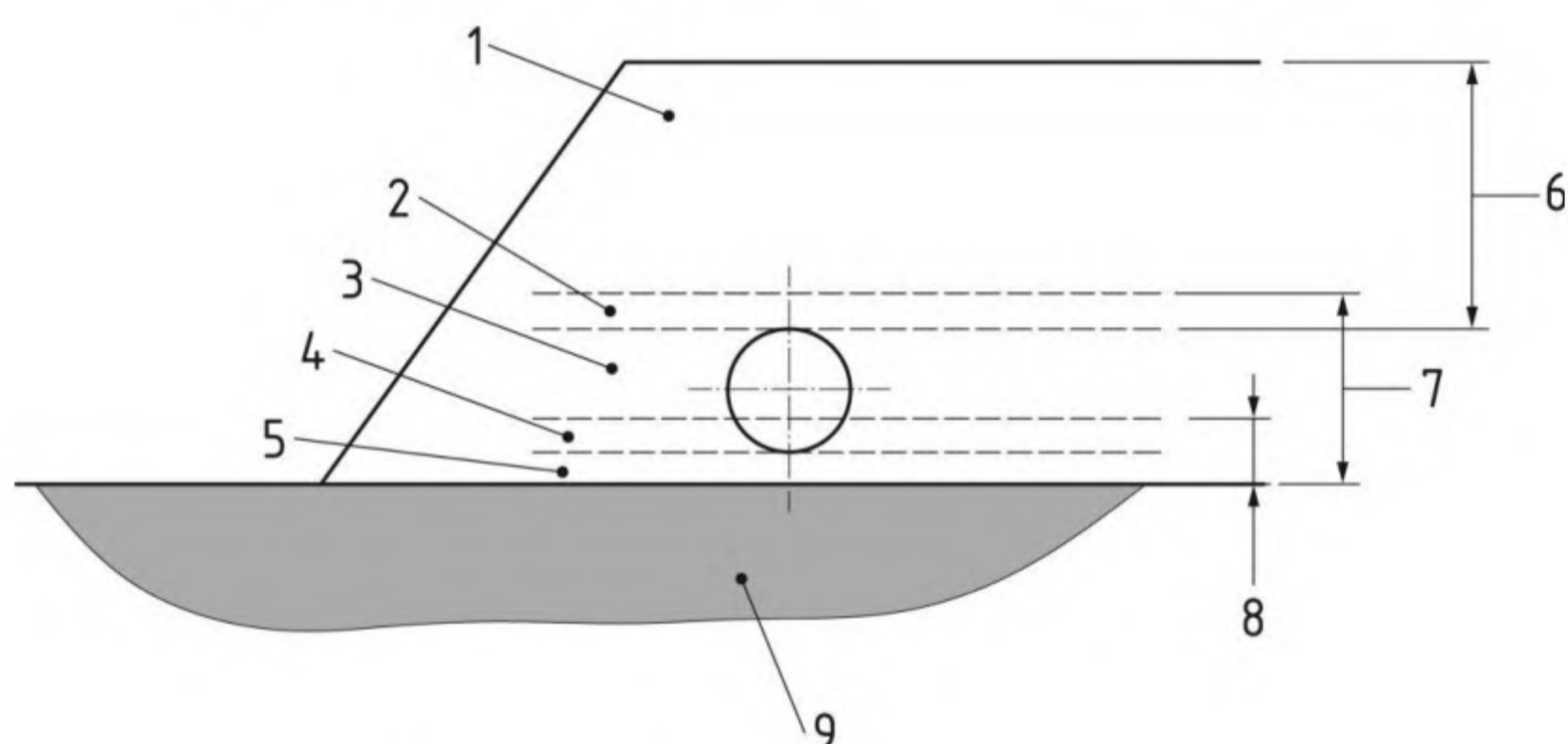
numerical designation of the size of a component, which is a whole number approximately equal to the actual dimension in millimetres which applies to either the internal diameter (DN/ID) or the external diameter (DN/OD)

## 3.5 Installation

Installation terms are shown for illustration in Figures 3 a) and 3 b).



a) Example of pipe laying in trenches with trench support



b) Example of pipe laying in embankments

**Key**

1	main backfill including road construction if any	6	depth of cover
2	initial backfill	7	embedment
3	side fill	8	bedding
4	upper bedding	9	ground surface
5	lower bedding		

**Figure 3 — Illustration of terms used in pipe installation****3.5.1****aggressive soil**

soil which can 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

Note 1 to entry: This definition applies to both short- and long-term values.

### 3.7.3

#### **ultimate load**

load which causes failure as defined in the product standards

### 3.7.4

#### **reference service life**

##### **RSL**

<water supply systems> service life of a pipeline with all its components to be expected under a particular set of in-use conditions, also forming the basis of estimating the service life under other in-use conditions

## 4 Requirements for water supply systems

### 4.1 Water quality and regulatory framework

#### 4.1.1 General

Water supply systems and their components are subject to European, national and local laws, regulations, directives, standards and technical approvals, in particular concerning water quality, other aspects of system design, construction, testing, operation and safety as covered by this document, taxing etc. Activities, objects and other infrastructure related to or close to water supply systems can also be subject to laws, regulations, directives and standards, and can, in combination with further local circumstances, affect water supply systems.

#### 4.1.2 Materials

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

#### 4.1.3 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, washouts and hydrants shall avoid water entering the system under normal operational conditions. EN 1717 [7] can be used as a guideline on the prevention of back flow.

For circumstances of high risks of unacceptable water deterioration, see 4.4 and A.3.

#### 4.1.4 Stagnation

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

The following arrangements leading to stagnation shall be carefully considered:

- mains with dead ends;
- spurs serving hydrants;
- pipes laid in advance of future development;
- sections with temporarily (e.g. seasonal) or permanently low flow rates;
- enhanced pipe diameters required for firefighting or other non-permanent purposes.

Where necessary, facilities shall be provided for mains flushing.

#### 4.1.5 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, taking into account 4.1.1, 4.1.2, 4.1.3 and 4.1.4.

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 antipollution device. 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.

#### 4.1.6 Contaminated soil

Special considerations regarding chemical resistance and permeability of all the materials used are needed for installations intended for use in contaminated soil, see also 7.6.

### 4.2 Planning horizon for water supply systems

Planning of water supply systems shall be based on the following long-term considerations:

- water supply systems shall be considered to fulfil their functional requirements to provide water now and for society for generations to come;
- parts of water supply systems, for example reservoirs, pumping stations and pipeline networks can have different spans of service life, depending on various factors, for example material composition, degradation and operating conditions. The water supplier has a scheme for specifying the intended service life and for regularly assessing the condition of those parts as well as for deciding on the need and scope of their maintenance and rehabilitation. All parts of the water supply system have their age profile set accordingly by the policy of the water supplier;
- future generations shall have to exist in a significantly different environment with more extreme weather events and impacts on the water supply systems due to flooding, wildfires, pollution and droughts, as well as a future with a very different carbon economy.

NOTE National regulations, where existing, can specify requirements for service life, maintenance and rehabilitation of water supply facilities. See also EN 15643.

### 4.3 Demand for water

#### 4.3.1 Water demand estimates

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

#### 4.3.2 Water for firefighting

Any use of potable water supply systems for firefighting purposes shall comply with 4.1.1, 4.1.2, 4.1.3 and 4.1.4 (see A.5).

### 4.4 System hazards and security

On the basis of a hazard analysis, measures to mitigate risks in accordance with EN 15975-2 should be applied for water supply systems. Due regard shall be paid to security of water supply systems with respect to technical failures including electrical blackout and IT failures, extreme weather, acts of terrorism including attacks on IT infrastructure, vandalism and other unlawful activity.

The hazard analysis measures, and the risks associated with reduced pressure, water quality and quantity due to water extraction for firefighting, with tree growth, with contamination, etc. are part of the system security.

Measures should be taken to reduce the probability of damage and/or the extent of the damage. 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.

The documentation of security measures and of key components such as documents, drawings and GIS information shall be treated confidentially.

NOTE There can be risks from external sources to water supply infrastructure that can affect essential services such as firefighting or hospitals. These risks are taken into consideration by the water supplier who will communicate these risks to other essential services.

## 5 Service levels

The water supplier shall specify the levels of service to be achieved at the point of connection to the consumer's installation. The specifications shall include service pressures, flow rates and continuity of supply and preservation of water quality (see 4.1.1 and A.6).

The water supplier also has a role in checking localized climate scenarios over the full life expectancy (including decommissioning) of the installations.

## 6 Rehabilitation

For works of repair, renovation or replacement, the relevant requirements of this document shall be followed. See also 13.2.

## 7 Design

### 7.1 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 document and the specified levels of service over the range of operating conditions, having regard to all relevant economic and ecological considerations including sustainability by using a life cycle analysis.

This includes looking at climate change scenarios and their potential impacts over the full asset life cycle.

NOTE EN 15643-5 [7] provides a framework on specific principles and requirements for civil engineering works.

### 7.2 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, including the expected effects of climate change on water demand (see A.7).

NOTE Other peak factors can be relevant. Peak factors will vary according to geography and national values.

### 7.3 Hydraulic design

#### 7.3.1 Sizing

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

The required capacity of a service reservoir to balance between supply and demand shall be in accordance with EN 1508.

In addition, other aspects shall be considered including, but not limited to, the following:

- estimate time to repair burst mains upstream;
- effect of pump/power failure;
- existence of alternative sources of supply;
- single or duplicate supply mains;
- degree of telemetry monitoring;
- ratio of peak hour to average flow rate;

- requirements with respect to water for industrial supplies, firefighting or other special circumstances.

### 7.3.2 Hydraulic calculations

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

- satisfy the current and future demand, taking into consideration future urban re-development;
- operate at acceptable velocities;
- operate within the required pressure range.

In addition, the design pressure (DP) and the maximum design pressure (MDP) shall be established at relevant points in the system, for example at nodal points of the network model.

The required diameters to satisfy the flow requirements for the hydraulic gradient available shall be verified by using the following Formulae (1), (2), (3) and (4):

$$H_r = \lambda \times \frac{L}{D} \times \frac{v^2}{g} \quad (1)$$

$$\Delta p = \lambda \times \frac{L}{D} \times \frac{\rho \times v^2}{2} \quad (2)$$

$$\frac{1}{\sqrt{\lambda}} = -2 \log_{10} \left\{ \frac{2.51}{Re \times \sqrt{\lambda}} + \frac{k}{3.71 \times D} \right\} \quad (3)$$

$$Re = \frac{v \times D}{\nu} \quad (4)$$

where

- $\Delta p$  is the pressure loss in pascals<sup>1)</sup>;
- $H_r$  is the total head loss in metres;
- $\lambda$  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;
- $\rho$  is the unit mass of water in kilograms per cubic metre;
- $Re$  is the Reynolds number;
- $\nu$  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.

<sup>1)</sup> 100 kPa = 1 bar.

### 7.3.3 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
- 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 also A.9).

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.

### 7.3.4 Flow velocities

Aspects to be considered in determining acceptable flow velocities shall include the following (see A.10):

- stagnation;
- turbidity;
- appearance/discolouration;
- pressure;
- surge;
- pumping facilities.

### 7.3.5 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.11).

### 7.3.6 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 firefighting in accordance with national or local requirements (see A.12).

### 7.3.7 Service pipes

#### 7.3.7.1 Domestic consumers

The diameter of service pipes for domestic purposes shall be determined from 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.

#### 7.3.7.2 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.

#### 7.3.7.3 Firefighting

In most parts of Europe there is likely to be an increase in demand for water for firefighting as a direct consequence of increases in the number and extent of wildfires due to climate change.

The designer shall assess and confirm with the water supplier to what extent the water distribution network can be used in compliance with 4.3.2.

Any predictions in increase in demand as a result of this shall be taken into consideration.

## **7.4 Structural design**

### **7.4.1 General**

Structural design shall comply with EN 1295-1.

### **7.4.2 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).

Pipelines shall be designed to avoid any sustained negative pressure by maintaining the pipe below the hydraulic gradient.

The design pressure (DP) and the maximum design pressure (MDP) shall be determined (see A.2). The system test pressure (STP) shall be taken into consideration (see 7.4.7 and 10.3.2).

### **7.4.3 External forces**

External forces other than described in EN 1295-1 shall be considered where water supply pipelines are not buried, for example at pipe bridges. The forces from the self-weight of the pipe, the weight of water and any other forces arising from installation result in stresses for the pipes and their local supports. These forces shall be taken into account.

### **7.4.4 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.

### **7.4.5 Unbalanced thrust**

Forces are exerted at valves, changes in direction and diameter, branches and blank ends. These forces shall be compensated by restrained joints, thrust blocks and/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.

### **7.4.6 Design requirements**

The designer shall state the assumptions related to the forces described above and additionally all the assumptions relevant to the structural design of the pipeline which shall at least include:

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

### 7.4.7 Hydrostatic design requirements

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. MDP is specified as either MDP<sub>c</sub> where the designer calculates the surge or MDP<sub>a</sub> where a designer adds a fixed allowance for surge. The fixed allowance included in MDP<sub>a</sub> shall be not less than 200 kPa.

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

The designer shall specify components which meet the conditions in Table 1.

**Table 1 — Pressure conditions for specifying components**

Components		System
PFA	≥	DP
PMA	≥	MDP
PEA	≥	STP

For an overview of pressures and their designation in English, French and German see Table 2.

**Table 2 — Designation of pressures in English, French and German**

Abbreviation a	English	French	German	
SP	service pressure	pression de service	Versorgungsdruck	System  Related
OP	operating pressure	pression de fonctionnement	Betriebsdruck	
DP	design pressure	pression de calcul en régime permanent	Systembetriebsdruck	
MDP	maximum design pressure	pression maximale de calcul	höchster Systembetriebsdruck	
STP	system test pressure	pression d'épreuve du réseau	Systemprüfdruck	
PFA	allowable operating pressure	pression de fonctionnement admissible	zulässiger Bauteilbetriebsdruck	Component  Related
PMA	allowable maximum operating pressure	pression maximale admissible	höchster zulässiger Bauteilbetriebsdruck	
PEA	allowable site test pressure	pression d'épreuve admissible sur chantier	zulässiger Bauteilprüfdruck auf der Baustelle	
a Valid for all language versions.				

#### 7.4.8 Unforeseen ground conditions

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

### 7.5 System layout

#### 7.5.1 Mains

The required layout of all mains will depend very much on local circumstances (see A.13), but in all cases consideration shall be given to the following:

- reliability of supply, including the consequences of a changing climate affecting water capture, storage and use;
- 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;
- soil conditions and stability;
- earth loads;
- traffic loads;
- ease of operation;
- national and local planning, environmental protection;
- depth of frost and heat penetration;
- risk of damage to and from other utilities, works and apparatus with local liaison between stakeholders required;
- 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.

## 7.5.2 Types of system configurations

Systems can have different degrees of interconnection. Guidance is given in A.14.

## 7.5.3 Service pipes

The location and depth of service pipe shall follow the same requirements as for mains (see 7.5.1 and A.15).

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, as necessary for shut-off purposes.

## 7.5.4 Valves

### 7.5.4.1 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.16).

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.16). Product standards and technical data sheets for valves provide guidance on their selection.

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

### 7.5.4.2 Draining

Washout facilities, depending upon local conditions, shall be provided according to operational requirements, for example 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.17).

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.

Washout arrangements shall be designed to avoid deterioration of water quality.

### 7.5.4.3 Isolating

The location of isolating valves shall be planned to facilitate shut-off in an emergency and for maintenance. 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.18).

### 7.5.4.4 Hydrants

Hydrants are used for operational purposes, for example filling, draining, venting and flushing of the main and temporary consumption of water, for example firefighting, construction and fairs. For determining locations and types of hydrants see 4.3.2 and A.19.

### 7.5.5 Surge limiting equipment

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

### 7.6 Protection against aggressive environment

The designer shall assess potential damage due to contact with soils and various pollutants (see A.20).

The designer shall consider, with reference to product standards, 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.

### 7.7 Reservoirs

Reservoirs including water towers, storage tanks shall be designed in accordance with EN 1508. 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.

### 7.8 Pumping stations

Determination of plant arrangements and pump duties for complex systems can 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 permissible limits (see also 4.1.1 and A.21).

### 7.9 Design service life

The water supply system, including the pipeline network, should be designed for a service life of at least 50 to 100 years. Local circumstances and economic considerations can be the cause to deviate from this.

Certain individual components, for example hydrants, valves, pumps etc. can require earlier maintenance or replacement.

Detailed information about Reference Service Life (RSL) can be found in EN 15804 [6].

Design service life shall not be shorter than their depreciation period.

Design service life shall also take into account social targets, environmental impacts and circular economy (see 4.1.1).

Information about the sustainability of construction works can be found in EN 15643 [4].

## 7.10 Documentation

A full record of any relevant design data and results shall be made and kept secure. This shall include details of the climate change data used, its source and its selection criteria. For traceability reasons the product data and, where available, the processing data and the location, shall be considered to be documented digitally.

## 8 General requirements for products

### 8.1 General

All components intended for water supply systems shall be designed, produced, tested and installed in water supply systems as specified in Clauses 4 to 7. They shall be capable of withstanding all conditions for which they have been designed, taking into account the additional requirements of this clause and any other requirement made by the designer to ensure fitness for purpose in the field of water supply.

Product standards that also contain further relevant information not given in this document, for example regarding transport, storage, installation and maintenance, are the most common instrument for establishing compliance with the above requirements. In the absence of a product standard, this document may be used as a reference for the establishment of a product specification. This document 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 specified and then tested, including their time-dependent degradation where applicable.

### 8.2 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.

### 8.3 Dimensions

#### 8.3.1 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; 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, 140, 160, 180, 200, 225, 250, 280, 315, 355, 400, 450, 500, 560, 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.

#### 8.3.2 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**

<b>DN</b>	<b>Minus tolerance on mean</b> mm	<b>Minus tolerance on individual value</b> 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

### 8.3.3 Length and wall thickness

Tolerances of wall thickness and lengths of components shall be specified in the product standards.

### 8.3.4 Geometry of pipes, fittings, and valves

Straight pipes shall be straight within tolerances specified in product standards. For coiled pipes, 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.

Angles for bends should be 11°15'; 22°30'; 30°; 45° and 90°.

The geometrical data for fittings and valves shall be declared by the manufacturer according to the relevant product standard.

### 8.3.5 Internal surface

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

### 8.3.6 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.

## 8.4 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 their relevant factors for their safe and reliable operation in water supply systems as described in 4.2 and 7.4, as well as the:

- maximum and minimum operating temperatures, and temperature-induced loads (see A.22);
- effects of sustained long-term loading on the material properties (e.g. creep, static fatigue);
- effects of dynamic loading on the material properties (e.g. dynamic fatigue);
- effects of potential hazards such as ground movements and/or earthquakes;
- effects of where the water table is above any hydrostatic pressure of ground water.

Components shall be designed to withstand, when installed, a transient pressure of 80 kPa below atmospheric (approximately 20 kPa absolute pressure). For components below the water table, this pressure difference shall be increased by the presence of hydrostatic pressure.

Product standards shall give information in accordance with EN 1295-1 to enable structural design. Examples of the type of information to be included in product standards are given in Table A.2. For products or materials not yet covered in product standards 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 ensured 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.

## **8.5 Mechanical requirements**

### **8.5.1 Circumferential resistance**

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

### **8.5.2 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).

## **8.6 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 8.4.

## **8.7 Joints**

### **8.7.1 General**

Product standards shall state the relevant European Standards specifying requirements for joints and their associated sealing materials.

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

- rigid joints;
- adjustable joints; or
- flexible joints.

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

- non-restrained joints shall have sufficient 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.

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

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.

### **8.7.2 Rigid joints**

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

### **8.7.3 Adjustable joints**

Product standards shall state the required performance of adjustable joints and shall specify the necessary tests to confirm performance.

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

### **8.7.4 Flexible joints**

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

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

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

## **8.8 Protective measures**

Where internal and external and other protective measures (e.g. lining, coatings, cathodic protection) 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 and shall also define the means necessary to ensure that the protective measures will be effective in use.

## **8.9 Durability**

The product standard shall give all requirements and test methods so as to ensure that the components fulfil the functional requirements given in 8.2 to 8.6 for the design service life given in 7.9 as appropriate.

## **8.10 Test methods**

### **8.10.1 General**

Product standards shall comply with 8.10.2 to 8.10.8 and shall specify test methods (type tests and/or quality tests) including those not mentioned in 8.10.

### **8.10.2 Measurement of diameter and wall thickness**

#### **8.10.2.1 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 measured section, in a perpendicular direction to each other, and the mean internal diameter calculated.

#### **8.10.2.2 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 8.10.2.1. If measurement of external diameter is done by calculation from the circumference, then care shall be taken to ensure that ovality is allowed in accordance with the product standard.

### 8.10.2.3 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.

### 8.10.3 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.

### 8.10.4 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.

### 8.10.5 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  $5 \times \text{DN}$  expressed in millimetres;
- the supports shall be designed to produce vertical reactions only.

### 8.10.6 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 and 65 IRHD International rubber hardness degree, in accordance with ISO 48; the maximum width of the bearing strip shall be as given in Table 4;
- a bottom bearer on which is located a V shaped support with a minimum included angle of  $170^\circ$ ; 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.

**Table 4 — Maximum width of bearing strip**

$\text{DN} \leq 400$	50 mm
$400 < \text{DN} \leq 1\,200$	$(0,12 \times \text{DN})$ mm
$\text{DN} > 1\,200$	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.

#### **8.10.7 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 8.10.6.

The determination of short-term ring stiffness and of long-term deformation behaviour shall be carried out in accordance with applicable EN and ISO standards.

#### **8.10.8 Pressure tests**

##### **8.10.8.1 General**

The product standards shall state the type and purpose of each test, for example 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).

##### **8.10.8.2 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 vented.

##### **8.10.8.3 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.

##### **8.10.8.4 Tests for fittings, accessories, valves, and other components**

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

#### **8.11 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.

#### **8.12 Quality management**

Product standards shall include type-tests and procedures for manufacturing control.

The manufacturer and the contractor shall have a quality management system.

Requirements for quality managements systems are specified in EN ISO 9001.

#### **8.13 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. Marking may be by code, logo, bar code, QR code etc. that is traceable.

Where not specified in the product standard the following information shall be provided as a minimum:

- identification of product standard number, i.e. EN XXXX;
- identification of the manufacturer;
- site of production;
- batch number or equivalent tracing;
- identification of year of manufacture;
- identification of Certification Body, if any;
- identification of classes, where applicable;
- identification for suitability for use with potable water.

## **9 Installation**

### **9.1 General requirements**

#### **9.1.1 Qualifications**

Competent personnel, capable of assessing the quality of the work within the scope of this document, 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.

#### **9.1.2 Rules for the execution of construction work**

Construction work shall be executed taking into account national standards, transposing European standards as available, the requirements of the water supplier and taking into account any specific instruction of the manufacturer of pipeline components.

#### **9.1.3 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, for example by robust capping of the openings. The pipeline components shall not be contaminated by earth, mud, sewage, or other deleterious substances. If any contamination has occurred, the components shall be cleaned and disinfected 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.

#### **9.1.4 Health and safety**

##### **9.1.4.1 General requirements**

Personal protection equipment shall be provided.

All personnel shall be instructed on the relevant accident prevention regulations.

Sites shall be equipped with 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.

#### **9.1.4.2 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.

Alternative installation methods, for example trenchless and narrow trench technology, shall be considered for safety, environmental and economic reasons.

Construction operations shall not cause damage to existing structures.

The storage, transport and laying/installing 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 (by wearing protective clothing and equipment when cutting, welding or otherwise treating materials etc.; see 4.1.1).

### **9.2 Pipe trenches**

#### **9.2.1 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 if necessary, width and condition of the trench bottom.

#### **9.2.2 Depth of cover**

The minimum depth of cover required for each pipeline shall be specified in accordance with 4.1.1, including considerations of temperature, ecology, pipe material, other utilities and loading conditions. The maximum depth can be specified.

The pipe trench shall be formed and excavated in such a way that all pipes are finally laid at a frost-free depth above the sewerage network. Where such depth is not possible, alternative frost protection against extreme ambient temperatures shall be provided. Depending on climactic conditions, the depth of temperature penetration during prolonged heat waves is a complementary or even more important point of consideration. The depth of cover shall be as specified unless a modification is agreed with the designer.

#### **9.2.3 Bedding**

The bedding shall be so constructed that the pipes rest on it throughout their barrel length. If necessary, 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 a specific type of pipe (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 9.6.2).

Special bedding measures shall be employed for non-loadbearing soil.

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

## 9.3 Installation of pipeline components

### 9.3.1 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 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.

In case of thermal or other influences due to other infrastructure (e.g. pipelines of a local heating/cooling network) the minimum distances shall be adjusted.

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.

### 9.3.2 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 securely capped.

### 9.3.3 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 can require the use of reinforced concrete. Provision shall also be made to resist thrust.

### 9.3.4 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.

### **9.3.5 Precautions against flotation**

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

## **9.4 Pipe joints**

### **9.4.1 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 be installed in accordance with the manufacturer's instructions (see also 4.1.1).

### **9.4.2 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 7.4.5). Concrete anchor blocks shall be of such a shape as to leave joints clear.

### **9.4.3 Restrained joints**

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

### **9.4.4 Welded joints**

Welding shall be carried out only by qualified and competent personnel.

All welding shall be carried out using welding equipment and methods approved by the pipe and fitting manufacturer.

### **9.4.5 Lubricants for joints**

All lubricants which can come into contact with potable water intended for human consumption shall not have any adverse effects on the water quality (see 4.1.2).

## **9.5 Protection against corrosion and contamination**

### **9.5.1 External protection**

#### **9.5.1.1 General requirements**

Repairs and additions to the pipe coatings at faults and at pipe joints shall be applied 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, for example plastic sleeving, bitumen sheathing, protective tape, anticorrosive blankets, shrink-on hoses or shrink-on formed parts.

Any exposed pipeline components after being cleansed, de-rusted and dried, shall be protected, for example, by 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.

### 9.5.1.2 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 or rejected.

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.

### 9.5.2 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 carried out in accordance with the design specification (see 4.1.2).

## 9.6 Embedment and main backfill

### 9.6.1 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.

### 9.6.2 Selected material for the embedment

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

- it shall be 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 to the pipes, their 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 or 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, geo-textiles can be used.

### 9.6.3 Execution of the embedment

Referring to the Figures 3 a) and 3 b), in 3.5 embedment shall consist of lower bedding, upper bedding, side fill, and initial backfill (in addition to any Geotextile membrane acting as a wrap if necessary) where 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 the voids left by the withdrawal of any temporary trench wall support system, avoiding any damage to the pipe, unless the effect of these 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.

#### **9.6.4 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.

#### **9.6.5 Control of the degree of compaction**

If the designer specifies a degree of compaction, the 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, for example, the method of compaction, the soil nature and condition, 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.

#### **9.6.6 Diametral deflection of flexible pipes after installation**

Where the designer specifies a maximum diametral deflection of a flexible pipe after installation this shall be checked along its length at specified cross sections only 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.

### **9.7 Records of tests during installation**

The results of tests carried out during the period of installation shall, be recorded and retained for the time specified.

## **10 Testing of pipelines**

### **10.1 General**

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.

The designer shall specify the procedure to be used and the pass/fail criteria.

The designer may propose a procedure in accordance with A.23 (for non-viscoelastic materials like metal, concrete or glass-reinforced plastic) or A.24 (for viscoelastic materials like PE and PVC), if more detailed and

specific national standards or guidelines in accordance with 4.1.1 are not available. Before proposing a procedure in accordance with A.23 or A.24, the designer shall check if any untypical aspects or particularities not covered by A.23 or A.24 need to be taken into account.

**NOTE** Owing to the fact that non-viscoelastic pipelines differ from viscoelastic pipelines in various features, A.23 contains more details than A.24.

Test mediums other than potable water (plus disinfectants, where necessary) shall not be used for the following reasons:

- pressurized gaseous test mediums (air, nitrogen etc.) involve serious safety hazards to persons and objects in the vicinity of test sections;
- pumps used for pressurization can cause residues in the test section that will adversely affect water quality after commissioning.

## **10.2 Safety**

### **10.2.1 Safety equipment and clothing**

Prior to the commencement of testing operations, a check shall be made that the required safety equipment is used and that personnel have the correct protective clothing.

### **10.2.2 Excavations**

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

### **10.2.3 Filling and testing**

Care shall be taken to fill pipelines with potable water slowly from the lowest point possible whilst all facilities for venting air are open and the pipelines are vented to avoid any air being pressurized and storing energy.

Disinfectant shall be added if required.

Prior to carrying out a pressure test a check shall be made to ensure that the test equipment is calibrated, it is in good working order and correctly fitted to the pipeline. 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 should take into account freezing conditions overnight or excessive heating during the day 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.

## **10.3 Pressure test**

### **10.3.1 Preparations**

#### **10.3.1.1 Backfilling and anchorage**

Prior to the pressure test, the pipes shall, where appropriate, be covered (e.g. with backfill material) such that changes in ground condition, which can be critical to pipeline integrity, are avoided and influence of temperature variance is minimized. Where joints remain uncovered, their tightness and integrity can be determined. However, too much temperature variance can occur so that backfilling over joints shall be considered accordingly. Permanent abutments or anchorages shall be constructed to withstand thrust at the test pressure. Concrete anchor blocks shall be allowed to develop their strength before testing begins.

Care shall be taken to ensure that caps or other temporary blanking fittings are fully 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 depressurised.

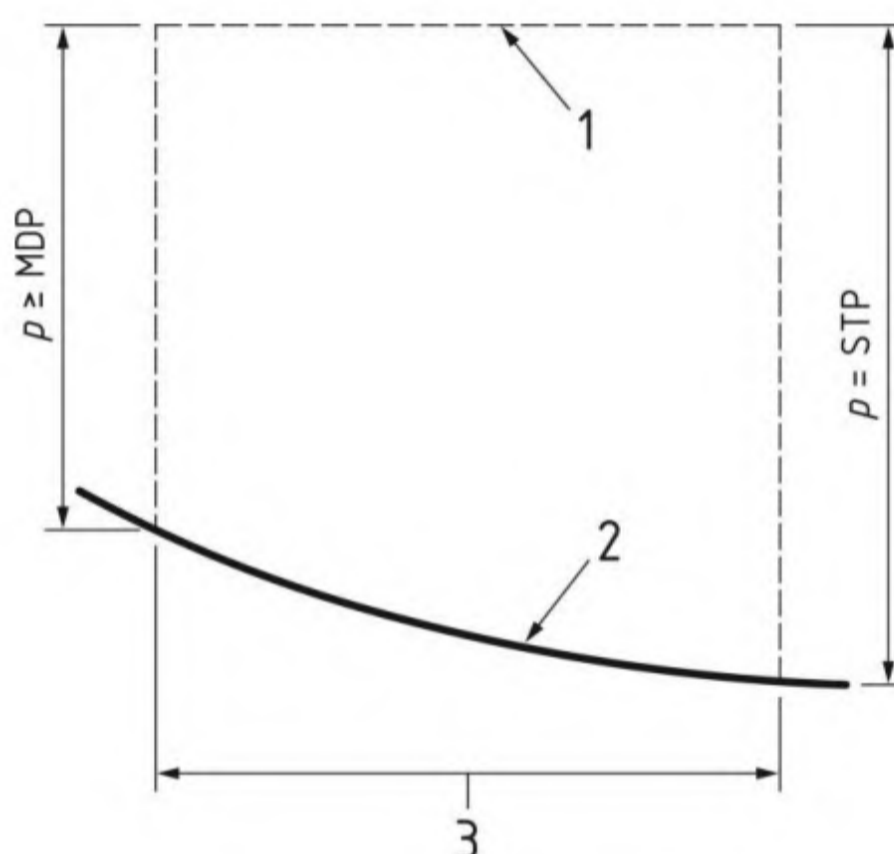
### 10.3.1.2 Selection and filling of the test section

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

Test sections should not exceed 3 km or, respectively, have too large volumes because that can pose unmanageable challenges during testing (e.g. finding leakage, providing test water and disposing of it).

The test sections shall be selected so that:

- the system test pressure (STP) is achieved and not exceeded at the lowest point of each test section as per Figure 4;
- a pressure of at least maximum design pressure (MDP) is achieved at the highest elevation point of each test section unless otherwise specified by the designer as per Figure 4;
- the necessary water for testing can be provided and removed without difficulty;
- care is taken to minimize the influence of changes in temperature where pipe and joints are exposed.



#### Key

- 1 hydrostatic pressure of the test section
- 2 pipeline
- 3 test section

**Figure 4 — Maximum difference in elevation between MDP and STP**

Any debris and foreign matter from inside the pipeline shall be removed before filling and testing. The test sections 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 can escape at facilities for venting.

### 10.3.2 Test pressure

For all pipelines, the system test pressure (STP) shall be calculated by the designer from the maximum design pressure (MDP) as shown in Formulae (5) and (6):

- surge calculated

$$STP = MDP_c + 100 \text{ kPa} \quad (5)$$

— surge non-calculated

$$\left. \begin{array}{l} STP = MDP_a \times 1,5 \\ \text{or } STP = MDP_a + 500 \text{ kPa} \end{array} \right\} \text{whichever is the least} \quad (6)$$

where (according to 3.1.5)

MDP is the designated MDP<sub>a</sub> when there is a fixed allowance for surge;

MDP is the designated MDP<sub>c</sub> when the surge is calculated.

For all pipelines, the test shall be carried out at the system test pressure (STP) in accordance with the requirements in Table 1, ensuring that the maximum test pressure does not exceed  $1,5 \times PFA$  in any of the lowest rated components in the pipeline or test section.

The fixed allowance for surge pressure included in MDP<sub>a</sub> shall be not less than 200 kPa.

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

### 10.3.3 Installation point for testing equipment

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 (STP), calculated for the lowest point of the test section, minus the difference in altitude.

### 10.3.4 Testing at operating pressure with visual inspection

In special cases, with the agreement of the water supplier, short lengths of pipeline or service pipes may be tested by visual inspection only with the operating pressure of the pipeline as the system test pressure (see 10.4.7 for unavoidable cases and 11.2.1 for limits or when using a coiled pipe without joints between its ends).

## 10.4 Testing procedure

### 10.4.1 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 carried out in three steps:

- 1) preliminary test;
- 2) pressure drop test, see 10.4.3 for alternatives;
- 3) main pressure test.

The details of the necessary steps shall be fixed by the designer.

### 10.4.2 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 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 maximum design pressure (MDP) at the highest point unless otherwise specified by the designer and up to the system test pressure (STP) at the lowest point, see 10.3.1.2. Care shall be taken that the pumping pressure at the entrance of the pipeline does not exceed the STP.

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

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

### **10.4.3 Pressure drop test**

Air in the test section of the pipeline can wrongly indicate leakage or, in some cases, mask a small leak, so that the presence of air will reduce the accuracy of the main pressure test. Excessive amounts of air in the pipeline can also constitute safety risks during the pressure test. Therefore, there should be a pressure drop test to determine if there is too much air content.

The pressure drop test enables assessment of the remaining volume of air in the test section. Pigging can be a means to aid the removal of air prior to the pressure test.

The designer shall specify the criteria of the pass/fail of the pressure drop test.

The designer may decide to skip the pressure drop test where the removal of air can be established otherwise by procedure (see 10.1 for applicable filling methods) and design, for example if the test section has:

- gradients, for example  $\geq 2$  mm/m;
- ventilation devices at all high points;
- no components prone to retaining cushions of air.

### **10.4.4 Main pressure test**

#### **10.4.4.1 General requirements**

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

Influences of temperature changes during the pressure test shall be taken into account. There are two basic test methods:

- pressure loss method;
- water loss method.

#### **10.4.4.2 Pressure loss method**

The pressure loss  $\Delta p$  and its development provide an indication of any leakage and water tightness.

The duration of the pressure loss test shall be 1 h or a longer period unless specified otherwise by the designer. During the main pressure test the pressure loss  $\Delta p$  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, plastic pipes;
- 40 kPa for non-cylinder concrete pipes.

#### 10.4.4.3 Water loss method

Two equivalent methods of measurement of the water loss can be used:

- a) measurement of the water volume drawn off;
- b) measurement of the water volume pumped in.

The designer shall specify which method is to be used.

#### 10.4.5 Depressurization

Pipelines shall be depressurised slowly and all facilities for venting shall be open when emptying pipelines to avoid negative pressures and pipeline collapse.

#### 10.4.6 Test evaluation

If any loss of pressure or water exceeds specified limits or if faults are identified, the pipeline shall be examined and rectified where necessary. The test shall be repeated until any loss complies with that specified.

#### 10.4.7 Final system test

Where a length of pipeline has been divided into two or more sections for pressure testing and all the sections have been tested satisfactorily, 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 (see also 10.3.4).

#### 10.4.8 Recording test results

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

### 11 Preparation for commissioning

#### 11.1 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 flushed and, where necessary, disinfected.

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.

All equipment used for flushing and disinfection operations shall be suitable for use in contact with potable water.

For flushing, the designer shall specify the velocity, the minimum period of time and whether or not air injection or pigging is to be used.

#### 11.2 Preparation for disinfection

##### 11.2.1 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. It is permissible not to separate the pipeline, where short lengths are laid, for service pipes of  $DN \leq 80$  and length not exceeding 100 m, unless otherwise specified by the designer. In these cases, care shall be taken that no migration of water from the disinfected section to the operational system can occur.

### **11.2.2 Disinfection equipment**

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

### **11.3 Selection of disinfectant**

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, for example pH values and in the case of calcium hypochlorite the hardness of the water (see 4.1.1 and A.25).

Recommendations for suitable disinfectants, maximum concentrations, limitations of use and neutralizing agents are given in Table A.9.

### **11.4 Disinfection procedures**

#### **11.4.1 General requirements**

The following methods for disinfection are permissible:

- 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.

#### **11.4.2 Static procedure**

Disinfection shall be carried out 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 the section to be disinfected shall be physically separated from the operational water supply system. In exercising this option, the designer shall take due regard of the environmental damage which can occur due to accidental release of disinfection solution.

#### **11.4.3 Dynamic procedure**

Disinfection shall be carried out 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.

#### **11.4.4 Disposal of disinfectant**

The disinfection solution shall be disposed of without harm to the environment. Where necessary, a neutralizing agent shall be used (see A.25).

### **11.5 Microbiological clearance and reporting**

Following the disinfection contact period, the section shall be flushed as many times as necessary to ensure that potable water quality is reached.

When the section is filled with potable water from the system, samples at positions and time intervals as specified by the designer shall be taken, taking into account 4.1.1. These samples shall be analysed for microbiological compliance as specified (see 4.1.1). If the results are satisfactory, the section shall be connected as soon as possible to the water distribution system to avoid any risk of recontamination.

If the results are unsatisfactory, a new disinfection procedure shall be carried out until microbiological clearance is achieved and before operation is commenced.

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

## 12 Additional requirements

The following additional requirements shall be fulfilled:

- 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 operation of the system, for example:
  - a) instructions for operating, servicing and functional checks of components;
  - b) measures against extremes of temperature;
  - c) measures against corrosion or contamination;
  - d) measures for pipelines which have low flow to avoid stagnation;
  - e) measures to maintain the quality of the water.

## 13 Operation

### 13.1 Inspection and monitoring

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;
- level of water losses in accordance with the relevant benchmarking index (e.g. Infrastructure Leakage Index);
- water quality, pressure, flow;
- customer contacts and complaints of failures in customer service and water quality;
- traffic loads, bedding conditions, soil quality, external forces;

— material of pipes, joints and other components.

### **13.2 Maintenance**

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

Plans for the future maintenance, including renovation, replacement and refurbishment of all parts of the water supply system shall be drawn up. Information on asset management can be found in ISO 24516-1 [2] and ISO 55000 [5] or local requirements.

## **14 Updating of the documentation**

All records shall be updated when changes are made with details of all principal components such as valves and hydrants. If required, new service pipes shall be included.

## Annex A (informative)

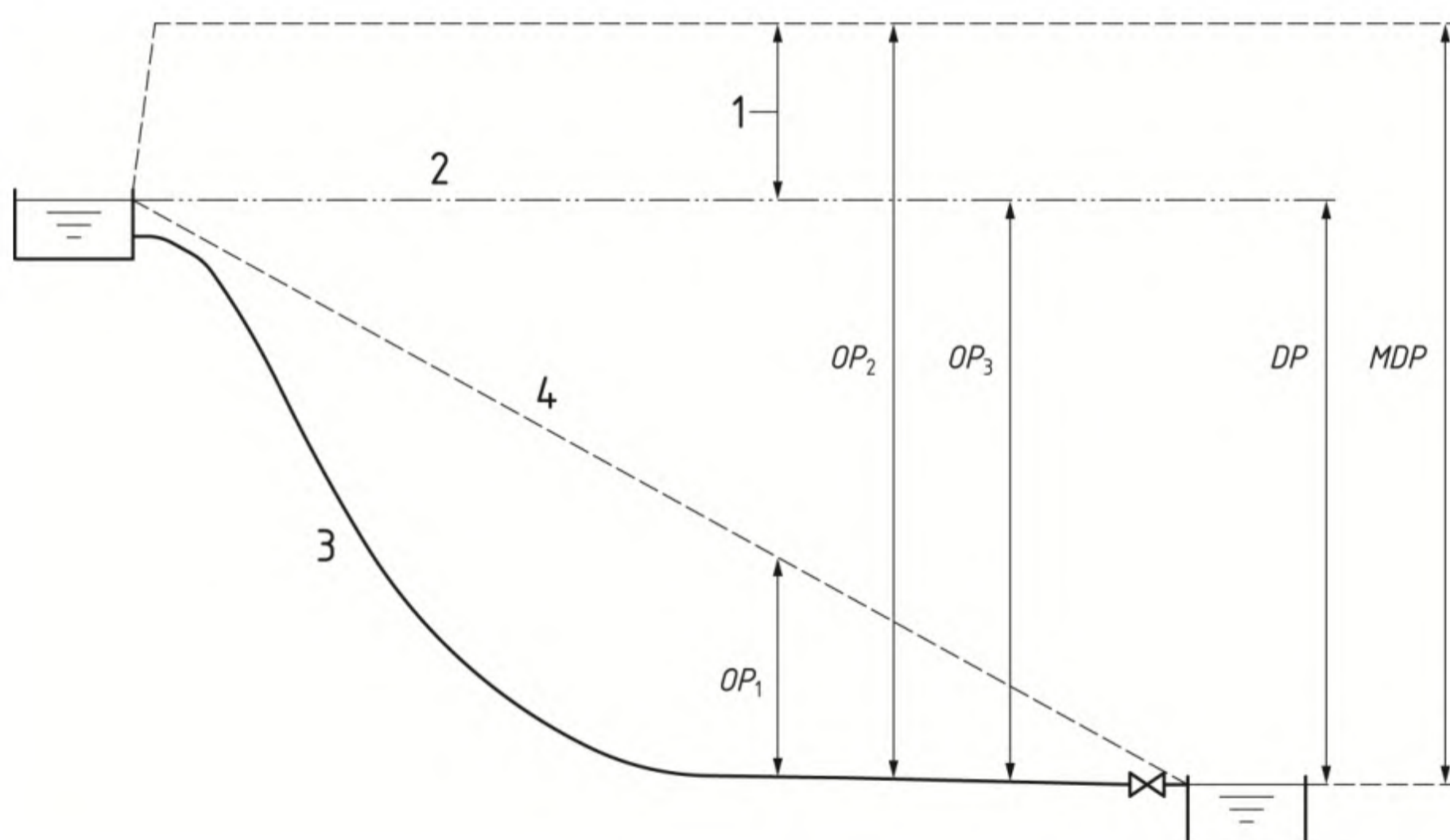
### Guidance to EN 805

#### A.1 General

This annex provides information on the application of this document in conjunction with other aspects that the designer identifies, taking into account the information given in 4.1.1. Details given in this Annex are intended to give guidance on the criteria to be considered. Alternative techniques can be applied where an improved design will result or where existing procedures are known to give satisfactory results.

#### A.2 Pressures

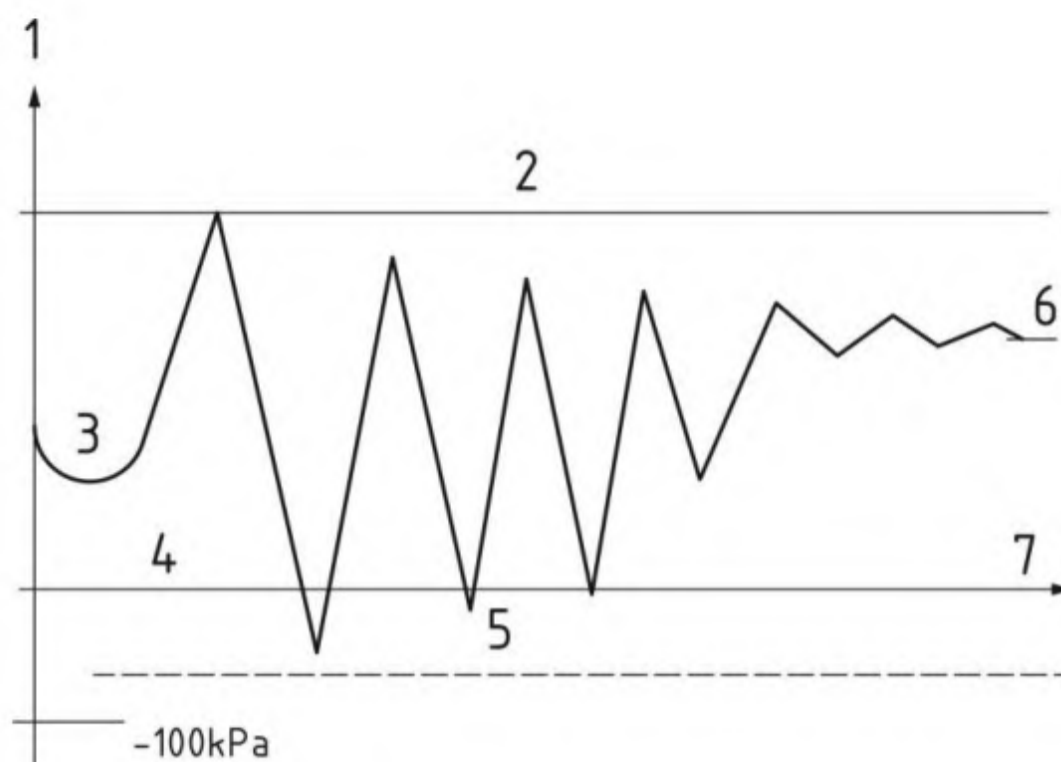
Surge is mainly related to flow velocity and not to internal pressure (see Figures A.1 and A.2).



#### Key

- 1 surge
- 2 no flow hydraulic gradient
- 3 pipeline profile
- 4 hydraulic gradient
- $OP_1$  operating pressure at flow conditions
- $OP_2$  operating pressure at static conditions (no flow) with surge
- $OP_3$  operating pressure at static conditions (no flow)

**Figure A.1 — Example of pressurized gravity main**

**Key**

- 1 pressure
- 2 MDP (maximum design pressure)
- 3 initial OP (operating pressure)
- 4 atmospheric pressure
- 5 saturated vapour pressure
- 6 new OP (operating pressure)
- 7 time

**Figure A.2 — Example of surge wave****A.3 Prevention of back siphonage**

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

**A.4 Water demand estimates**

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

In the absence of detailed flow measurements or historical data the average daily demand can 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 are made for other uses for example street cleaning, 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 can be taken as being between 120 and 150 l per person per day depending on social and climatic conditions excluding specific industrial demands. Future population changes can be taken into account together with any predicted variations in per capita consumption.

Allowances can be made for industrial demand and other special features.

**A.5 Water for firefighting**

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

## A.6 Service objectives

Service objectives concerning the duration of interruptions and their frequency can be achieved by providing trunk mains and associated service reservoir capacity, standby arrangements or alternative supplies.

## A.7 Peak flow factors

Where no better information in local guidelines is available the multiplying factor for the peak day can be assumed to vary from  $1,5 \times$  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 can range from twice the average hourly rate in that day for over 10 000 people to more than  $5 \times$  the average for less than 2 000. Where consumer storage is provided the peak hour flow factors can be significantly lower than those suggested above.

Industrial and other special demands will also influence flow factors.

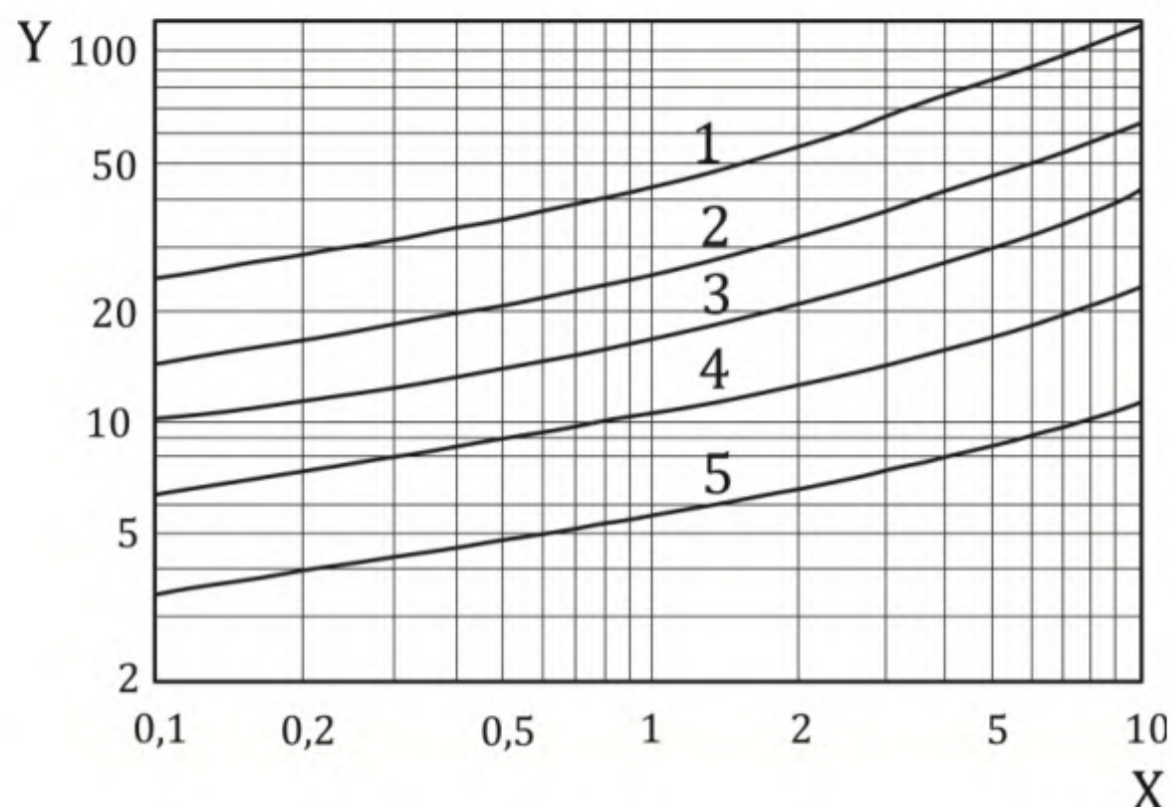
## A.8 Sizing

The capacity and flow requirements of the various system components are given 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 are not always required to meet full peak flow rates.

## A.9 Hydraulic roughness value

The design roughness value  $k_2$  will normally lie between  $0,1 \times 10^{-3}$  m and  $0,4 \times 10^{-3}$  m for trunk and principal mains and between  $0,4 \times 10^{-3}$  m and  $1,0 \times 10^{-3}$  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**

x	pressure loss (kPa)
y	roughness value ( $\text{m} \times 10^{-3}$ )
1	D = 100 mm
2	D = 150 mm
3	D = 200 mm
4	D = 300 mm
5	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)**

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.10 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 can be considered appropriate. However, in special circumstances velocities up to 3,5 m/s can be acceptable. For pumping mains, a financial appraisal can 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.11 Network analysis

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

The objectives of the analysis are clearly identified as they will determine the type of model useful in terms of the details included and whether to use a static (snapshot or point in time) or a dynamic (simulation) model.

The basic data used for modelling are as follows:

- record drawings of system;
- pumping station and reservoir details;
- locations of installed flow meters;
- current and anticipated water usage that includes adapting to weather patterns and extreme events due to climate change and other environmental impacts;
- pipework materials, class and roughness;
- details of operating and other conditions.

Models are 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 is done for a 24 h simulation period.

## A.12 Local mains

Since the population served will be small there is an increased 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 firefighting, Table A.1 can be used to determine the size of mains for domestic developments serving less than 250 persons. The table is based on the assumption that the mains are supplied from one end only.

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

DN	Suggested number of persons
50 <sup>a</sup>	30
80	100
100	250
<sup>a</sup> Providing the length of main does not exceed approximately 100 m.	

The sizes given in Table A.1 can 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 are determined by calculation.

## A.13 Mains

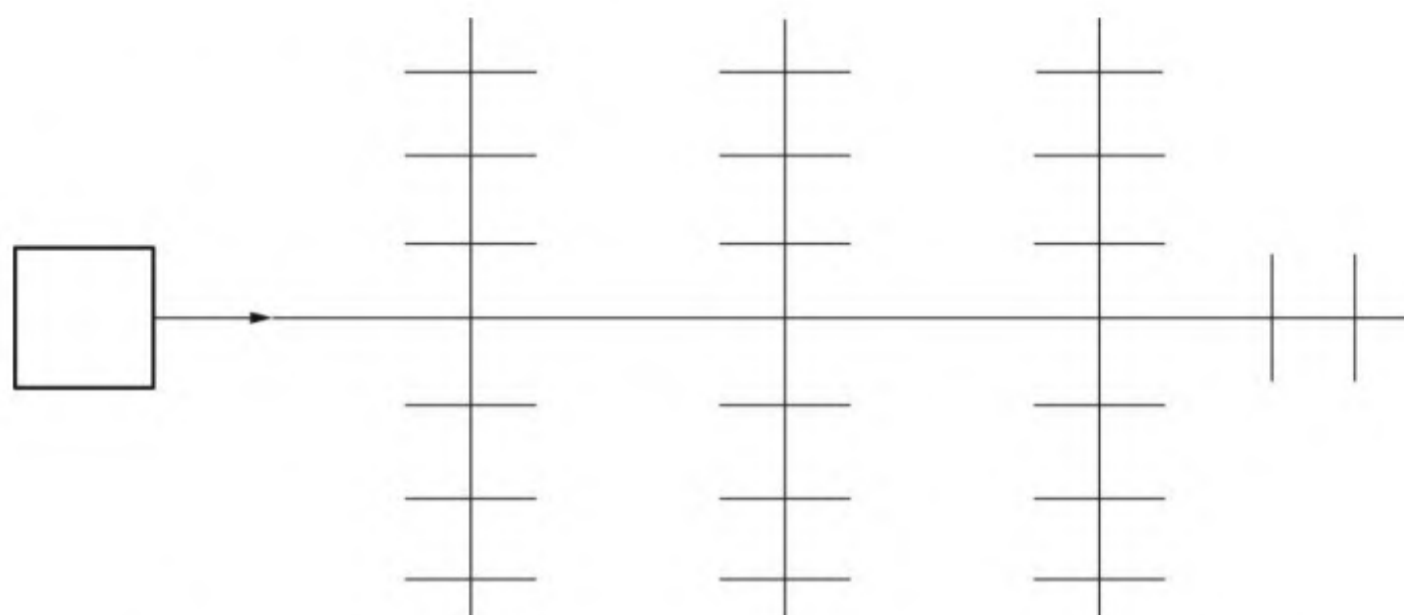
Arrangements for entry onto private land will vary according to local legislation and the policy of the water supplier. Wherever possible, the construction of buildings and other structures or changes in ground level are avoided within a specified distance of the main for at least the lifetime of the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

The well-proven minimum gradient is 1/500.

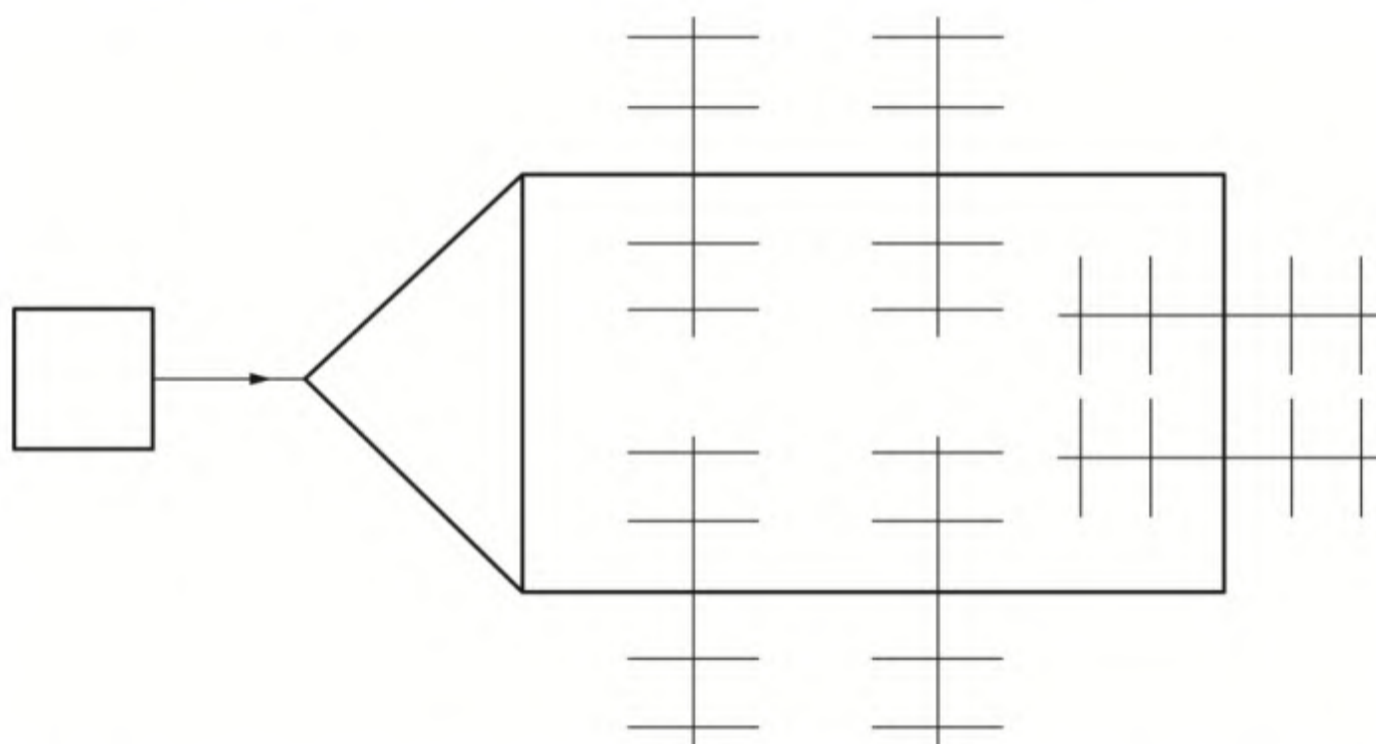
Whenever possible mains are located to allow easy vehicular access for repair and maintenance. Mains running parallel to or crossing foul or combined sewers are located at higher levels. If this is not possible precautions are taken to preclude ingress of contaminated water to the main.

## A.14 Types of system configuration

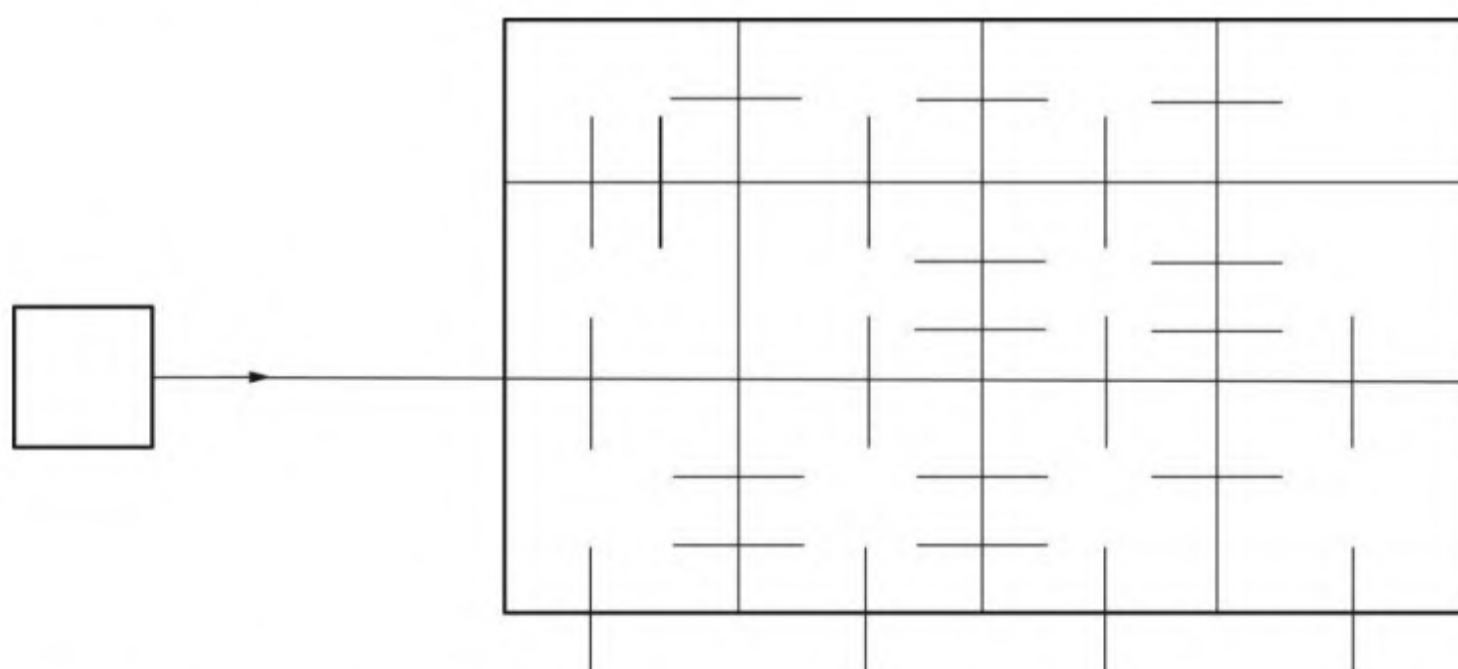
For types of system configuration see Figure A.4.



a) Example of linear main with individual branch mains



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



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

Figure A.4 — Examples of system configuration

Whenever practical and economical, ring systems with interconnected branches are employed. The use of linear arrangements is 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 shutdown can be limited by valve operation with flow in both directions; however, flow reversals can give rise to discoloured water;
- unusual high demands can more easily be met;
- maintenance of supply is improved in the event of firefighting.

### A.15 Service pipes

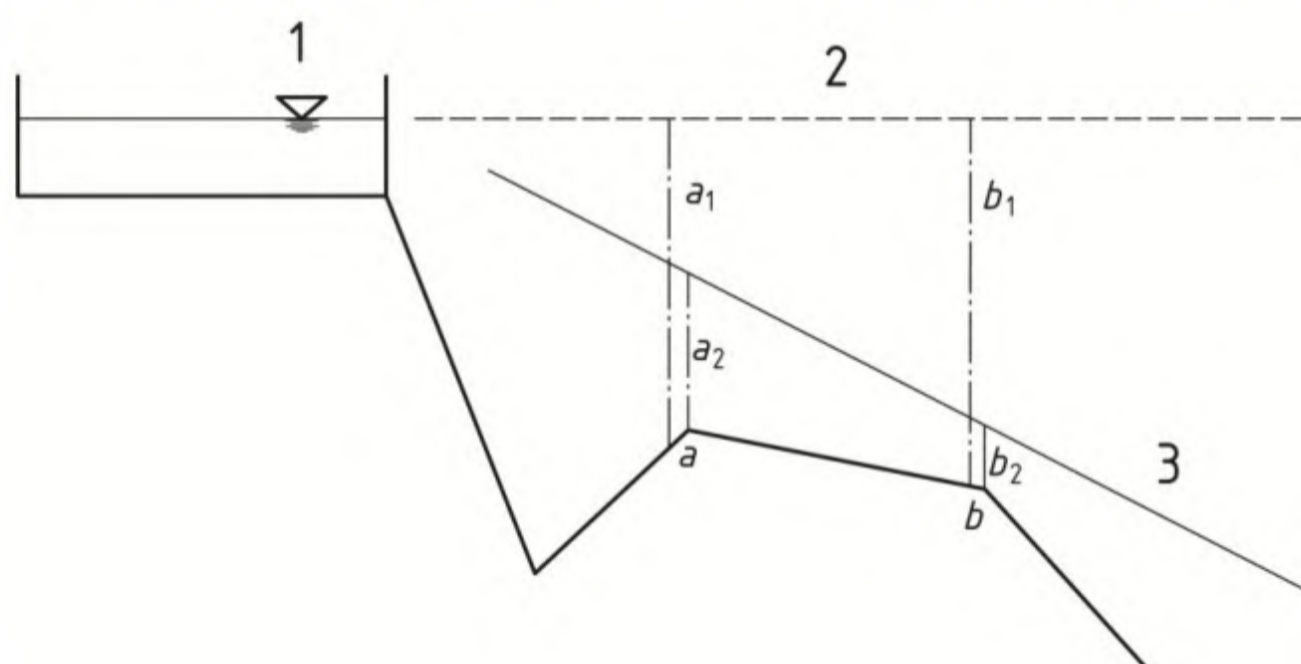
The path taken by the pipe is chosen to ensure that pipe installation is unobstructed, that the pipe remains accessible and is easy to monitor.

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

Service pipes are not used as a means of electrical earthing.

### A.16 Entry and release of air

Air collects at high points, the location of which can change depending on the variation of the hydraulic gradient, see Figure A.5. Air valves incorporating isolating valves are 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.17 Draining

The discharge diameter does not normally exceed DN 200.

## A.18 Isolation

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

Valve location and metering installation are chosen to facilitate leak detection procedures.

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

For trunk mains where man entry can be useful, manways are provided to allow access with a maximum traverse of 500 m. Risk of extensive damage due to a broken main can be reduced by the use of control valves actuated by flow measurement or telemetered control systems.

The distance and location of shut-off valves are fixed according to local conditions.

In general, the intervals between shut-off valves do 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.19 Hydrants

Where hydrants are installed on trunk mains or principal mains, isolating valves are usually provided.

Consideration is given to avoiding stagnation at hydrants.

## A.20 Protection against aggressive environment

Protective measures 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, can have adverse effects upon:

- the quality of potable water (by permeation of organic substances through the pipeline walls);
- the properties of some plastic 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 are taken into consideration by the designer:

- change vulnerable materials 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.21 Pumping stations

Consideration of; the range of each pump duty, the installation of a combination of pumps, either operating in series or parallel, the application of variable speed units can all be useful. The duplication of pumping units and other equipment is considered where continuity of supply can be affected by breakdowns and maintenance work. At important sites, standby capacity is provided to safeguard supplies in the event of power failure. At other sites, the availability of mobile generators can be sufficient.

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

Delivery main valves are 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, there is a possibility that such isolation valves are not always appropriate. Automatically closing or non-return valves can be used, but consideration is given to the effects of rapid closure.

## A.22 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 materials. 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 <sup>b</sup>	C <sup>b</sup>	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 %	-	-	-		C	C	RT <sup>e</sup> or <sup>d</sup>	RT <sup>e</sup> or <sup>e</sup>	C <sup>e</sup>	C <sup>e</sup>	C <sup>e</sup>	C <sup>e</sup>
Strain chemical resistance	-	-	-		-	-	-	RT	-	-	-	-
Compressive strength	-	-	RT <sup>c</sup>	C	-	-	-	-	-	-	-	-
Ring tensile strength	RT	C	-	-	C	C	T	T	C	C	C	C
Longitudinal bending strength	RT <sup>a</sup>	C <sup>a</sup>	-	-	C	C <sup>a</sup>	-	-	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 <sup>f</sup>	-	-	-	-	-	-	-	-	-
S short-term value	T		test method to be indicated		-		no information necessary					
L long term value	RT		requirement and test method to be given									
C characteristics only to be given	SR		standard reference to be given									
<sup>a</sup> depending on diameters	<sup>b</sup> sometimes		<sup>c</sup> for concrete depending on process									
<sup>d</sup> ultimate	<sup>e</sup> allowable		<sup>f</sup> cement admixtures, aggregates, steel, water additives									

## A.23 Testing of non-viscoelastic pipelines (metals, concrete, GRP)

### A.23.1 General

Every pipeline undergoes a water pressure test to ensure the integrity of pipes, joints, fittings and other components such as anchor blocks.

Test mediums other than potable water (plus disinfectants, where necessary) are not used.

The following description is applicable to metallic (ductile iron or steel) pipelines with any kind of lining, such as cement mortar lining. It takes into account that push-in joints, restrained push-in joints, flanged joints and welded joints installed in a pipeline, have different behaviours during the pressure testing procedure (for example displacement, anchorage).

It is applicable in analogy to other non-viscoelastic (for example concrete or glass-reinforced plastic GRP) pipelines, taking into account differences in lining, joining or other features. Figure A.6 provides a flowchart of the pressure testing procedure.

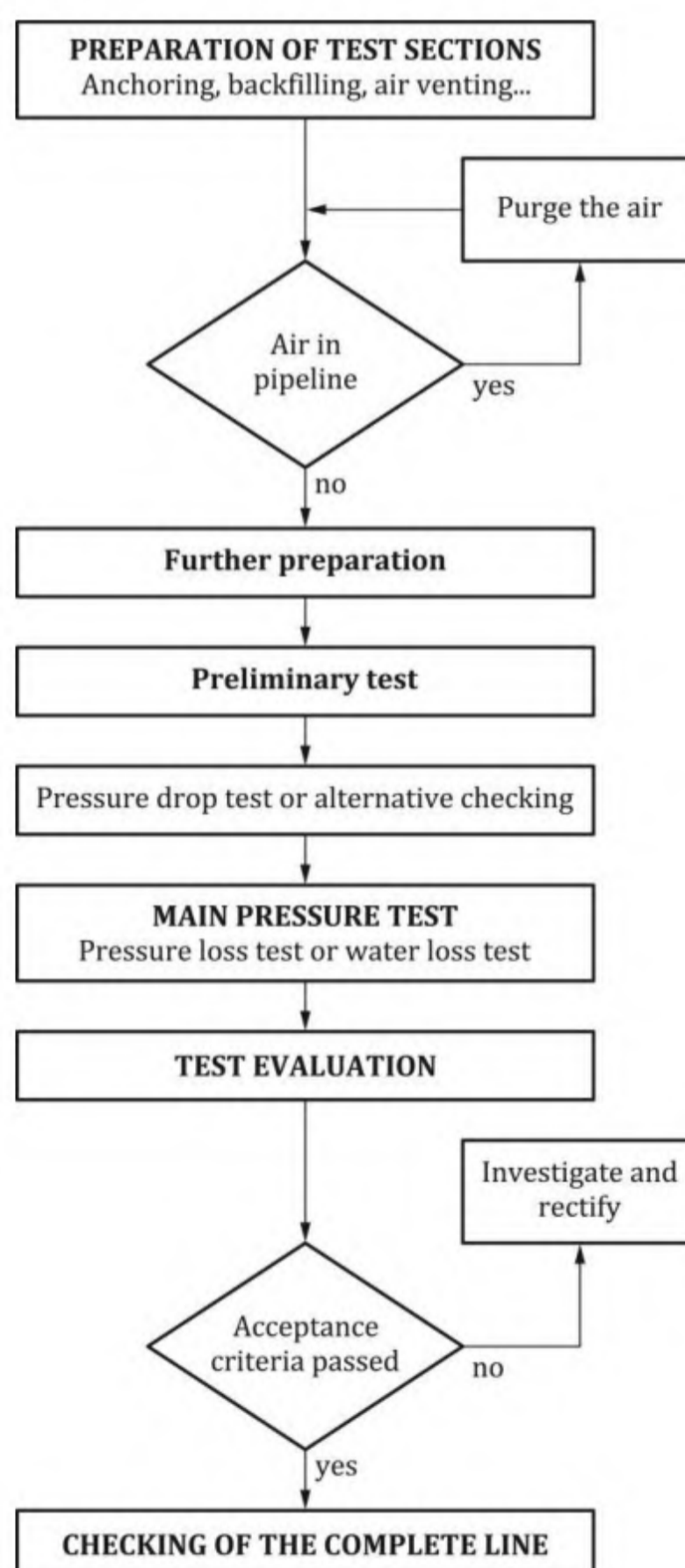


Figure A.6 — Flowchart of the pressure testing procedure

### A.23.2 Safety

Related to personnel, the following issues are taken care of:

- at all stages of testing, the planned procedure and any possible variation of it are carried out in a way to avoid danger to personnel;
- all personnel are clearly informed of the intensity of the loading on temporary fittings and supports and the consequences if failure occurs;
- where disinfectants are used, all personnel are clearly informed of their appropriate handling;
- prior to the commencement of any pressure testing procedure, a check is made so that the appropriate safety equipment is available and that personnel have the correct protective clothing.

Related to construction of pipelines and any associated works, the following issues are taken care of:

- permanent abutments or anchorages are constructed to withstand thrust at the test pressure;
- concrete anchor blocks are allowed to develop strength before testing begins;
- caps or other temporary blanking fittings are anchored, with the load distributed according to the strength of the supporting ground. Gate valves, fire hydrants, water hammer release equipment or safety valves are not used as blanking fittings;
- any temporary supports or anchorage at the ends of the test section are not removed until the test section has been depressurized;
- after completion of construction and up to backfilling, all excavations remain guarded. Any activity not related to pressure tests is not carried out in pipe trenches during pressure tests;
- during the application of pressure, the pipe trench and its surroundings are guarded with a safety distance. Only competent personnel enter the guarded area, where necessary, to perform their specific duties.

Related to test equipment, it is checked prior to carrying out a pressure test, if it is calibrated, in good working order and correctly fitted to the test section.

During the test, the following issues are taken care of:

- air is exhausted from the test section as fully as reasonably possible. Filling takes place slowly from, if possible, the lowest point in the test section and in such a way as to prevent back siphonage and so that air can escape at facilities for venting;
- the test section is filled with water slowly whilst all facilities for venting are open and the test section is vented;
- water used for testing is disposed of properly without flooding or adversely affecting the work site.

### A.23.3 Preparation of a test section

#### A.23.3.1 General

The length of test sections is determined on the basis of the following considerations:

- local conditions (concerning access for example);
- availability of suitable water;

- number of fittings and accessories (e.g. valves, hydrants, etc.);
- difference in elevation between different parts of the test section;
- existence of restrained joints.

Test sections are selected so that:

- the typical length of a test section does not exceed 1 500 m;
- the system test pressure STP can be built up in the specified time;
- the system test pressure STP is achieved at the lowest point of each test section;
- a pressure of at least maximum design pressure (MDP) is achieved at the highest elevation point of each test section (see Figure 4 for an illustration of a pressure profile).
- where supply systems operate with pumps, the system test pressure STP takes into account the pump pressure in addition to the operating pressure;
- the necessary water for testing can be provided and removed without difficulty;
- the influence of changes in temperature is minimized where pipe and joints are exposed, in particular when weather conditions cause freezing or excessive heating.

In the event of partial locking of fittings with pipes to ensure self-anchoring, locked areas can be tested together with unlocked areas. In case of a completely locked section, provision is made to allow the pipe to pull under pressure. The ends of these sections are not stopped.

Any debris and foreign matter are removed from the test section before testing.

#### **A.23.3.2 Anchoring and closures**

Isolation of test sections is achieved by using blank flanges or equivalent types of closures.

Hydraulic loads exerted on the ends of the test section are evaluated. Anchors are set up, where necessary, so as to absorb the loads in timbers buried across the trench or in sheet piling.

All changes in direction and/or cross-section of the test section, such as bends, tees, tapers (reducers) and blank flanges, are fully restrained (or anchored) before testing by means of thrust blocks or restrained (self-anchoring) joints.

Other components such as gate valves, fire hydrants, water hammer release equipment or safety valves are not used instead of blank flanges. If for practical reasons, valves are used as closure pieces, their rated pressure (PN or PFA) will not be lower than the system test pressure STP.

The thrust force on a pipeline closure (such as blank flanges) is increasing with the square of the diameter. Table A.3 provides examples of thrust forces generated by a pressure of 1 bar on pipeline closure as follows:

- thrust force calculated:  $F = (P \times \pi \times D^2) / 4$

where

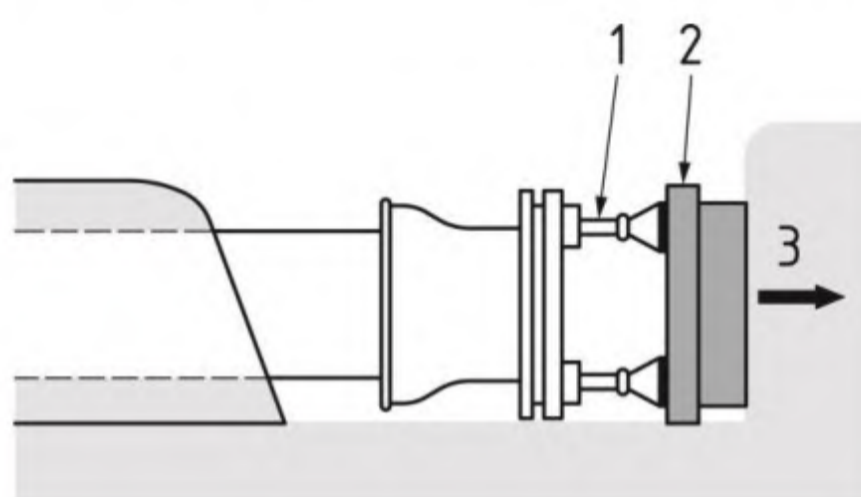
$P$  is the pressure in bar;

$D$  is the outer diameter in cm for socketed pipes/fittings, or the inner diameter for not-socketed pipes/fittings.

**Table A.3 — Examples of thrust forces generated by a pressure of 1 bar on socketed pipeline closure**

DN	F in daN	DN	F in daN	DN	F in daN	DN	F in daN	DN	F in daN
60	47	250	590	600	3 167	1 200	12 370	2 200	41 115
80	75	300	835	700	4 278	1 400	16 787	2 400	48 891
100	109	350	1 122	800	5 568	1 500	19 236	2 600	57 340
125	163	400	1 445	900	7 014	1 600	21 851		
150	227	450	1 809	1 000	8 626	1 800	27 612		
200	387	500	2 223	1 100	10 405	2 000	34 045		

In order to compensate possible subsidence, screw jacks can be used (see Figure A.7).

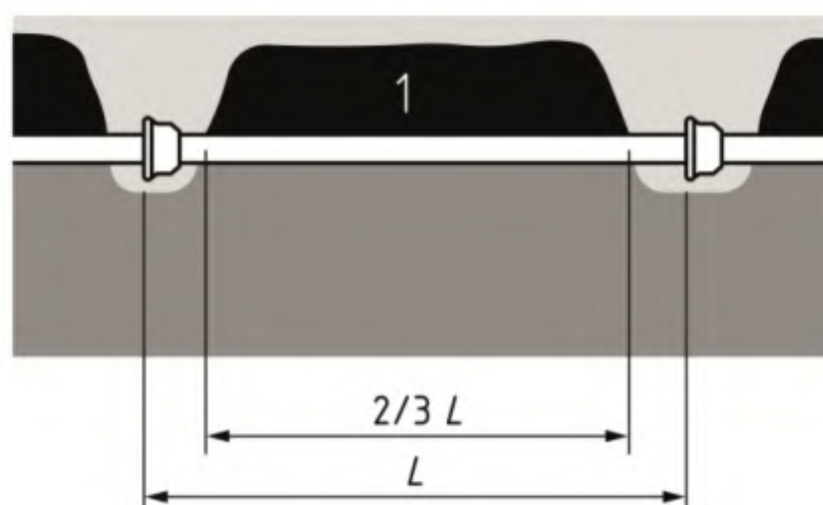
**Key**

- 1 screw jacks
- 2 thrust block
- 3 thrust force

**Figure A.7 — Example of anchoring with jacks****A.23.3.3 Partial backfilling**

Test sections are normally partially backfilled leaving pipe joints accessible for inspection. Only if too much temperature variance can occur backfilling over joints or another covering will be considered.

Backfill material is applied to prevent movement of the test section (see Figure A.8). In particular, restrained-joint parts of the test section, which derive their stability from their interaction with the soil, are backfilled prior to testing.

**Key**

- 1 backfill
- $L$  standardized length of pipe

**Figure A.8 — Partial backfilling before testing**

#### A.23.3.4 Filling with water and air venting

The test section is completely filled with water and air vented. The pressure is raised up to Operating Pressure (OP), without exceeding the system test pressure (STP). The ends of the test section are blocked, usually with blank flanges fitted with venting valves.

The pumped water can contain air that will, over a period of time, leave the solution. If vented, the volume previously occupied by the air can be replaced by water and, in doing so, the pressure can decrease. The kinetics of dissolution of air in water is a function of many parameters, in particular:

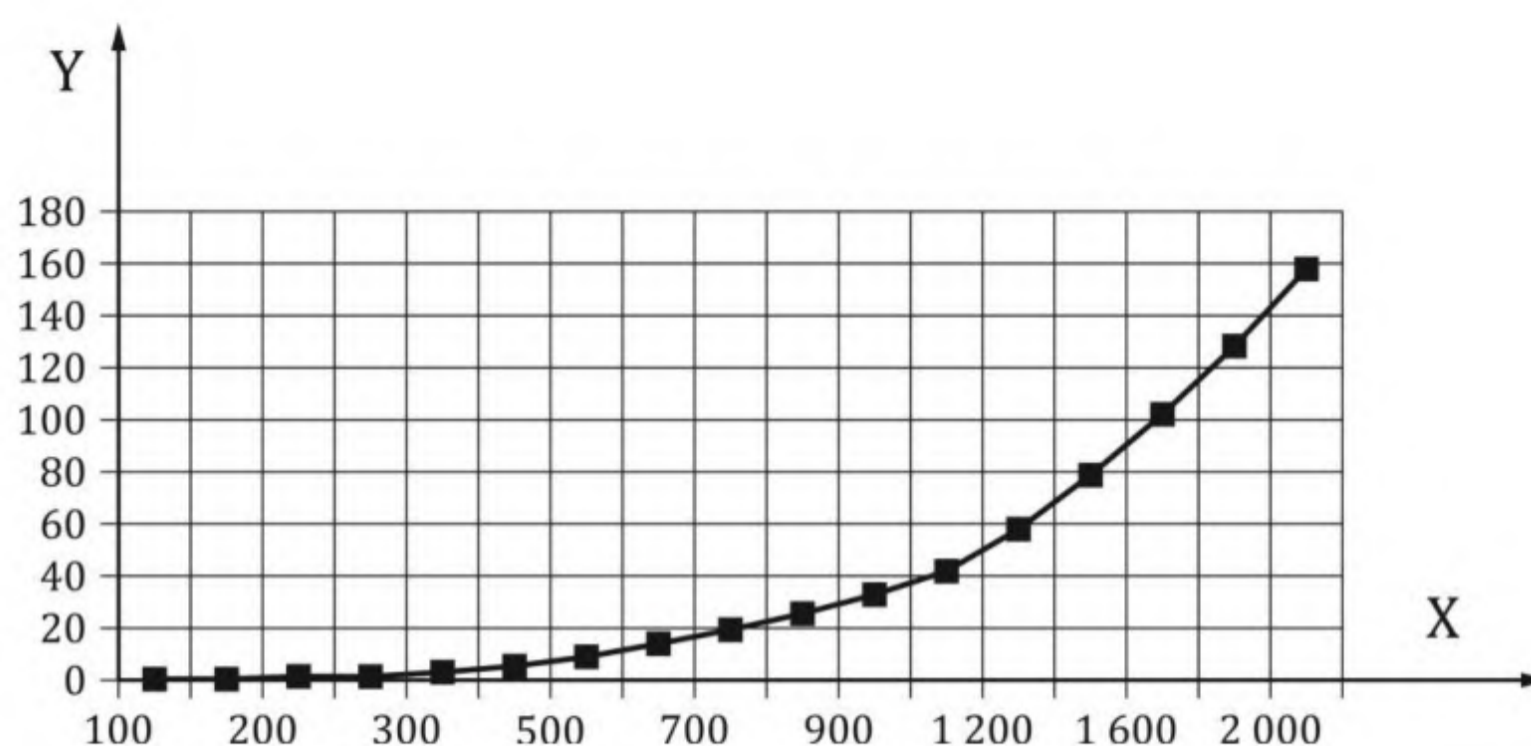
- the initial saturation level of the pumped water;
- the water temperature (the amount of dissolved air decreases with increasing temperature);
- water pressure (the amount of dissolved air decreases with decreasing pressure);
- the location of air pockets;
- the dimension of the interface zones between air and water.

The test section is filled slowly, with open ventilation devices, from the lowest point, so that no back siphonage occurs and the air can escape through the ventilation devices. Too fast filling can cause trapped air cushions.

The full air valve inspection is made by checking that each automatic air valve and any manual air valve does not release any further air.

In the case of varying elevation without ventilation at all high points, pigging can be applied, particularly if even higher filling speeds cannot help to remove air.

Figure A.9 indicates typical filling flow rates.

**Key**

X pipe DN

Y filling flow rate in litre/second

**Figure A.9 — Typical filling flow rates**

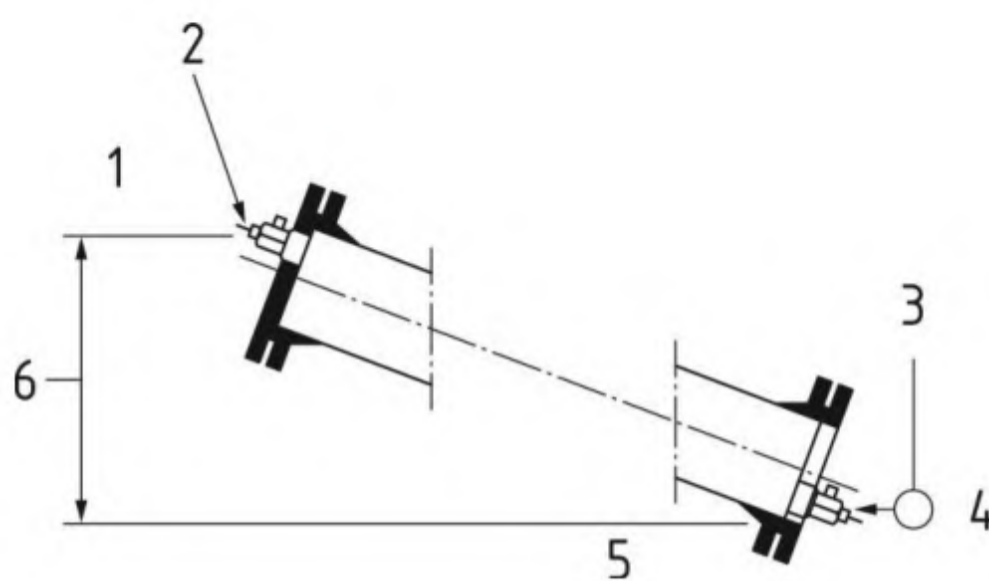
The absorption of water by cement mortar lining takes time, depending on air humidity before filling, temperature, the thickness of the lining and its texture.

After filling and before starting the preliminary test, the test section is maintained at operating pressure OP as long as necessary for stabilization with respect to possible line movement and water absorption (can be 24 h or even longer).

All exposed joints, fittings, anchorages and closures are inspected visually. Any defects discovered at this point are repaired, after draining the test section, where necessary.

**A.23.4 Pressure testing procedure****A.23.4.1 General**

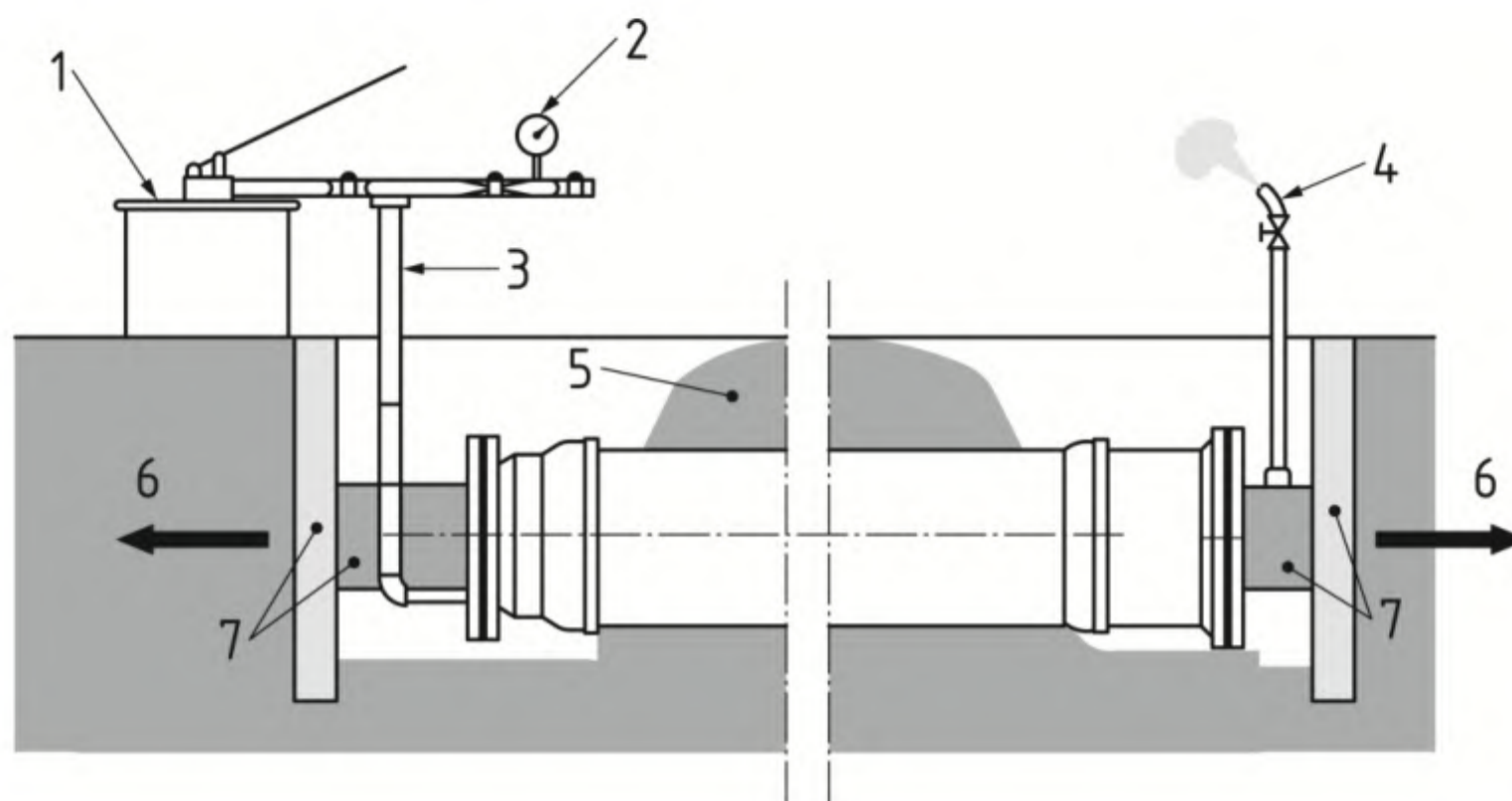
The test pressure is the system test pressure, calculated for the lowest point of the test section. If possible, a calibrated pressure meter with range relevant to the STP is installed at the lowest point of the test section (see Figure A.10).

**Key**

- 1 higher end
- 2 air vent
- 3 test pump and pressure meter
- 4 applicable pressure (STP)
- 5 lower end
- 6 altitude between higher and lower end

**Figure A.10 — Filling and applicable pressure**

Typical components for pressure testing are shown in Figure A.11.



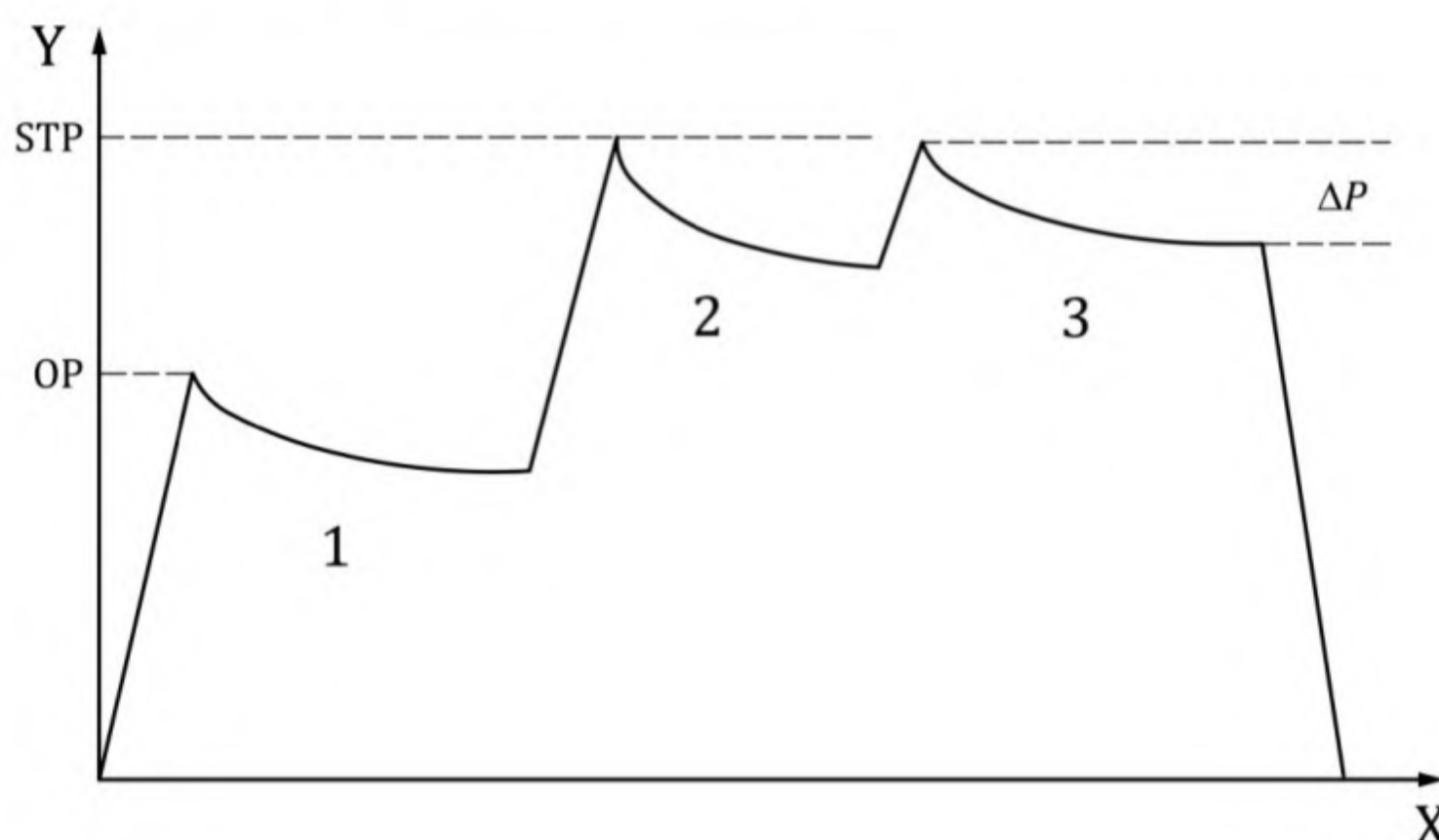
**Key**

- 1 test pump
- 2 pressure gauge
- 3 pump connection
- 4 air vented
- 5 backfill
- 6 thrust force
- 7 anchor system

**Figure A.11 — Components for pressure testing**

Considering the preparation in accordance with A.23.3 as a first separate step, testing is carried out in two further steps (see Figure A.12) or three further steps as following:

- the preliminary test;
- the pressure drop test, if not skipped by the designer in accordance with 10.4.3;
- the main pressure test (pressure loss test or water loss test).



#### Key

- X time (hours)
- Y pressure (bars)
- 1 preparation (up to 24 h or longer)
- 2 preliminary test (1h or longer)
- 3 main test (1h or longer)

**Figure A.12 — Steps in the testing procedure, including preparation, with alternative check instead of the pressure drop test (see also Figure A.6)**

#### A.23.4.2 Preliminary test

When the visual inspection in accordance with A.23.3.4 is satisfactory, pressure is raised steadily until the system test pressure (STP) is attained, in order to further stabilize the test section. The duration of the preliminary test and the need for repumping to hold up pressure depends mostly upon the further absorption of water as in A.23.3.4.

The system test pressure (STP) is calculated from the maximum design pressure (MDP) as follows:

- surge calculated:  $STP = MDP_c + 100 \text{ kPa}$
- surge non-calculated: (whichever is the least)
- $STP = MDP_a + 500 \text{ kPa}$
- $STP = MDP_a \times 1,5$

where

MDP is designated  $MDP_a$  when there is a fixed allowance for surge;

MDP is designated MDP<sub>c</sub> when the surge is calculated.

The test pressure does not normally exceed the maximum test pressure (PEA) of any component (pipes, fittings, flanges, valves and other accessories), nor the design pressure of any restraining device. The test pressure at the highest point of the test section is not less than the MDP at this point.

Temperature variation can affect the pressure inside the test section. This effect is minimized by ensuring that the start and end temperatures of the pipe wall at each step of the testing procedure, most importantly for the main pressure test, are approximately the same.

A pressure drop test is done to determine if there is too much air content, if not skipped by the designer in accordance with 10.4.3 to make an alternative check.

#### A.23.4.3 Pressure drop test

After successful completion of the preliminary test, all ventilation devices of the test section are closed and all isolating valves within the test section are left open from now on.

The pressure in the test section is raised to the system test pressure STP, taking care that venting of the test equipment takes place.

A volume of water  $\Delta V$  is removed from the test section and measured. The resultant pressure drop  $\Delta p$  is also measured.

The removed volume of water  $\Delta V$  is compared with the allowable water loss  $\Delta V_{\max}$  corresponding to the measured pressure drop  $\Delta p$ . The pressure drop test is successful if  $\Delta V \leq \Delta V_{\max}$ .

The allowable water loss  $\Delta V_{\max}$  is calculated by using Formula A.1:

$$\Delta V_{\max} = 1,5 \times V \times \Delta p \times \left( \frac{1}{E_w} + \frac{D}{e \times E_R} \right) \quad (\text{A.1})$$

where

- $\Delta V_{\max}$  is the allowable water loss in litres;
- $V$  is the volume of the test section in litres, calculated with the internal pipe diameter  $D$ ;
- $\Delta p$  is the measured pressure drop in kilopascals;
- $E_w$  is the bulk modulus of water in kilopascals;
- $D$  is the internal pipe diameter in metres, without taking into account cement mortar lining,  $D = ID$ , see 3.4.2;
- $e$  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 allowance factor for unavoidable air content, axial movement, absorption by cement-mortar lining etc.

#### A.23.4.4 Main pressure test

##### A.23.4.4.1 General

After successful completion of the preliminary test and the pressure drop test, the pressure is raised steadily until the system test pressure (STP) is attained.

Stabilization phenomena can continue, causing pressure variations without necessarily implying any leakage. These phenomena can mainly be due to:

- increasing volume of the test section due to longitudinal or lateral movements of joints;
- presence of unremoved air in the test section;

- dissolution in the water of the air still present in the test section;
- temperature variations.

The main pressure test will be done in accordance with the decision of the designer (either pressure loss test method according to A.23.4.4.2 or water loss test method according to A.23.4.4.3).

#### A.23.4.4.2 Pressure loss test

Having attained the system test pressure (STP), the duration of the pressure loss test is 1 h. The pressure loss is directly read. The pressure loss  $\Delta p$  will display a regressive tendency and not exceed 20 kPa after 1 h, if the pipeline is tight, see also 10.4.4.2.

#### A.23.4.4.3 Water loss test

A further choice is made in accordance with the decision of the designer:

- a) Measurement of the water volume drawn off.
  - Having attained the system test pressure (STP), STP is maintained by pumping, if necessary, for a period of not less than one hour.
  - The pump is disconnected, and no more water is allowed to enter the test section for 1 h.
  - After 1 h, the reduced pressure is measured, STP is restored by pumping and then the loss of water  $\Delta V$ , by drawing off water until the previously reduced pressure reached after 1 h is reached again, is measured.
- b) Measurement of the water volume pumped in.
  - Having attained the STP, it is maintained by pumping, if necessary, for a period of 1 h.
  - The quantity of water  $\Delta V$  necessary to be pumped in order to maintain STP is measured.

If the test section is tight, the measured water loss  $\Delta V$  will not exceed the value  $\Delta V_{\max}$  calculated using Formula (A.2):

$$\Delta V_{\max} = 1,2 \times V \times \Delta p \times \left\{ \frac{1}{E_w} + \frac{D}{e \times E_R} \right\} \quad (\text{A.2})$$

where

- |                   |  |
|-------------------|--|
| $\Delta V_{\max}$ | is the allowable water loss in litres;   |
| $V$               | is the volume of the test section in litres, calculated with the internal pipe diameter $D$ ;                    |
| $\Delta p$        | is the allowable pressure loss as stated in 10.4.4.2 in kPa;   |
| $E_w$             | is the bulk modulus of water in kPa;   |
| $D$               | is the internal pipe diameter in metres, without taking into account cement mortar lining, $D = ID$ , see 3.4.2; |
| $e$               | is the wall thickness of the pipe in m;  |
| $E_R$             | is the modulus of elasticity of the pipe wall in the circumferential direction in kPa;                           |
| 1,2               | is the allowance factor for unavoidable air content.   |

#### A.23.5 Finalization of testing

For depressurizing test sections, evaluating/recording test results and visually inspecting joints between test sections and the existing supply system see 10.4.5, 10.4.6, 10.4.7 and 10.4.8.

## A.24 Testing of viscoelastic pipelines (PE, PVC-U, PVC-O)

### A.24.1 General

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

Test mediums other than potable water (plus disinfectants, where necessary) are not used.

### A.24.2 Safety

Related to personnel, the following issues are taken care of:

- at all stages of testing, the planned procedure and any possible variations of its delivery are carried out in a way to avoid danger to personnel;
- all personnel are clearly informed of the intensity of the loading on temporary fittings and supports and the consequences if failure occurs;
- where disinfectants are used, all personnel are clearly informed of their appropriate handling;
- prior to the commencement of any pressure testing procedure, a check is made so that the appropriate safety equipment is available and that personnel have the correct protective clothing;
- related to construction of pipelines and any associated works, the following issues are taken care of:
  - permanent abutments or anchorages are constructed to withstand thrust at the test pressure;
  - concrete anchor blocks are allowed to develop strength before testing begins;
  - caps or other temporary blanking fittings are anchored, with the load distributed according to the strength of the supporting ground. Gate valves, fire hydrants, water hammer release equipment or safety valves are not used as blanking fittings;
- any temporary supports or anchorage at the ends of the test section are not removed until the test section has been depressurized;
- after completion of construction and before the commencement of backfilling, all excavations remain guarded. Any activity not related to pressure tests is not carried out in pipe trenches during pressure tests;
- during the application of pressure, the pipe trench and its surroundings are guarded with a safety distance. Only competent personnel enter the guarded area, where necessary, to perform their specific duties;
- related to test equipment, it is checked prior to carrying out a pressure test, if it is calibrated, in good working order and correctly fitted to the test section;
- during the test, the following issues are taken care of:
  - air is exhausted from the test section as fully as reasonably possible. Filling takes place slowly from, if possible, the lowest point in the test section and in such a way as to prevent back siphonage and so that air can escape at facilities for venting;
  - the test section is filled with water slowly whilst all facilities for venting are open and the test section is vented;
  - water used for testing is disposed of properly without flooding or adversely affecting the work site.

### A.24.3 Preparation of a test section

#### A.24.3.1 General

The length of test sections is determined on the basis of the following considerations:

- local conditions (concerning access for example);
- availability of suitable water;
- number of fittings and accessories (e.g. valves, hydrants, etc.);
- difference in elevation between different parts of the test section.

Test sections are selected so that:

- MDP and  $0,7 \times \text{PFA}$  are not exceeded at any point of the test section during filling:
  - where MDP or  $0,7 \times \text{PFA}$  is exceeded during filling, it is considered part of pressure build-up during the preliminary test within the limitations of time according to A.24.4.2 and pressure according to A.24.4.3;
  - if MDP is exceeded during filling, it is an indication, that MDP can also be exceeded during the later operating phase of the pipeline, so that the design is reconsidered (in particular the placing of pressure reducing valves);
- the typical length of a test section does not exceed 1500 m;
- the system test pressure (STP) can be built up in the specified time during the preliminary test;
- the system test pressure (STP) is achieved at the lowest point of each test section;
- a pressure of at least maximum design pressure (MDP) is achieved at the highest elevation point of each test section (see Figure 4 for an illustration of a pressure profile);
- where supply systems operate with pumps, the system test pressure (STP) takes into account the pump pressure in addition to the operating pressure;
- the necessary water for testing can be provided and removed without difficulty;
- the influence of changes in temperature is minimized where pipe and joints are exposed, in particular when weather conditions cause freezing or excessive heating.

Any debris and foreign matter are removed from the test section before testing.

#### A.24.3.2 Anchoring and closures

Isolation of test sections is achieved by using blank flanges or equivalent types of closures.

Hydraulic loads exerted on the ends of the test section are evaluated. Anchors are set up, where necessary, so as to absorb the loads in timbers buried across the trench or in sheet piling.

All changes in direction and/or cross-section of the test section, such as bends, tees, tapers (reducers) and blank flanges, are fully restrained (or anchored) before testing by means of thrust blocks or restrained (self-anchoring) joints.

Other components such as gate valves, fire hydrants, water hammer release equipment or safety valves are not used instead of blank flanges. If for practical reasons, valves are used as closure pieces, their rated pressure will not be lower than the system test pressure (STP). When evaluating the overall leakage allowance for a test section, due consideration is taken of the allowable leakage rate(s) of the valve(s).

### **A.24.3.3 Partial backfilling**

Test sections are normally partially backfilled leaving pipe joints accessible for inspection. Only if too much temperature variance can occur backfilling over joints, or another covering is considered.

Backfill material is applied to prevent movement of the test section. In particular, restrained-joint parts of the test section, which derive their stability from their interaction with the soil, are backfilled prior to testing.

### **A.24.3.4 Filling with water and air venting**

The test section is completely filled with water and air vented. The pressure is raised up to Operating Pressure OP (see limitations in A.24.3.1). The ends of the test section are blocked, usually with blank flanges fitted with venting valves.

The pumped water can contain air that will, over a period of time, leave the solution. If vented, the volume previously occupied by the air can be replaced by water and, in doing so, the pressure can decrease. The kinetics of dissolution of air in water is a function of many parameters, in particular:

- the initial saturation level of the pumped water;
- the water temperature (the amount of dissolved air decreases with increasing temperature);
- water pressure (the amount of dissolved air decreases with decreasing pressure);
- the location of air pockets;
- the dimension of the interface zones between air and water.

The test section is filled slowly, with open ventilation devices, from the lowest point, so that no back siphonage occurs and the air can escape through the ventilation devices. Too fast filling can cause trapped air cushions.

The full air valve inspection is made by checking that each automatic air valve and any manual air valve does not release any further air.

In the case of varying elevation without ventilation at all high points, pigging can be applied, particularly if even higher filling speeds cannot help to remove air.

### **A.24.3.5 Temperature and pressure-derating**

During the entire test period, the test section is protected against temperature increases to avoid the outside pipe wall temperature exceeds 20°C. This can be assessed by checking external temperature, considering the temperature of the fluid (cooling or heating effect). The temperature will take time to balance in the pipe wall.

If temperatures above 20 °C cannot be avoided, a de-rating factor is applied in accordance with Table A.4.

**Table A.4 — Pressure de-rating factor for temperatures above 20 °C**

Temperature T [°C]	Pressure de-rating factor	
	Material	
	PE	PVC-U, PVC-O
20	1,00	1,00
21	0,99	1,00
22	0,97	1,00
23	0,96	1,00
24	0,95	1,00
25	0,94	1,00
26	0,92	0,98
27	0,91	0,96
28	0,90	0,94
29	0,88	0,92
30	0,87	0,90
31	0,86	0,88
32	0,84	0,86
33	0,83	0,84
34	0,82	0,82
35	0,81	0,80
36	0,79	0,78
37	0,78	0,76
38	0,77	0,74
39	0,75	0,72
40	0,74	0,70
Based on pressure de-rating factor for: PE 1,3 % / °C, between 20 °C and 40 °C; PVC-U or PVC-O 2,0 % / °C, between 25 °C and 40 °C.		

#### **A.24.4 Pressure testing procedures**

##### **A.24.4.1 General**

The test pressure is the system test pressure, calculated for the lowest point of the test section., A calibrated pressure meter with range relevant to the STP is installed, if possible at the lowest point of the test section.

The testing is carried out in three steps:

- 1) preliminary test;

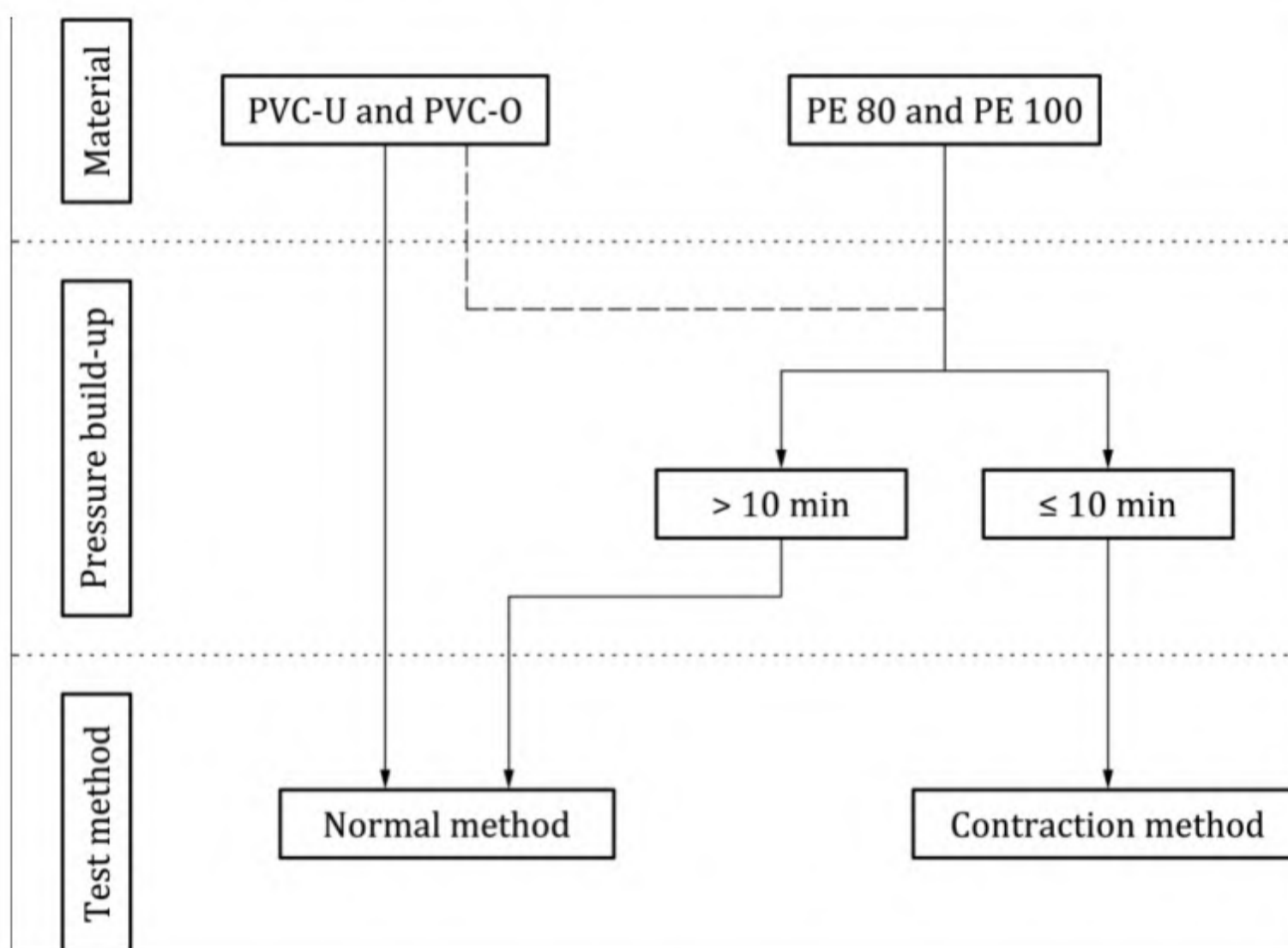
- 2) pressure drop test (in general, conditions to skip the pressure drop test according to 10.4.3 are not given);
- 3) main pressure test.

One of the following test methods are followed:

- 1) the contraction method is the typical test method for PE and can alternatively be used for PVC-U and PVC-O. The contraction method uses the viscoelastic property of the pipe material and provides reliable results for tightness in a short time. (A.24.5);
- 2) the normal method is the typical test method for PVC-U and PVC-O and can alternatively be used for PE. (A.24.6).

#### A.24.4.2 Selection of test method

Figure A.13 gives an overview of the selection process.



**Figure A.13 — Selection of test method**

The application of the contraction method is based on the assumption that the System Test Pressure (STP) can be achieved within 10 min after exceeding MDP at the lowest point of the test section.

#### A.24.4.3 Test pressure for viscoelastic pipes

The system test pressure (STP) is calculated from the maximum design pressure (MDP) in accordance with 10.3.2:

- $STP = 1,5 \times MDP$ ; or
- $STP = MDP + 5 \text{ bar}$  (whichever is least).

Due to the behaviour of viscoelastic materials, which absorb energy from surge events, for viscoelastic pipes conforming to European product standards (EN 12201, EN 17176, EN ISO 1452), there is no allowance for surge pressure [9]. Therefore, MDP can be assumed to be identical to DP.

To initiate the effect of pipe contraction the minimum test pressure for the contraction method to be applied is  $0,7 \times \text{PFA}$  (i.e.  $0,7 \times \text{PN}$ ). Examples are shown in Table A.5.

Example calculations for minimum test pressures are shown below:

<p>Designed pipe system PN 10 – MDP = 10 bar</p> <p>System test pressure <math>\rightarrow \text{STP} = 1,5 \times \text{MDP} = 15 \text{ bar}</math></p> <p>Pipe installed: PE 100 / SDR 7,4 / PN25.</p> <p>To initiate contraction the minimum test pressure for a pipe PE 100 / SDR 7,4 / PN25 (where PFA = PN) is</p> <p><math>0,7 \times \text{PFA} = 17,5 \text{ bar}</math>.</p> <p>The system test pressure of 15 bar for a PN 10 pipe system is lower than the minimum test pressure of 17,5 bar.</p> <p><math>\rightarrow</math> Contraction method is not applicable</p>	<p>Designed pipe system PN 16 – MDP = 16 bar</p> <p>System test pressure <math>\rightarrow \text{STP} = \text{MDP} + 5 = 21 \text{ bar}</math></p> <p>Pipe installed: PE 100 / SDR 11 / PN16.</p> <p>To initiate contraction the minimum test pressure for a pipe PE 100 / SDR 11 / PN16 (where PFA = PN) is</p> <p><math>0,7 \times \text{PFA} = 11,2 \text{ bar}</math></p> <p>The system test pressure of 21 bar for a PN 16 pipe system is higher than the minimum test pressure of 11,2 bar.</p> <p><math>\rightarrow</math> Contraction method is applicable</p>
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Table A.5 provides STP values for MDPs for typical PN and SDR.

**Table A.5 — Values of STP based on MDP**

Maximum design pressure MDP	System test pressure <sup>a</sup> STP at $\leq 20^\circ\text{C}$		Pipe pressure classification PN	Standard dimension ratio SDR ( $d_n/e_n$ )		
MDP [bar]	STP <sup>b</sup> [bar]	Minimum test pressure <sup>c</sup> [bar]		PE 100	PVC-O	PVC-U
0	0	4,2	PN6			
1	1,5					
2	3,0					
3	4,5					
4	6					
5	7,5					
6	(9) <sup>d</sup>	5,6	PN8	26	N/A	41
7	10,5					
8	(12) <sup>d</sup>			21	N/A	33
9	(13,5) <sup>d</sup>	7	PN10			
10	(15) <sup>d</sup>			17	65	26
11	16					
12	17	8,75	PN12,5	13,6	57	21

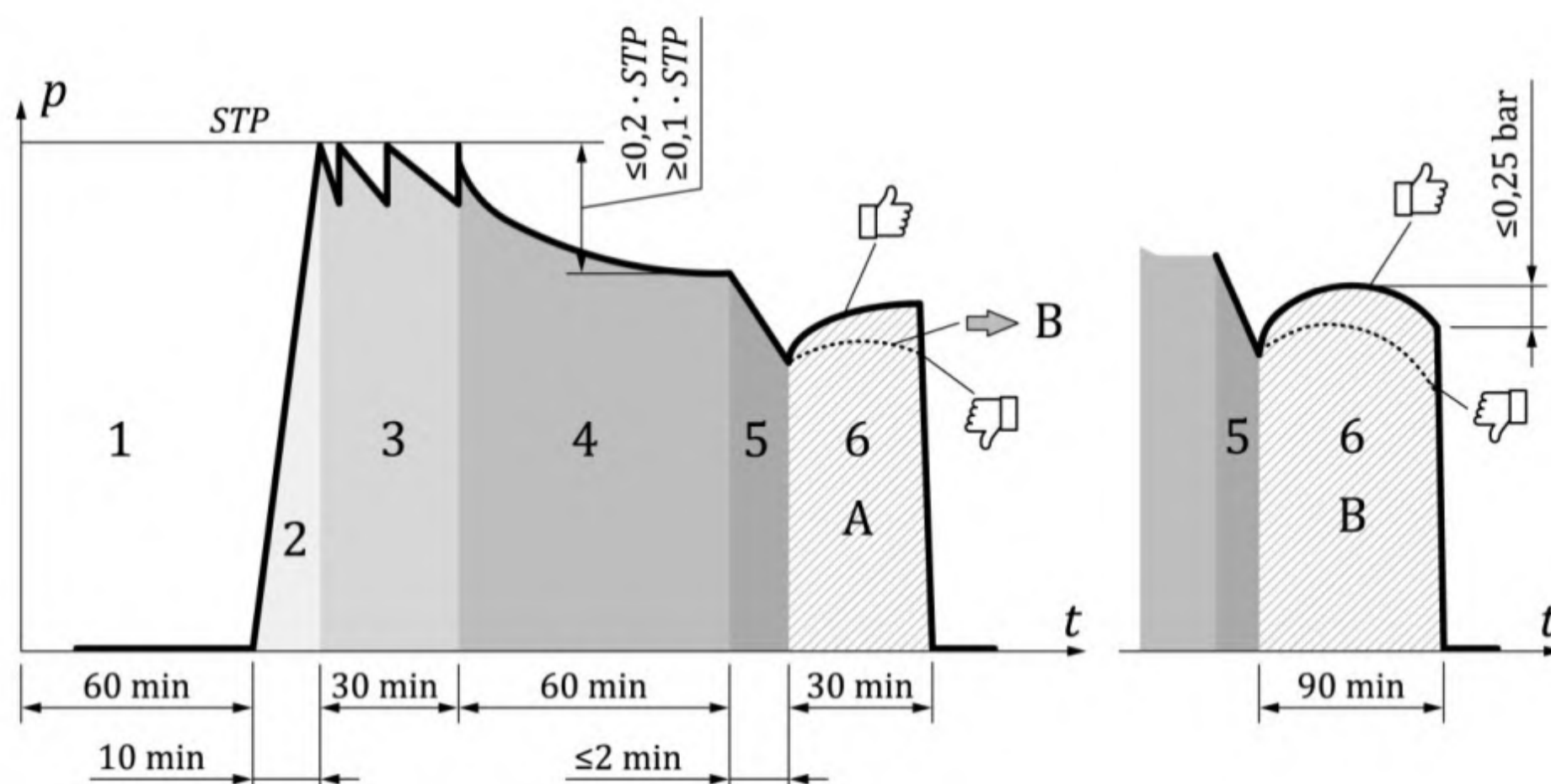
Maximum design pressure MDP	System test pressure <sup>a</sup> STP at ≤ 20 °C		Pipe pressure classification PN	Standard dimension ratio SDR (d <sub>n</sub> /e <sub>n</sub> )		
MDP [bar]	STP <sup>b</sup> [bar]	Minimum test pressure <sup>c</sup> [bar]		PE 100	PVC-O	PVC-U
13	18	11,2	PN16			
14	19					
15	20					
16	21			11	45,8	17
17	22	14	PN20			
18	23					
19	24					
20	25			9	37	13,6
21	26	17,5	PN25			
22	27					
23	28					
24	29					
25	30			7,4	29	11
<div><div><div><div><div><div></div><div>a</div></div><div>The maximum pressure during a test is determined by the lowest rated component which is not always the viscoelastic pipe.</div></div></div><div><div><div></div><div>b</div></div><div>STP is calculated, as lower value of (MDP + 5 bar) or (MDP × 1,5).</div></div></div><div><div><div></div><div>c</div></div><div>A calculated test pressure of at least 0,7 × PFA (where PFA = PN) allows contraction method to be applied (see A.24.5), otherwise the normal method is applied (see A.24.6).</div></div></div> <div><div><div></div><div>d</div></div><div>STP for contraction method only, where pipe manufacturer confirms test parameters. Alternatively, a pipe of higher PN can be selected.</div></div>						

## A.24.5 Testing procedure using the contraction method

### A.24.5.1 General

Figure A.14 shows the pressure curve and the durations of the different steps of testing:

- preliminary test;
- pressure drop test;
- main pressure test.



### Key

#### Preliminary test (A.24.5.2)

- 1 preparation
- 2 pressure build-up
- 3 pressure maintenance phase
- 4 resting phase ( $0,1 \times STP \leq \text{pressure loss} \leq 0,2 \times STP$ )

#### Pressure drop test (A.24.5.3)

- 5 pressure drop ( $\Delta p$  in bar; values shown in Table A.6)

#### Main pressure test (A.24.5.4)

- 6 main pressure test (Scenario A if successful after 30 min; Scenario B in case of doubt after 30 min, Scenario B lasting 90 min altogether)

**Figure A.14 — Sketch of pressure test using the contraction method**

### A.24.5.2 Preliminary test

The preliminary test is intended to:

- 1) thermally stabilize the test section so that the temperature in the pipe wall does not change during the main pressure test;
- 2) raise the pressure to system test pressure (STP);
- 3) check for air in the test section.

Additionally, the preliminary test is used to enable the pressure-dependent increase in volume of flexible pipes to occur prior to the main test and so eliminate distorting phenomena in the test result as far as possible.

If necessary, pigging is carried out to remove excess air. If unacceptable changes of the position of any part of the test section, and/or leaks are apparent, the test section is de-pressurized, and the faults are rectified.

The preliminary test is carried out in the following steps (1-4, see Figure A.14):

- 1) preparation (relaxation): after filling, open the valve at the highest point for 1 hour. No air enters the line during this time;
- 2) pressure build-up: close the valve and raise the pressure to at least the maximum design pressure (MDP) at the highest point without exceeding the system test pressure (STP) at the lowest point. STP is reached

within 10 min. To reach STP in no more than 10 min, the maximum pipe segment volume is typically 30 m<sup>3</sup>. For higher volumes, larger pumps can be selected;

- 3) pressure maintenance: maintain the pressure at STP by continuously pumping for a period of 30 min;
- 4) resting for 1 h: Stop pumping and measure the pressure loss in the test section. During this time, the pressurised test section undergoes viscoelastic deformation.

During the resting phase:

- a pressure loss exceeding 20 % is an indication of a leak (if the test section has not been exposed to an inadmissible temperature increase);
- a pressure loss of less than 10 % is an indication of too much air in the test section.

In both cases, the preliminary test including the one-hour relaxation period is repeated after the test section has been set to the resting conditions described above.

#### A.24.5.3 Pressure drop test

The pressure drop test is an integral part of the main pressure test.

The pressure drop test is used to determine if the remaining air content in the test section is too high. Too high air content can adversely impact the results of the test.

The pressure drop test is carried out directly after the successful completion of the resting phase of the preliminary test (no restoring of STP) as follows:

- remove water  $\Delta V$  to achieve a pressure drop  $\Delta p$  within a maximum of 2 min and measure the volume  $\Delta V$ . Table A.6 gives target values for  $\Delta p$  for various grades of PE and PVC materials. Compare  $\Delta V$  with the allowable water loss  $\Delta V_{\max}$ , calculated in accordance with Formula (A.3) or Formula (A.4);
- calculate the allowable water loss using the following Formula (A.3):

$$\Delta V_{\max} = f \times V \times \Delta p \times \left( \frac{1}{E_w} + \frac{I D}{e \times E_R} \right) \quad (\text{A.3})$$

where

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

$V$  is the volume of the test section in litres, calculated with the internal pipe diameter  $ID$ ;

$\Delta p$  is the actual (measured) pressure drop which can deviate slightly from its target value as stated in Table A.6 in bar;

$E_w$  is the bulk modulus of water in kilopascals;

$ID$  is the internal pipe diameter in mm;

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

$f$  is the compensation factor for unavoidable air inclusions  $f = 1,05$  for thermoplastic pipelines;

$e$  is the calculated pipe wall thickness, considering an average plus tolerance, in mm; where  
 $e = e_n + (0,1 \times e_n + 0,2) \times 0,5$ .

or

$$\Delta V_{\max} = V_c \times L \quad (\text{A.4})$$

where

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

$L$  is the length of the test section in m;

$V_c$  is the calculated water volume due to expansion of the plastic pipe according Table A.7. For other pipe dimensions,  $\Delta V_{\max}$  is calculated using Formula (A.3).

Venting of the test section is sufficient, when:

$$\Delta V \leq \Delta V_{\max}$$

where

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

$\Delta V$  is the drained water volume in litres.

**Table A.6 — Pressure drop  $\Delta p$**

Pipe material	E-Modulus $E_R$ in N/mm <sup>2</sup> a	Pipe series SDR	Pipe series S	Pressure drop (target values) $\Delta p$ in bar <sup>b</sup>
PE 80	850	11	5	2,2
PE 100/RC	1 100	17	8	2,0
PE 100/RC	1 100	11	5	3,2
PE100/RC	1 100	7,4	3,2	5,2
PVC-U	2 600	21	10	3,8
PVC-U	2 600	13,5	6,25	5,9
PVC-O	3 500	57	28	2,0
PVC-O	3 500	45,8	22,4	2,6
PVC-O	3 500	37	18	3,2
PVC-O	3 500	29	14	4,0
a Typical values for a 2 h modulus of elasticity, 1 N/mm <sup>2</sup> = 1 000 kPa.				
b These pressure drop values are not calculated but from experience in the field.				

Table A.7 — Calculated water volume  $V_c$  (ml/m) in accordance with Formula (A.3)

OD	PE80	PE100/RC		PVC-U		PVC-O	PVC-O	PVC-O	PVC-O
SDR <sup>a</sup> b	11	17	11	21	13.5	57	45.8	37	29
63	4,97	5,78	4,93	7,19	6,19	-	-	6,58	8,22
75	7,34	8,36	7,28	10,15	8,81	-	9,04	11,13	11,90
90	10,45	11,92	10,36	14,78	12,79	11,46	13,63	16,77	17,38
110	15,70	18,12	15,55	21,96	19,13	19,43	21,39	26,17	26,03
125	20,20	23,63	19,94	28,57	24,83	27,26	29,09	34,18	33,90
140	25,70	29,86	25,47	36,05	31,26	34,33	38,68	43,26	42,80
160	33,25	38,77	32,97	46,86	40,82	45,02	50,70	57,51	55,89
180	42,19	49,45	41,83	59,96	51,66	57,16	64,35	72,17	70,73
200	52,17	60,75	51,74	73,69	63,78	70,75	79,63	90,29	87,32
225	66,05	76,70	65,48	93,40	81,23	89,78	101,01	114,26	111,74
250	82,10	96,18	81,39	116,65	100,03	111,06	124,93	141,05	137,33
280	102,79	120,39	101,90	145,49	125,85	139,59	156,99	177,95	173,16
315	130,45	152,23	129,31	185,48	159,39	176,99	199,02	224,48	219,44
355	165,86	192,17	164,41	235,87	203,36	225,17	253,15	285,66	278,27
400	210,54	245,69	208,71	298,56	257,51	286,30	321,82	364,68	355,04
<sup>a</sup> Ratio of nominal pipe outside diameter to nominal wall thickness									
<sup>b</sup> For the calculation of SDRs not stated, consider the nominal outside pipe diameter $d$ and pipe wall thickness $e$ , considering an average plus tolerance; where: $e = e_n + (e_n \times 0,1 + 0,2) \times 0,5$ with $e_n$ as nominal pipe wall thickness.									

#### A.24.5.4 Main pressure test

The reduction in pressure during the pressure drop test (step 5, see Figure A.14) leads to an immediate contraction in the test section with a slight pressure increase (step 6). As shown in Figure A.14 the pressure stabilizes after about 30 min.

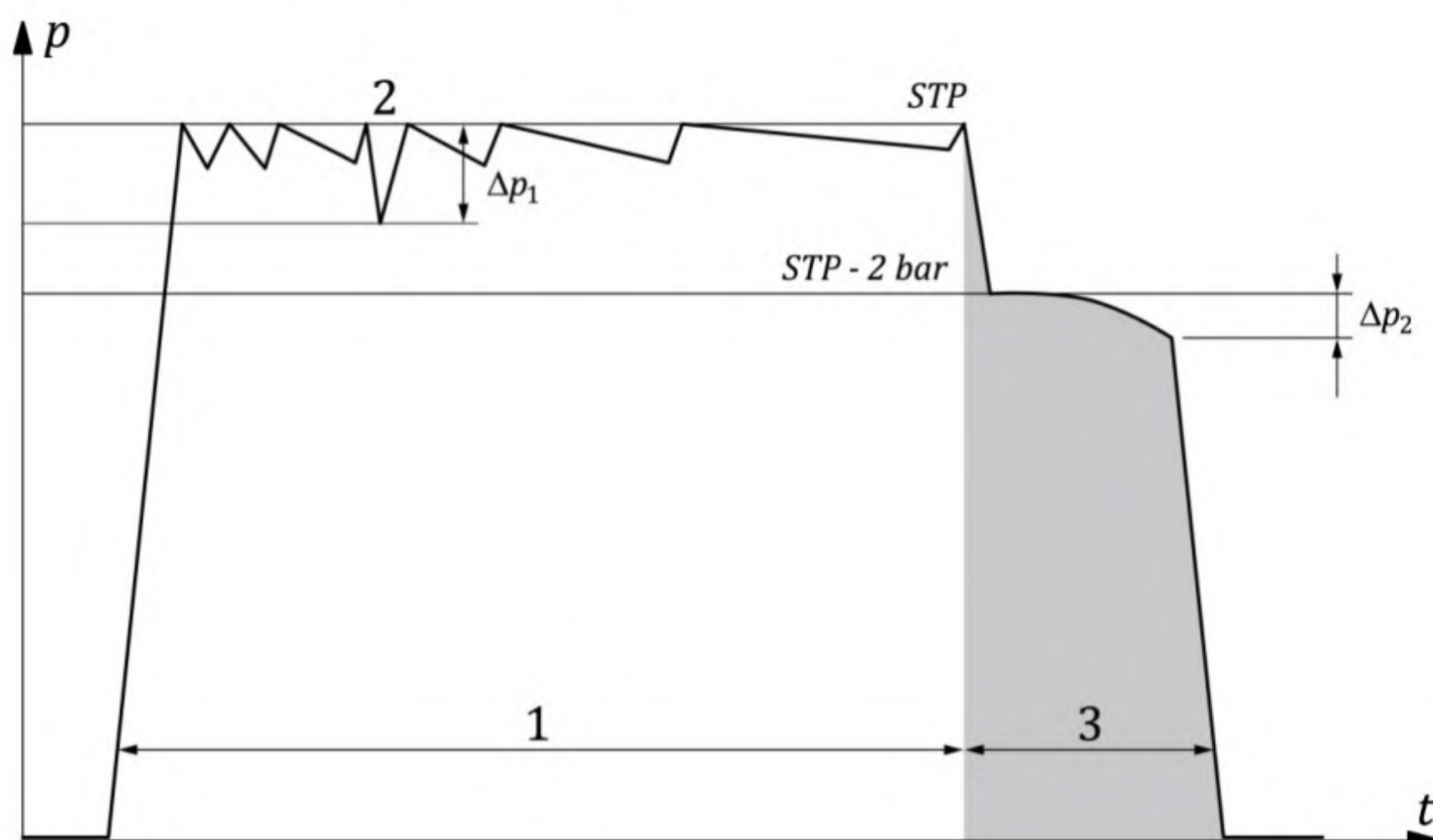
The test section is considered tight, if during the contraction time the pressure line shows an increasing to constant tendency (Figure A.14, Scenario A).

In cases of doubt, the test duration can be extended up to 90 min (Figure A.14, Scenario B). The main pressure test is successful if the pressure decrease does not exceed 0,25 bar, measured from the maximum value after the increase during contraction.

## A.24.6 Testing procedure using the normal method

### A.24.6.1 General

Figure A.15 show the pressure curve and the durations of the steps for the normal method (with or without pressure reduction in accordance with Table A.8).



#### Key

- 1 preliminary test
- 2 pressure drop test (vent control)
- 3 main pressure test

**Figure A.15 — Sketch of pressure test using the normal method**

### A.24.6.2 Preliminary test

The preliminary test and the pressure drop test are intended to:

- 1) thermally stabilize the part of the test section so that the temperature in the pipe wall does not change during the main pressure test;
- 2) raise the pressure to system test pressure (STP) at the lowest point of the test section;
- 3) check for air in the test section.

If necessary, pigging is carried out to remove excess air. If unacceptable changes of the position of any part of the test section and/or leaks become apparent, the test section is de-pressurized, and the faults are rectified.

Carry out the following four steps:

- 1) pressure build-up: close the valve and raise the pressure as quickly as possible to at least the maximum design pressure (MDP) at the highest point without exceeding the STP at the lowest point;
- 2) pressure maintenance: maintain the pressure at STP by continuous pumping for a period of 1 h before carrying out the pressure drop test;
- 3) pressure drop test according to A.24.6.3;

- 4) further pressure maintenance (in accordance with Table A.8 minus 1 h): maintain the pressure at STP by continuous pumping until the start of the main pressure test.

#### A.24.6.3 Pressure drop test

The pressure drop test is an integral part of the preliminary test to determine if the air content in the test section is too high.

The pressure drop test, conducted 1 h after starting the preliminary test, enables the assessment of the remaining volume of air in the test section, as too much air in the test section will result in erroneous data. Pigging can be a means to aid the removal of air prior to the pressure test.

The pressure drop test is carried out as follows:

Remove water  $\Delta V$  to achieve, roughly, a pressure drop of 1 bar and measure the volume  $\Delta V$  and the actual pressure drop  $\Delta p_1$  (which will not necessarily be exactly 1 bar, but for example 0,9 bar or 1,1 bar). Compare  $\Delta V$  with the allowable water loss  $\Delta V_{\max}$ , calculated in accordance with Formula (A.5) or Formula (A.6).

Calculate the allowable water loss using the following Formulae (A.5) and (A.6):

$$\Delta V_{\max} = f \times V \times \Delta p \times \left( \frac{1}{E_w} + \frac{I D}{e E_R} \right) \quad (\text{A.5})$$

where

$\Delta V_{\max}$	is the allowable water loss in litres;
$V$	is the volume of the test section in litres, calculated with the internal pipe diameter $ID$ ;
$\Delta p$	is the actual (measured) pressure drop in bar;
$E_w$	is the bulk modulus of water in kilopascals;
$ID$	is the internal pipe diameter in mm;
$E_R$	is the modulus of elasticity of the pipe wall in the circumferential direction in kilopascals;
$f$	is the compensation factor for unavoidable air inclusions, $f = 1,05$ for thermoplastic pipelines;
$e$	is the calculated pipe wall thickness, considering an average plus tolerance, in mm; where $e = e_n + (0,1 \times e_n + 0,2) \times 0,5$ .

Venting of the test section is sufficient, if:

$$\Delta V \leq \Delta V_{\max} \quad (\text{A.6})$$

where

$\Delta V_{\max}$	is the allowable water loss in litres;
$\Delta V$	is the drained (and measured) water volume in litres.

#### A.24.6.4 Main pressure test

After the preliminary test, including the pressure drop test, has been carried out successfully, pressure maintenance is stopped (see Figure A.15). The pressure is reduced by 2 bar (STP - 2 bar; see Figure A.15) As

a result of lowering the test pressure by 2 bar, an elastic contraction of the plastic pipe occurs, but by not as much as in the contraction method.

The main pressure test is passed if the pressure loss  $\Delta p_2$  after stopping pressure maintenance and reducing pressure by 2 bar does not exceed both the maximum pressure loss  $\Delta p_{\max}$  and the time according to Table A.8.

Table A.8 — Example testing values for normal procedure

Pipe material	Pipe pressure classification PN	MDP in bar	DN/OD	Preliminary testing/ keeping pressure		Main test (no pumping)		
				STP in bar	Time in h	Pressure in the beginning STP-2 bar	Pressure loss $\Delta p_{\max}$ in bar	Time in h
PVC-U	10/16	10/16	$\leq 150$	15/21	12	13/19	$\leq 0,2$	3
PVC-U	10/16	10/16	$> 150 \leq 400$	15/21	12	13/19	$\leq 0,2$	6
PVC-O	12,5	11	$\leq 150$	16	12	14	$\leq 0,2$	1,5
PVC-O	12,5	11	$> 150 \leq 400$	16	12	14	$\leq 0,2$	1,5
PVC-O	12,5	11	$> 400$	16	12	14	$\leq 0,2$	1,5
PVC-O	16	16	$\leq 150$	21	12	19	$\leq 0,2$	1,5
PVC-O	16	16	$> 150 \leq 400$	21	12	19	$\leq 0,2$	1,5
PVC-O	16	16	$> 400$	21	12	19	$\leq 0,2$	1,5
PVC-O	20	20	$\leq 150$	25	12	23	$\leq 0,2$	1,5
PVC-O	20	20	$> 150 \leq 400$	25	12	23	$\leq 0,2$	1,5
PVC-O	20	20	$> 400$	25	12	23	$\leq 0,2$	1,5
PVC-O	25	25	$\leq 150$	30	12	28	$\leq 0,2$	1,5
PVC-O	25	25	$> 150 \leq 400$	30	12	28	$\leq 0,2$	1,5
PVC-O	25	25	$> 400$	30	12	28	$\leq 0,2$	1,5
PE80, PE100/RC	10/16	8/16	$\leq 150$	12/21	12	10/19	$\leq 0,3$	3
PE80, PE100/RC	10/16	8/16	$> 150 \leq 400$	12/21	12	10/19	$\leq 0,6$	6
PE80, PE100/RC	10/16	8/16	$> 400$	12/21	12	10/19	$\leq 1,2$	12

### A.24.7 Finalization of testing

For depressurizing test sections, evaluating/recording test results and visually inspecting joints between test sections and the existing supply system, see 10.4.5, 10.4.6, 10.4.7 and 10.4.8.

### A.25 Selection of disinfectants

For details of disinfectants see Table A.9.

Storage, handling and use of all these disinfectants can be hazardous, see manufacturer's instructions.

**Table A.9 — Details of chemicals typically used for disinfection of water distribution systems**

Disinfectant (in solution)	Typical maximum concentration mg/l	Neutralizing agents
Sodium hypochlorite NaClO	50 (as Cl)	Sulfur dioxide (SO <sub>2</sub> ) Sodium thiosulfate (Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ) Hydrogen peroxide H <sub>2</sub> O <sub>2</sub>
Calcium hypochlorite Ca(ClO) <sub>2</sub>	50 (as Cl)	Sulfur dioxide (SO <sub>2</sub> )  Sodium thiosulfate (Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> )
Potassium permanganate KMnO <sub>4</sub>	50 (as KMnO <sub>4</sub> )	Sulfur dioxide (SO <sub>2</sub> ) Sodium thiosulfate (Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ) Iron sulfate (FeSO <sub>4</sub> )
Hydrogen peroxide H <sub>2</sub> O <sub>2</sub>	150 (as H <sub>2</sub> O <sub>2</sub> )	Sodium thiosulfate (Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ) Sodium sulfite (Na <sub>2</sub> SO <sub>3</sub> ) Calcium sulfite (CaSO <sub>3</sub> )
Chlorine dioxide ClO <sub>2</sub>	50 (as Cl)	Sodium thiosulfate (Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> )

## Bibliography

- [1] EN ISO 9001, *Quality management systems — Requirements (ISO 9001)*
- [2] ISO 24516-1, *Guidelines for the management of assets of water supply and wastewater systems — Part 1: Drinking water distribution networks*
- [3] EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025)*
- [4] EN 15643, *Sustainability of construction works — Sustainability assessment of buildings and civil engineering works*
- [5] ISO 55000, *Asset management — Overview, principles and terminology*
- [6] EN 15804, *Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products*
- [7] EN 1717, *Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow*
- [8] EN 15975-2, *Security of drinking water supply — Guidelines for risk and crisis management — Part 2: Risk management*
- [9] IGN 4-37-02, *Design against surge and fatigue conditions for thermoplastic pipes*, available online: <https://www.water.org.uk/wp-content/uploads/2018/11/ign-4-37-02.pdf>

# **National Annex NA** (informative)

## **Guidance for UK users**

### **NA.1 Background**

The attention of UK users of this standard is drawn to the following regulations.

#### Water Quality Regulations

- The Water Supply (Water Quality) Regulations 2016, in England [N1].
- The Water Supply (Water Quality) Regulations (Northern Ireland) 2017, in Northern Ireland [N2].
- The Public Water Supplies (Scotland) Regulations 2014 as amended, in Scotland [N3].
- The Water Supply (Water Quality) Regulations 2018, in Wales [N4].

These national regulations apply standards of wholesomeness (including material requirements) to water provided in the public mains water supply (municipal supply) and are referred to as the “Water Quality Regulations” [N1, N2, N3, N4].

#### Private Water Supplies Regulations

- The Private Water Supplies (England) Regulations 2016, in England [N5].
- The Private Water Supplies Regulations (Northern Ireland) 2017, in Northern Ireland [N6].
- The Private Water Supplies (Scotland) Regulations 2006 [N7] and The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017, in Scotland [N8].
- The Private Water Supplies (Wales) Regulations 2017, in Wales [N9].

These national regulations apply standards of wholesomeness (including material requirements) to water provided from private water sources (non-municipal supply) and are referred to as the “Private Water Supplies Regulations” [N5, N6, N7, N8, N9].

#### Water Fittings Regulations/Byelaws

- The Water Supply (Water Fittings) Regulations 1999, in England and Wales [N10].
- The Water Supply (Water Fittings) (Scotland) Byelaws 2014, in Scotland [N11].
- The Water Supply (Water Fittings) Regulations (Northern Ireland) 2009, in Northern Ireland [N12].

These national regulations apply to water supply and plumbing systems within premises (outside and inside of buildings, also see BS EN 806) to which a supply of public mains water is, or is to be, provided by a water undertaker (water company) and are referred to as “Water fittings Regulations/Byelaws” [N10, N11, N12]. These regulations may also apply to premises that have a private water source such as from boreholes, wells, etc., if they are provided with a supply of public mains water as a backup. These are particularly relevant to subclauses 9.2.2 and 10.3.2 in connection to water systems which are within premises but external to any buildings.

## **NA.2 General**

When using this standard, account ought to be taken of where the water system is to be located and who is operating the water system, e.g. a public water company. This will affect whether the Water Quality Regulations [N1, N2, N3, N4] or Private Water Supplies Regulations [N5, N6, N7, N8, N9] apply. This is particularly relevant to the materials of components, pipes, etc. (see 4.1.2 and 8.2), which are in contact with water intended for human consumption and/or domestic purposes.

Where the water system is located within premises, the requirements of Water Fittings Regulations/Byelaws [N1, N2, N3] may also apply. These regulations apply to any system within premises, internal and external, where a supply of public mains water is, or is to be, supplied by a water undertaker (water company). They also apply to premises where a public water supply backup is provided to a private water source such as from boreholes, wells, etc. This is a particularly important consideration during the design, installation or commissioning of water systems and account ought to be taken of its requirements and applied. The regulations do not distinguish on the basis of water system ownership.

If there are any doubts on the applicability of the Water Fittings Regulations/Byelaws [N1, N2, N3], further guidance can be sought from the local water company's Water Fittings Regulations team.

## **NA.3 Guidance to Clause 9**

Where Water Fittings Regulations/Byelaws [N1, N2, N3] apply (see NA.2), the UK committee would advise that the system inhibit damage by freezing or any other cause.

The UK committee advises users that systems of water fittings have a depth of cover which is  $\geq 0,75$  m and  $\leq 1,35$  m. Where this cannot be achieved, the UK committee would encourage UK users to notify the water company and obtain consent before installing the system.

## **NA.4 Guidance to subclauses 10.3.2, A.23 and A.24**

Where Water Fittings Regulations/Byelaws [N1, N2, N3] apply (see NA.2), UK good practice would see the system of water fittings subject to a pressure test of not less than 1,5 times the maximum pressure to which the installation is designed to be subjected in operation. For detailed guidance on pressure testing PE and PE Barrier pipes, WIS 4-01-03 might be consulted, noting that 1,5 times the maximum pressure is always the same pressure, i.e. at system test pressure (STP). Their variation is that of the length of time (minutes) of the test and whether additional water is added during the test or not.

## **National bibliography**

- [N1] GREAT BRITAIN. The Water Supply (Water Quality) Regulations 2016. London: The Stationery Office.
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- [N12] NORTHERN IRELAND. The Water Supply (Water Fittings) Regulations (Northern Ireland) 2009. Belfast: The Stationery Office