INTERNATIONAL WORKSHOP AGREEMENT

**IWA 24**

First edition
2016-09-01

# Non-sewered sanitation systems — General safety and performance requirements for design and testing

*Systèmes d'assainissement non collectifs — Exigences de performance et de sécurité générale pour la conception et les essais*



Reference number
IWA 24:2016(E)



ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

# Table of Contents

# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html .

The committee responsible for this document is the ISO/TMB, *Technical Management Board*.

# Introduction

The purpose of this document is to facilitate the development of non-sewered sanitation systems in general and, in particular, for populations that currently do not have access to safe sanitation. According to the Joint Monitoring Programme (JMP), in 2015, 2,4 billion people still lack improved sanitation facilities. However, it should be noted that improved sanitation does not necessarily mean safe sanitation. The devastating consequences of these practices include an estimated 1 million preventable deaths per year, primarily from dysentery-like diarrheal diseases[1].

In March of 2013 the United Nations (UN) issued a global call to action for the comprehensive elimination of open defecation by 2025. According to the UN, countries where open defecation is most common have the highest levels of child death and disease, as a result of ingesting human fecal matter that has entered the food or water supply[2]. A lack of safe, private sanitation is also associated with the highest overall levels of malnutrition, poverty, and disparity between rich and poor, and makes women and girls more vulnerable to violence[3].

In 2011, the Water, Sanitation & Hygiene program of the Bill & Melinda Gates Foundation initiated the Reinvent the Toilet Challenge to bring sustainable sanitation solutions to the 2,5 billion people worldwide who do not have access to safe, affordable sanitation[4].

The Reinvent the Toilet Challenge criteria were as follows:

— Removes pathogens from human waste and recovers valuable resources such as energy, clean water, and nutrients.

— Operates “off the grid” without connections to water, sewer, or electrical lines.

— Costs less than USD 0.05 per user per day.

— Promotes sustainable and financially profitable sanitation services and businesses that operate in poor urban and rural settings.

— Is a truly aspirational next-generation product that everyone will want to use in developed as well as developing nations.

This document is intended to facilitate the development of sanitation systems that promote economic, social, and environmental sustainability through strategies that may include minimizing resource consumption (e.g. water, energy) and maximizing reusable output. Although this document may be applied to systems requiring connection to a networked water supply system and/or electric power grid, the aim of the document is to promote the development of sanitation systems that are independent of these networks.



---

1 http://www.wssinfo.org/fileadmin/user_upload/resources/JMP-Update-report-2015_English.pdf

2 United Nations, http://www.un.org/waterforlifedecade/waterforlifevoices/open_defecation.shtml

3 United Nations, http://www.un.org/millenniumgoals/pdf/MDG%20Report%202012.pdf

4 Bill & Melinda Gates Foundation – Water, Sanitation & Hygiene: Reinvent The Toilet Challenge – Fact Sheet, https://docs.gatesfoundation.org/Documents/Fact_Sheet_Reinvent_the_Toilet_Challenge.pdf

# Non-sewered sanitation systems — General safety and performance requirements for design and testing

## 1 Scope

This document specifies technical requirements, test methods, and sustainability considerations for non-sewered sanitation systems. A non-sewered sanitation system, for the purposes of this document, is a sanitation system that 1) is not connected to a networked sewer system and 2) collects, conveys, and fully treats the specific input, to allow for safe reuse or disposal of the generated output.

This document is applicable to sanitation systems containing both frontend and backend components that are either manufactured as one package or designed to be integrated as a set of pre-fabricated elements to be assembled in one location without the use of any additional engineering and/or civil engineering structures. This document also applies to individual pre-fabricated backend components that are designed to be integrated with one or more specified frontends that meet relevant national and/or international standards without demanding any additional engineering and/or civil engineering structures. This document is not applicable to sanitation systems constructed in-situ.

NOTE Assembly without the use of any additional engineering and/or civil engineering structures means that pre-fabricated components of non-sewered sanitation systems within the scope of this document do not require further construction in order to be integrated into complete sanitation systems that can perform all of their specified operations.

This document is applicable to sanitation systems that perform their treatment processes in one location through one or more treatment units comprising the backend of the sanitation system. This document does not address transportation of treated output outside of the sanitation system (e.g. manual transport, transportation by truck or trunk pipes) for further treatment, reuse, or disposal. Furthermore, neither any treatment processes taking place at another location separate from that of the frontend and backend components, nor reuse and disposal are addressed in this document.

Figure 1 provides, within the blue dashed lines, a conceptualization of the scope of the document and the areas with which it is concerned. The document sets minimum requirements for treatable input (see 4.3.1), and excludes greywater as input aside from greywater from hand washing. Requirements for the output of sanitation systems are set forth in this document regarding solid and liquid materials as well as odor, air, and noise emissions (see 4.4).



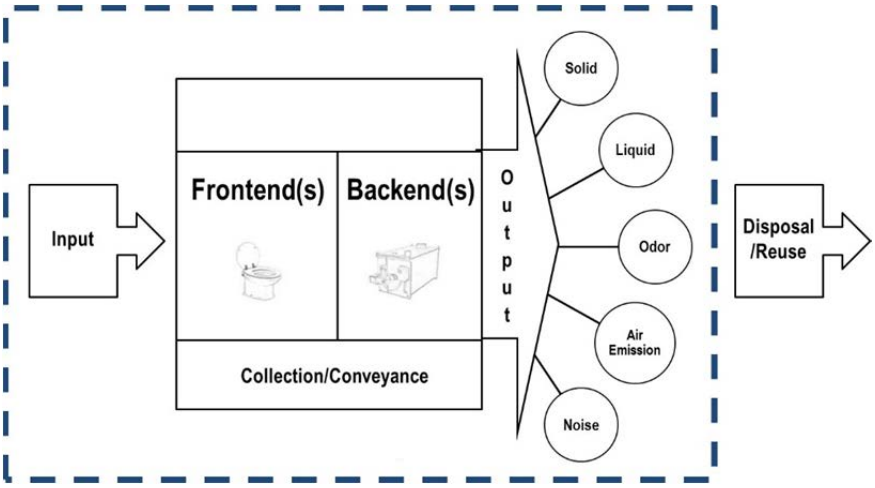



**Figure 1 — Scope of document**

Within sanitation systems to which this document applies, the frontend includes user interfaces such as a urinal, squatting pan, or WC pan, which may apply evacuation mechanisms ranging from conventional flush, pour flush, and dry toilets to novel evacuation mechanisms such as those employing mechanical forces requiring little to no water. Conventional and novel evacuation mechanisms are in some cases combined with urine diversion applications (e.g. urine diversion flush toilet, urine diversion dry toilet). Backend treatment technologies and processes of non-sewered sanitation systems range from biological or chemical to physical mechanisms (e.g. aerobic digestion, combustion, electrochemical disinfection, membranes). Some systems use only one of these technologies or processes while others apply various mechanisms in combination through serial treatment units.

This document is intended to serve as a basis by which to certify non-sewered sanitation systems. Such certification would convey the safety, functionality, usability, reliability, and maintainability of the system, as well as its compatibility with environmental protection goals. This document does not provide guidelines for selection, installation, operation and maintenance, and management of sanitation systems and neither incorporates nor substitutes for manufacturers' instructions and user manuals.

The technical requirements specified in this document are based on hazard and risk assessments following sound engineering practices. Thus, this document provides fundamental requirements for ensuring health and safety. A list of significant hazards addressed in this document is provided in B.2.



## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10816-1:1995, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 1: General guidelines*

ISO 17065:2012, *Conformity assessment — Requirements for bodies certifying products, processes and services*

IEC 60942:2003, *Electroacoustics — Sound calibrators*

IEC 61260-1:2014, *Electroacoustics — Octave-band and fractional-octave-band filters — Part 1: Specifications*

IEC 61672-1:2013, *Electroacoustics — Sound level meters — Part1: Specifications*

EN 13725, *Air quality — Determination of odour concentration by dynamic olfactometry*

EPA Method 1A, *Sample and Velocity Traverses for Stationary Sources with Small Stacks or Ducts*

*WHO Guidelines for Drinking Water Quality*, 4th edition

# 3 Terms, definitions, units and abbreviations

## 3.1 Terms and definitions

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

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

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

### 3.1.1 System structure

**3.1.1.1**
**non-sewered sanitation system**
sanitation system that is not connected to a networked sewer system, and collects, conveys, and fully treats the specific *input* (3.1.2.1) to allow for safe reuse or disposal of the generated solid *output* (3.1.2.2) and/or *effluent* (3.1.2.6)

Note 1 to entry: Components and processes involved in reuse or final disposal of *output* (3.1.2.2), as well as those involving transportation to and/or treatment at another location, are not considered part of the sanitation system for the purposes of this document.

Note 2 to entry: Non-sewered sanitation systems can be either manufactured as one package or designed to be integrated as a set of pre-fabricated elements.

**3.1.1.2**
**evacuation mechanism**
mechanism that delivers energy/movement to convey the *input* (3.1.2.1) to the *backend* (3.1.1.4) of the *non-sewered sanitation system* (3.1.1.1), such as conventional flushing mechanisms, pour flush, dry, and novel mechanisms

**3.1.1.3**
**frontend**
user interfaces such as urinal, squatting or WC pan of a *non-sewered sanitation system* (3.1.1.1) employed for human defecation and urination, including the *evacuation mechanism* (3.1.1.2) and all system components that are clearly visible to the user

**3.1.1.4**
**backend**
combined set of system components encompassing the physical assets used to treat the *input* (3.1.2.1) entering the system via the *frontend* (3.1.1.3), in order to allow for the safe reuse or disposal of the generated *output* (3.1.2.2)

**3.1.1.5**
**superstructure**
additional structure added on top of the primary *non-sewered sanitation system* (3.1.1.1) structure in order to provide shelter to users

### 3.1.2 System inputs and outputs

**3.1.2.1**
**input**
substances entering the *non-sewered sanitation system* (3.1.1.1) primarily comprising human *feces* (3.1.2.4) and *urine* (3.1.2.3), menstrual blood, bile, flushing water, anal cleansing water, toilet paper, and, in some systems, greywater resulting from hand washing, menstrual hygiene products, and/or organic waste

Note 1 to entry: Input to *non-sewered sanitation systems* (3.1.1.1) within the scope of this document excludes greywater apart from greywater resulting from hand washing.

**3.1.2.2**
**output**
substances exiting the *non-sewered sanitation system* (3.1.1.1), which include the products of the backend treatment process (solid output and effluent) as well as noise, air, and odor emissions

**3.1.2.3**
**urine**
liquid product of the human excretory system produced by the kidneys and expelled through the urethra via urination (i.e. micturition)

**3.1.2.4**
**feces**
solid waste products of the human digestive system, including microorganisms

Note 1 to entry: Feces vary significantly in appearance (i.e. size, color, texture), according to the state of the digestive system, diet, and general health.

**3.1.2.5**
**diarrhea**
loose, watery *feces* (3.1.2.4), often resulting from viral or bacterial infection

**3.1.2.6**
**effluent**
treated liquid discharged from the *backend* (3.1.1.4)

**3.1.2.7**
**chemical and biological additives**
substances added to the *non-sewered sanitation system* (3.1.1.1) either to support the treatment process or to clean the system, including, but not limited to, chemical substances, biological agents, and other deodorants, bactericides, bacteriostats, microbiocides, chemical reactants, surfactants, or enzymatic agents

**3.1.2.8**
**energy supply**
supply of energy from electrical grid, photovoltaic, or other source (e.g. mechanical storages, pressurized air reservoirs) that powers the *non-sewered sanitation system* (3.1.1.1)



**3.1.2.9**
**electrical energy**
energy derived from an electric current, which can be supplied by a variety of means such as connection to upstream electric power grid, batteries, or photovoltaic systems

### 3.1.3 System safety and integrity

**3.1.3.1**
**hazard**
potential source of harm

Note 1 to entry: Harm can include physical injury, aversive psychological experience, or damage to health.

**3.1.3.2**
**risk**
combination of the probability of occurrence of harm and the severity of that harm

[SOURCE: ISO 12100:2010, 3.12]

**3.1.3.3**
**risk analysis**
combination of the specification of the limits of the machine, hazard identification, and risk estimation

[SOURCE: ISO 12100:2010, 3.15]

**3.1.3.4**
**risk evaluation**
judgment, on the basis of *risk analysis* (3.1.3.3), of whether the risk reduction objectives have been achieved

[SOURCE: ISO 12100:2010, 3.16]

**3.1.3.5**
**risk assessment**
overall process comprising a *risk analysis* (3.1.3.3) and a *risk evaluation* (3.1.3.4)

[SOURCE: ISO 12100:2010, 3.17]

**3.1.3.6**
**guard**
physical barrier, designed as part of a *non-sewered sanitation system* (3.1.1.1) to provide protection

[SOURCE: ISO 12100:2010, 3.27, modified – non-sewered sanitation system specified]

**3.1.3.7**
**safe state**
operating mode of a *non-sewered sanitation system* (3.1.1.1) with an acceptable level of *risk* (3.1.3.2) for users and professional service personnel

Note 1 to entry: The safe state mode protects the user or service personnel by preventing potentially hazardous conditions (e.g., in the event of a malfunction or following intentional stoppage).

[SOURCE: ISO 25119-1:2010, 3.43, modified – non-sewered sanitation system specified and note added]

**3.1.3.8**
**exposed materials**
materials used within the *non-sewered sanitation system* (3.1.1.1) that come into contact with human *urine* (3.1.2.3) or *feces* (3.1.2.4), or intermediate and residual products in the course of operation of the system

**3.1.3.9**
**water tightness**
ability of the closed *non-sewered sanitation system* (3.1.1.1) to resist water penetration

[SOURCE: ISO 15821:2007, 3.6, modified – non-sewered sanitation system specified]

**3.1.3.10**
**technical tightness**
inherent characteristics of a *non-sewered sanitation system* (3.1.1.1) that prevent fluids, gases, or dusts from passing from the external through to the internal environment, or from the internal to the external environment, or both; the sanitation system or components thereof are considered technically tight if the leakage rate does not exceed 0,000 01 mbar 1/s

[SOURCE: ISO 11933-4:2011, 3.5, modified - sanitation system and leakage rate specified]

**3.1.3.11**
**strength safety factor**
ratio between the load (or pressure) at the material yield strength and the limit load (or pressure)

Note 1 to entry: The strength safety factor prevents structures from experiencing fractures, deformation, and fatigue.

[SOURCE: ISO 14622, 2.10, modified]

**3.1.3.12**
**proven**
demonstrated through testing and validation, systematic analysis of operational experience, or other suitable qualification methods to be safe, effective, and reliable for the intended usage

### 3.1.4 System use and impact

**3.1.4.1**
**intended use**
use of a *non-sewered sanitation system* (3.1.1.1) in accordance with the information for use provided in the instructions and the design limits of the manufacturer

**3.1.4.2**
**reasonably foreseeable misuse**
use of a *non-sewered sanitation system* (3.1.1.1) in a way not intended by the supplier, but which may result from readily predictable human behavior

Note 1 to entry: Behaviors of interest include incorrect operation of the system such as overuse, inappropriate activation of mechanical and electrical controls, and depositing inappropriate materials into the frontend.

[SOURCE: ISO/IEC Guide 51:1999, modified – note added and sanitation system specified]

**3.1.4.3**
**intended users**
for the purpose of this document, the intended users refer to 90% of people worldwide who currently do not have access to safe sanitation

Note 1 to entry: Meeting the needs of the intended users is expected to also ensure that non-sewered sanitation systems complying with this document meet the needs of users from all countries and contexts with regard to general safety and performance requirements.

**3.1.4.4**
**sustainability**
state of the global system, including environmental social and economic aspects, in which the needs of the present are met without compromising the ability of future generations to meet their own needs

[SOURCE: ISO Guide 82]

## 3.2 Abbreviations

| | |
|---|---|
| AHRI | Air Conditioning, Heating, and Refrigeration Institute |
| APHA | American Public Health Association |
| ANSI | American National Standards Institute |
| ASME | American Society of Mechanical Engineers |
| BOD | Biological oxygen demand |
| CAPEX | Capital expenditure |
| CEN/CENELEC | European Committee for Standardization/European Committee for Electrotechnical Standardization |
| COD | Chemical oxygen demand |
| EMC | Electromagnetic compatibility |
| EN standards | European standards |
| EPA | U.S. Environmental Protection Agency |
| HACCP | Hazard analysis and critical control point |
| HAZOP | Hazard and operability study |
| IEC | International Electrotechnical Commission |
| IP | Ingress Protection |
| IS standards | Indian standards |
| JMP | Joint Monitoring Programme |
| MOP | Maximum operating pressure |
| NIOSH | National Institute of Occupational Safety and Health |
| NPV | Net present value |
| NSF | NSF International |
| OPEX | Operating expense |
| OSHA | Occupational Safety & Health Administration |
| PSLC | Product safety life cycle |

| | |
|---|---|
| RCD | Reliability centered design |
| SSF | Strength safety factors |
| TSS | Total suspended solids |
| TTC | Thermo-tolerant coliforms |
| UN | United Nations |
| UNICEF | United Nations Children's Emergency Fund |
| VDI | Verein Deutscher Ingenieure (Association of German Engineers) |
| WC | Water closet, used in "WC pan," which refers to receptacle portion of the frontend on which a user sits |
| WHO | World Health Organization |

### 3.3 Units

| | |
|---|---|
| bar | metric unit of pressure equal to 100,000 Pa and thus, approximately equal to the average atmospheric pressure at sea level. |
| cm | centimetre |
| dB | decibels |
| dBA | A-weighted decibels |
| g | gram |
| kg | kilogram |
| kJ | kilojoule |
| kPa | kilopascal |
| kWh | kilowatt hour |
| l | litre |
| m | metre |
| mg | milligram |
| mm | millimetre |
| MOP | maximum operating pressure |
| N | newton |
| s | second |
| USD | United States dollar |
| °C | degrees Celsius |



## 4 General requirements

### 4.1 User requirements

The non-sewered sanitation system shall be designed and realized in such a way as to ensure that the intended users can use the system safely and in the manner intended by the manufacturer. The design and realization of the system shall ensure that users who are illiterate and those who do not have technical experience are able to safely and effectively use the technology.

NOTE Additional requirements for specific users, such as people with disabilities or small children, are provided, for example, in CEN/CENELEC-Guide 6 (Guidelines for standards developers to address the needs of older persons and persons with disabilities), ISO/IEC Guide 71 (Guide for addressing accessibility in standards) and ISO TR 22411(Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities).

## 4.2 Metric system

Design and construction of non-sewered sanitation systems shall be specified and realized in metric units of measurement.

## 4.3 Design capacity

### 4.3.1 Treatable input

Non-sewered sanitation systems shall be capable of treating, at a minimum, feces, urine, menstrual blood, bile, flushing water, anal cleansing water, and toilet paper.

NOTE Systems treating greywater, aside from greywater from hand washing, are outside the scope of this document.

### 4.3.2 Treatment capacity

The design capacity with regard to human feces and urine shall be indicated as expected uses per day (fecal uses/day and urine uses/day). The average amount of feces (kg/use) and urine (l/use) per use shall be determined as the basis for capacity calculations and shall be clearly indicated. Additionally, the expected daily capacity for further input (such as water, menstrual hygiene products, and organic waste) shall be indicated by the manufacturer (in units such as kg/day or l/day).

EXAMPLE A 2014 international report on fecal sludge management [Strande, Ronteltap, and Brdjanovic, 2014], measured the average fecal production rate as 250 g/person/day to 350 g/person/day for low income countries, 250 g/person/day for urban low-income settings and 350 g/person/day for rural low-income settings, and found general urine production rates for adults to be 1 000 to 1 300 ml/person/day.

### 4.3.3 Menstrual hygiene products

Mechanisms and/or devices for disposal of menstrual hygiene products should be incorporated into the design of the sanitation system or the superstructure.

### 4.3.4 Overload protection

A reasonable safety factor shall be incorporated into the design and indicated by the manufacturer in order to prevent overload. In order to indicate when the system is nearing maximum capacity (design capacity plus safety factor) the system shall be equipped with a mechanism indicating to the user that the system is overloaded and therefore not usable. Should overload occur, the system shall enter into a safe state that prevents any hazards due to overload.

### 4.3.5 Operability following non-usage or short-term shutdown

The system shall remain operable after a minimum period of 60 h of system non-usage without causing malfunctions or requiring additional efforts to resume operation that exceed normal operating procedures.

Following short-term shutdown of a minimum period of 60 h, the system shall be usable immediately.

NOTE Potential periods to which 4.3.5 applies include non-usage when the user is traveling or shutdown for maintenance.

#### 4.3.6 Long-term shutdown

The sanitation system manufacturer shall provide precise instructions for preparing the system for long-term shutdown (i.e. more than 60 h). The instructions shall describe the procedures for achieving safe and stable system shutdown conditions.

The manufacturer shall clearly indicate the duration of time necessary to complete the long-term shutdown process. The long-term shutdown process should not require more than 10 h for completion.

The sanitation system shall be usable immediately following long-term shutdown.

#### 4.3.7 Continuous use

The sanitation system shall allow continuous use of the system without unreasonable waiting times between users.

### 4.4 Performance requirements

#### 4.4.1 General

When operated, maintained, and used in accordance with the manufacturer's instructions, the following requirements shall be met under all potential operating conditions (see 4.8). Continuous monitoring or regular testing of output requirements may be implemented after installation.

#### 4.4.2 Solid output and effluent requirements

Solid output and effluent shall be fully treated within the sanitation system allowing for its safe reuse or disposal. Solid output and effluent shall meet the requirements specified in 7.2.9.2.1 and 7.2.9.2.2 at all times.

#### 4.4.3 Odor emissions requirements

In order to minimize odor emissions from the sanitation system, the requirements in 7.2.9.3 shall be met when tested according to A.3.5.

NOTE Potential origins of odor emissions from the sanitation system include fecal odors (feces and urine, and aging of feces and urine), and process odors such as those emerging during drying, pyrolysis, combustion, and discharge of output.

#### 4.4.4 Noise requirements

Noise emissions from the non-sewered sanitation system shall not pose risks to the health and psychological wellbeing of the user. When tested according to A.3.7, the sanitation system shall meet the requirements specified in 7.2.9.4.

#### 4.4.5 Air emissions requirements

Potential air emissions from non-sewered sanitation systems can be classified as pollutants or explosive gases. The monitoring of explosive gases during operation is addressed in 4.13.2. The following provision addresses air pollutants. Air pollutants from the non-sewered sanitation system released indoors and outdoors shall not exceed a level that poses risks to the health of the user. When tested according to A.3.6, the sanitation system shall meet the requirements specified in 7.2.9.5.

### 4.5 Expected design lifetime

Non-sewered sanitation systems shall be designed for a serviceable life of not less than 10 years, assuming use and maintenance according to the manufacturer's specifications. See 4.14 for maintenance requirements and Annex C for user manual requirements.



## 4.6 Aspirational and ergonomic design

Non-sewered sanitation systems shall be designed and realized not only for functionality but also for comfort. Non-sewered sanitation systems should also be designed for aesthetic satisfaction and sensory appeal. Designers should strive to evoke cleanliness in the appearance and user experience of the frontend.

## 4.7 Secure design

In order to prevent theft or tampering, all accessories, parts, and components of the non-sewered sanitation system shall be assembled or affixed in such a way as to deter removal or dismantling by unauthorized parties.

EXAMPLE Design requiring the use of tools for removal or dismantling of any accessories, parts, and components can help to deter theft.

## 4.8 Operating conditions

### 4.8.1 Ambient temperature range

Non-sewered sanitation systems shall operate safely and reliably in environments with ambient temperatures between 5°C and 50°C, which shall be understood as the requisite primary range for all systems complying with this document. Technologies designed for use in environments with ambient temperatures above or below this range shall additionally demonstrate their capability to operate safely and reliably in these expanded ambient temperature ranges.

### 4.8.2 Ambient air humidity

Non-sewered sanitation systems shall operate safely and reliably in ambient air humidity conditions between 20% and 100%.

### 4.8.3 Atmospheric pressure

Non-sewered sanitation systems shall operate safely and reliably under atmospheric pressure conditions ranging from sea level (101 kPa) to 2 500 m altitude (76 kPa).

## 4.9 Sanitary requirements

### 4.9.1 General

Non-sewered sanitation systems shall operate safely and reliably within sanitation environments such as those involving wastewater or sludge. Relevant materials, equipment, components, connections, and joining elements of the non-sewered sanitation system shall be selected based on their suitability for such applications, and should be explicitly designed or approved for application in sanitation systems. Proof of appropriateness shall be provided for any relevant materials, equipment, components, connections, and joining elements not explicitly designed or approved for use in sanitation systems and can be demonstrated through risk assessments or other commonly accepted methods (e.g., failure mode and effects analysis, material testing, material safety data sheets).

### 4.9.2 Hygienic design

Non-sewered sanitation systems shall be designed and realized in such a way as to mitigate any risk of infection due to potential pathogens from human urine or feces or the intermediate and residual products of the sanitation system.

Non-sewered sanitation systems shall be closed systems that minimize the entry of insects and vermin to the subsystems.

### 4.9.3 Tightness

All installations that contain, transport, or store liquids shall achieve water tightness, at a minimum. In cases in which the results of a safety assessment (see 5.1) indicate hazards that require mitigation through a higher degree of system tightness (e.g., potentially dangerous gases), technical tightness shall be achieved.

NOTE Flood resistance of non-sewered sanitation systems is an additional consideration for flood-prone areas.

Related testing procedures are provided in A.3.1.

### 4.9.4 Cleanability of surfaces

Surfaces of exposed materials and related joining elements, reservoirs, and piping shall be smooth and easily cleanable. Thus, relevant surfaces shall be:

a) clear of pits and occlusions and have neither ridges nor crevices that could harbor organic materials; and

b) designed and realized in such a way as to minimize projections, edges, and recesses.

Surfaces of exposed materials shall be designed and realized in such a way as to ensure that feces and residual substances can be removed by common cleaning methods and without requiring the use of specialized chemical cleaning agents. Overall cleanability should be equal to or exceeding that of a No. 3 100 to 120 grit finish on stainless steel.

NOTE No.3 100 to 120 grit steel is stainless steel featuring short, relatively coarse, parallel polishing lines, which extend uniformly along the length of the coil, achieved with 100 to 120 grit abrasives.

### 4.9.5 Chemical and biological additives

Non-sewered sanitation systems should not necessitate the use of chemical and/or biological additives. Systems that do require such additives shall not necessitate their use in a manner or to a degree that exceeds acceptable health or environmental risks. The manufacturer of the sanitation system shall provide documentation concerning risks and instructions on proper use and handling of any additives necessary for system function (e.g. safety data sheets from the manufacturer of the relevant additives) and declaring compliance with the relevant national regulations and laws (see Annex C).

## 4.10 Material requirements

### 4.10.1 Durability of materials

Materials used for non-sewered sanitation systems shall be structurally stable, durable, and, where relevant, watertight, and shall be resistant to the effects of:

a) any potentially damaging or corrosive substances to which they are exposed in the course of operation in sanitation environments, such as those involving wastewater or sludge (e.g., municipal wastewater, aerosols, sewage gases, and other atmospheric or micro-atmospheric influences);

b) extended use of any chemical and/or biological additives associated with normal operation and maintenance of the system;

c) typical chemical agents used for regular cleaning and disinfection;

d) fatigue, ageing, and degradation; and

e) stresses and wear during shipping, assembly, installation, operation, and maintenance.

Durability shall be achieved either through the use of materials inherently resistant to corrosion (e.g., stainless steel) or through the application of suitable coating. Where possible, anti-corrosion protection shall be integrated into the system manufacturing process.

If two or more different materials are connected within the sanitation system, detrimental galvanic corrosion shall be prevented. If components that bear mechanical loads are made of plastic material, detrimental effects of the environment (e.g. UV-radiation, temperature) shall be prevented.

#### 4.10.2 Fire resistance of materials

Non-sewered sanitation systems shall achieve acceptable fire resistance. Relevant surfaces shall not ignite, progressively glow, smolder, or show evidence of being functionally impaired when exposed to a source of ignition. Materials shall be certified in accordance with ISO 10295 or equivalent.

### 4.11 Connections and joining elements

Connections (e.g. welds, joints) within non-sewered sanitation systems shall be durable and capable of withstanding stresses and wear during shipping, assembly, installation, operation, and maintenance. Connections shall resist corrosion. Joining elements applied (e.g. nuts, bolts, washers, screws) that are in contact with sanitation environments such as those involving wastewater or sludge shall be corrosion resistant (e.g. stainless steel of class A2 or A4; for more information see ISO 3506-1, ISO 3506-2, ISO 3506-3).

Applied connection methods shall conform to proven state-of-the-art approaches. Connections identified as essential to safe operation or process reliability (see 5.1) shall be maintenance free. Location, type, and specification of relevant connections should be clearly indicated by the manufacturer in schematic diagrams provided with the system.

Reasonably foreseeable errors in applying connections and joining elements that could be a source of risk shall be prevented, primarily by the selection and combination of these elements, as well as their design and realization. The direction of movement or conveyance of moving parts and transition components of the sanitation system shall be clearly indicated by the manufacturer in schematic diagrams. Where a faulty connection (e.g., electric wiring or pipework) could pose a risk, incorrect connections shall be made impossible by design (e.g., by means of mechanical coding).

### 4.12 General safety design requirements

#### 4.12.1 Safety of edges, angles, and surfaces

Surfaces and parts of non-sewered sanitation systems with which users or service personnel can come into contact shall not present hazards in the form of rough or sharp edges or unduly sharp points.

#### 4.12.2 Fire and explosion protection

Non-sewered sanitation systems shall be designed and realized in such a way as to avoid any risk of fire or overheating caused by operation or malfunctions of the non-sewered sanitation system itself, or by gases, liquids, dust, vapors, or other substances generated or used in the process of the system's operation.

Non-sewered sanitation systems shall be designed and realized in such a way as to avoid any risk of explosion caused by explosive atmospheres or substances generated by the backend treatment technologies and processes including gases, liquids, dust, vapors, or other substances produced.

Hazardous accumulations of potentially explosive gases, liquids, dust, vapors or other substances shall be monitored reliably, and appropriate mitigation measures shall be taken by the manufacturer, accounting for, at a minimum, the lower explosive limit and the evaluation of the potential sources of ignition. This protection can be realized either through appropriate design of the sanitation system that makes safety inherent, or through incorporation of safety-related installations and equipment that control any risk of explosion.

In systems in which combustion/incineration processes are applied, relevant fire and explosion hazards shall be controlled through safety-related functions with proven reliability (see 5.6.3).

NOTE Potential sources of hazards include slagging, blockage of the exhaust, and inferior quality of the fuel material.

### 4.12.3 Structural integrity

Materials, equipment, components, connections, and joining elements within the sanitation system shall be capable of withstanding both static and dynamic stresses of expected operation.

Where a risk of rupture or disintegration remains despite countermeasures, the parts concerned shall be mounted, positioned, and/or guarded in such a way as to contain any hazards. Installations and pipes, whether rigid or flexible, that carry fluids and/or gases shall be capable of withstanding the defined internal and external stresses, and shall be firmly attached and/or protected to ensure that no risk is posed by a rupture.

Strength safety factors (SSF) shall be proven to achieve the following levels (see ISO 14622 for further information):

— For hazards that can cause injuries and fatalities, SSF $\geq$ 3

— For hazards that halt backend operations, SSF $\geq$ 2

— For hazards that cause inconvenience, SSF $\geq$ 1.5

### 4.12.4 Reuse of effluent

Sanitation systems that do not meet effluent requirements for flushing or handwashing (see 7.2.9.2.2) shall prevent this type of reuse in the design of the system through reasonably practical means.

### 4.12.5 Underground systems

Components of non-sewered sanitation systems positioned below ground level (e.g., for protection against extreme low temperatures) shall be capable of withstanding exposure to geotechnical impacts such as earth and hydrostatic pressures throughout the course of operation without loss of structural integrity.

### 4.12.6 External impacts

Non-sewered sanitation systems and their components and fittings shall be stable to prevent tilting, overturning, falling, or uncontrolled movements. If the shape or structure of the system does not offer both sufficient tilting stability and sufficient stability under mechanical load, then appropriate means of anchorage shall be incorporated in the manufactured product and their use shall be specified in the user manual (see 4.15.5).

The system shall reliably resist reasonably expected external mechanical impacts incurred during transport, installation, normal operation, and maintenance.



## 4.13 Information and marking

### 4.13.1 Information and warnings

Information and warnings on non-sewered sanitation systems shall be provided through clear and unambiguous symbols or pictograms to ensure the intended user's comprehension.

A data plate, label, or sticker visible to the user in the vicinity of the frontend and near to the failure signal shall include, at a minimum,

a) expected number of users and uses per day (users/day and uses/day); (see 4.3.2),

b) expected daily capacity for further input such as water, menstrual hygiene products, and organic waste (kg/day or l/day); (see 4.3.2),

c) common items that shall not be added to the system, and

d) instructions for obtaining service.

Additionally, if the effluent of the system does not meet drinking water requirements (see 7.2.9.2.2), a data plate, label, or sticker shall be placed in a location visible to the user in the vicinity of the backend warning the user that the effluent is not drinkable.

Plates and labels shall be permanent and clearly legible.

Written information and warnings shall be composed at the reading level of the intended users and shall incorporate all information specified in Annex C. Information shall be provided a) in the official local language(s) of the country of use and additionally b) in the English language. Warnings shall clearly indicate the extent of the safety risk.

### 4.13.2 Marking and labeling

Non-sewered sanitation systems shall have permanent and legible data plates. The information shall be provided a) in the official local language(s) of the country of use and additionally b) in the English language.

Data plates shall include, at a minimum,

a) manufacturer's name and address,

b) model number,

c) serial number,

d) date of manufacture, and

e) tare weight of the system.

## 4.14 Maintenance

### 4.14.1 Reasonable configuration, adjustment, and maintenance activities

Non-sewered sanitation systems shall be designed and realized in such a way that frequency and complexity of configuration, adjustment, and maintenance activities to be performed by the user and the professional service personnel are reasonable with respect to the expectations, technology, and level of professional training present in the setting of intended users.

See D.2 to determine the suitability of a sanitation system for a given location and users regarding frequency and complexity of configuration, adjustment, and maintenance activities.

### 4.14.2 Location and access of configuration, adjustment, and maintenance points

Configuration, adjustment, and maintenance points shall be located separate from any hazardous areas. Removal of system blockages, when necessary, shall be processed from the outside of the sanitation system and shall not necessitate any disassembly.

Non-sewered sanitation systems shall be designed and realized in such a way as to ensure that configuration, adjustment, and maintenance can be performed while the sanitation system is in a safe state. Configuration, adjustment, and maintenance shall not necessitate contact with feces, urine, intermediate process products, or residual products.

NOTE The provisions of 4.15.2 relate to preventing contamination and minimizing risk of infection.

### 4.14.3 Discharge and cleaning

Non-sewered sanitation systems shall facilitate the complete discharge of liquids, gases and aerosols, and solids from the system, including those deriving from the system's use as well as those derived from cleaning, disinfecting, and rinsing. Sanitation systems should include a safe state mode for this purpose. Systems shall provide a clear and distinctive indication when discharge is completed.

If it is necessary to discharge partially treated materials, either liquid or solid, these partially treated materials need not meet the requirements for solid output and effluent put forth in this document.

### 4.14.4 Tools and devices

If specialized tools are required for emptying and maintaining the non-sewered sanitation system, then these specialized tools shall be addressed in the user manual (see 4.14.5) and supplied with the system.

### 4.14.5 User manual

A user manual with clear and definitive instructions to users and service personnel for configuration, adjustment, and maintenance of the non-sewered sanitation system shall be provided. At a minimum, the user manual shall clearly define all necessary procedures, activities, and schedules for configuration, adjustment, and maintenance that are essential to keeping the system safe and operational. Detailed requirements for user manuals are provided in Annex C.

### 4.14.6 Handling and transport of the sanitation system

Non-sewered sanitation systems shall be capable of safely withstanding handling and transport to another location and, if required, withstanding storage safely and without incurring damage. The manufacturer shall clearly indicate which ambient conditions the sanitation system can withstand during handling and transport if the values differ from those specified in 4.8.1.

When transported, systems shall not produce sudden movements or unintended discharge of tanks, pipes, or any instability-related hazards. If required, appropriate attachments for lifting gears or fixation points shall be provided to ensure the safe transport of the system.

NOTE Although 4.14.6 is not intended to represent non-sewered sanitation systems as primarily mobile systems, it does apply to such mobile solutions.



# 5 Technical requirements

## 5.1 Safety assessment

The manufacturer of a non-sewered sanitation system shall carry out either an iterative risk assessment or an equally effective assessment capable of demonstrating proven safety of sanitation systems. The safety assessment shall:

a) determine the particular health and safety requirements that apply to the product;

b) determine risk-mitigating measures to be taken; and

c) demonstrate the safety of the product.

This assessment should be carried out during the design process; the assessment may be carried out after the design process. The assessment shall cover the relevant life cycle of the sanitation system, giving consideration to its expected use and reasonably expected misuse.

Additional requirements for risk assessments are provided in B.1.

A product safety life cycle (PSLC) should be implemented as part of a risk management process that considers all relevant progressions within the general product development process (e.g., research and development, procurement and production, quality assurance, quality management). PSLC requirements are provided in B.3.

## 5.2 Operational requirements

### 5.2.1 General

The sanitation system shall meet basic functionality requirements such as starting of sanitation system operation, stopping of sanitation operation, and activating an emergency stop.

### 5.2.2 Intentional starting of sanitation system operation

Starting and restarting of the system through voluntary actuation, including restarting after a stoppage, shall either be enabled through a single dedicated control device or, in systems in which the backend treatment processes prevent the use of a single dedicated device, shall be enabled through a logical sequence of control actions that is clearly indicated by the manufacturer.

If the starting of the sanitation system operation requires mechanical force to be applied by users, this force shall be no greater than 75 % of the maximum physical force that can reliably be generated by a female in the 5th percentile of size within the intended users. If no data is available, a maximum physical force between 20 N and 25 N can be assumed.

NOTE The 5th percentile value relates to the distribution of anthropometric values. This subclause is intended to ensure that the system can be comfortably operated by adults in the intended users, including its smallest women.

### 5.2.3 Intentional stopping of sanitation system operation

The non-sewered sanitation system shall be equipped with a control device or clearly indicated sequence of control actions that brings relevant processes and operations safely to a complete stop and safe state. If a safe state cannot be immediately achieved upon activation of the control device/sequence and requires a transition period following initiation of the stop control(s), the duration of this transition period shall be clearly indicated by the manufacturer. The safety of the system during this transition period shall be ensured by a safety-related function (see 5.6.3). The stop control shall retain priority over the start and operational controls.

#### 5.2.4 Emergency stop

If relevant and applicable, the non-sewered sanitation system shall be equipped with one or more emergency stop devices that safely halt all mechanical and electrical processes and operations and cut off energy supply. Manufacturers of non-sewered sanitation systems should consult ISO 13850 for additional guidance concerning emergency stop functions.

### 5.3 Reliability and safety requirements for energy supply

#### 5.3.1 Security of energy supply

Failure of the primary energy supply (e.g., through deficiency, absence, or failures in energy return) shall not trigger hazardous system conditions. This hazard prevention may be realized through automatic system transition to a safe state or through the provision of an appropriate redundant source of energy. The minimum capacity of the redundant source of energy should be sufficient to allow the safe preparation of the system for a long-term shutdown (see 4.3.6). The amount of energy supplied by the redundant source shall be indicated to the user.

In sanitation systems in which photovoltaic energy serves as the primary energy source, the capacity of the redundant source of energy shall reflect the specific solar radiation disruptions in the geographic setting for which the non-sewered sanitation system is designed.

#### 5.3.2 Safety requirements for electrical energy supply

##### 5.3.2.1 Separation and isolation

The energy supply shall be separable and isolatable from the sanitation system through state-of-the-art safety devices such as circuit power switches, fuses, or other proven interlock devices. Isolators shall be made clearly noticeable by marking and arrangement and shall be capable of being locked if reconnection could endanger humans (e.g., during configuration, adjustment, and maintenance).

If the non-sewered sanitation system is plugged into an electrical outlet, removal of the plug is sufficient to satisfy these requirements for separation and isolation of the energy source, provided that the operator can verify from any of the points to which he or she has access that the plug remains removed.

##### 5.3.2.2 Energy discharge

The non-sewered sanitation system shall be equipped with a means of discharging any energy remaining or stored in the system following isolation from the energy supply (see 5.3.2.1) in order to achieve a safe state and prevent hazards in accordance with 5.2.4.

Subsystems of the sanitation system that autonomously supply or store energy need not be discharged if these subsystems can be separated from the system (e.g., through separation switches) in such a way as to ensure that the safe state of the system is not affected and hazards do not emerge from the subsystem.

#### 5.3.3 Safety requirements for non-electrical primary energy supply

Non-sewered sanitation systems deriving energy from sources other than electrical energy shall be designed, realized, and equipped in such a way as to ensure that hazards associated with the energy supply are prevented. If applicable, the requirements given in 5.3.2 shall be met for systems deriving their primary energy supply from non-electrical sources.

## 5.4 Mechanical requirements

### 5.4.1 Pressurized equipment

Pressurized equipment with a nominal operation pressure higher than 0,5 bar shall be designed and realized so as to withstand the mechanical loading pressure to which the equipment is subjected, including appropriate structural strength safety factors.

Overpressures shall be controlled by appropriate and proven safety relief valves.

### 5.4.2 Pipes, hoses and tanks

Pipes and hoses shall be positioned and, if necessary, restrained to minimize deterioration resulting from contact with other elements of the system (e.g., hot surfaces, sharp edges). Pipes, hoses, and fittings shall be safely accessible for visual inspection.

Tanks and other storage vessels shall be capable of withstanding the stresses of prolonged containment of the relevant substances without breakage or other structural damage or deformation.

NOTE Some cosmetic damage is expected during the lifetime of the tanks and storage vessels.

Storage vessels shall be provided with means of determining their fluid levels (e.g. fluid level indicators). Excessive pressure in storage vessels exceeding MOP shall be automatically compensated via a suitable device (e.g., vent, safety valve).

### 5.4.3 Moving and rotating parts

Risks associated with moving and rotating parts of the sanitation system shall be minimized either through design that prevents human contact with such parts or through the application of appropriate guards or protective devices.

Non-sewered sanitation systems shall be designed and realized so as to prevent accidental blockage of moving parts.

### 5.4.4 Backflow prevention

If the sanitation system is connected to the water supply system, then backflow shall be prevented in accordance with ASME A112.1.2 or an equivalent national or international standard.

## 5.5 Requirements for radiation

### 5.5.1 High temperatures of parts and surfaces

Accessible parts or surfaces of the sanitation system that exceed the temperature of 60°C shall be equipped with protection measures or fixed guards sufficient to prevent burn injuries.

### 5.5.2 Low temperatures of parts and surfaces

Accessible parts or surfaces of the sanitation system that fall below the temperature of minus 20°C shall be equipped with protection measures or fixed guards sufficient to prevent injuries due to low temperatures.

### 5.5.3 Other sources of radiation

Undesirable radiation emissions from the sanitation system shall be eliminated or be reduced to safe levels.

NOTE Other sources of radiation include laser, ultraviolet, or infrared radiation.

## 5.6 Electrical and electronic equipment

### 5.6.1 Safety and reliability of electrical and electronic equipment

Electrical equipment such as pumps, drives, fans, or control systems shall be durable, require minimal maintenance, be adequately protected from any aggressive environment, and be capable of being easily serviced. These safety requirements shall be achieved by appropriate safety devices such as circuit breakers and fuses. Requirements of applicable equipment standards (such as applicable parts of IEC 60335) should be met.

Minimum safety requirements shall provide, at a minimum:

a) adequate insulation and protection against hazards of direct and indirect live parts, and appropriate protection measures against short circuits and arcs;

b) electrical protection appropriate to the operating conditions, at a minimum complying with IP44 where required (further information on electric protection classes can be found in IEC 61140); and

c) compliance with the requirements of electromagnetic compatibility (EMC), i.e. sanitation system operation shall not be disturbed by any external source of a relevant electromagnetic field, nor shall the electromagnetic field of the sanitation system disturb the operation of external electrical equipment (further information on EMC and suitable thresholds can be found in IEC 61000-6-1 and IEC 61000-6-3).

### 5.6.2 Control system

The non-sewered sanitation system should incorporate a control system that serves to acquire and process data and information regarding the safe, reliable, and efficient operation of the system. Information on relevant safety requirements can be found in ISO 13849-1.

Necessary control actions and required measurements shall be specified at an early design stage and shall reflect operation and installation conditions and the results of the assessment described in 5.1.

The control system shall ensure that:

a) devices of conveyance and treatment processing shall not start unexpectedly if by doing so they would pose a hazard to the user or professional service personnel; further, their startup shall be indicated on the control display;

b) automatic or manual stopping of the controlled moving parts of sanitation system shall be unimpeded;

c) protective devices identified as necessary (see 5.1) shall remain fully effective or issue a stop command; and

d) the signaling system shall indicate status and include failure modes to inform the user of system availability or operational failure (e.g., electrical, mechanical, or hydraulic failure) of the system. The manufacturer shall indicate the type of failure corresponding to each alarm.

The control system shall be capable of detecting, at a minimum:

— failure of electrical and mechanical components critical to the treatment processes, and shall deliver a visible or/and audible failure signal to the user; and

— the overall availability for use, and shall deliver a visible or/and audible signal to notify the user of system unavailability.

Further control points should be defined based on HACCP, HAZOP, or a comparable proven method. Control systems shall be designed and realized in such way as to ensure functional robustness with respect to external impacts, component failure (hardware and software), and human-machine interface. Failure shall reliably bring the system into safe state mode.

#### 5.6.3 Safety-related function of the control system

If the safety assessment (see 5.1) reveals the need for additional safety-related functions within the control system, then these control functions should be developed, designed, verified, and validated in consideration of the principles contained in ISO 13849-1 and ISO 13849-2.

The safety-related functions shall be designed and realized in such a way as to meet the safety integrity requirements and effectively mitigate the risks identified in the safety assessment (see 5.1).

NOTE Safety integrity requirements relate to architecture, diagnostic capacity, and reliability of the safety-related function.

### 5.7 Reliability of conveyance devices

The mechanical and hydraulic design of conveyance devices (e.g., internal pipework, connections and screws) shall prevent back flows, blockage, and surcharging during normal operation. Conveyance devices shall be designed and realized so that transport capacity and performance meet the requirements of 4.3.2.

### 5.8 Transitions from the backend

Process transitions produced by the backend shall not provoke sensations of discomfort for the user nor result in hazards to the system's integrity.

NOTE Typical transition phenomena include vibration, shock, cold, or heat.

When tested according to ISO 10816-1, the vibration level in the XYZ-axis at any possible area of the frontend user interface of non-sewered sanitation systems shall not exceed 0,5 $m/s^2$.

## 6 Additional requirements for the frontend

### 6.1 General

Requirements specific to the frontend apply to non-sewered sanitation systems in which frontend components are included as part of the manufactured product.

### 6.2 Use and operation

#### 6.2.1 General usability requirements

The design of the frontend shall meet ergonomic requirements of the intended users. Anthropometric data of the intended users should inform the design of all areas and parts accessed by the users, in accordance with ISO 7250.

The sanitation system shall be easy to use. The frontend shall meet the usability needs of the intended users. Designers shall ensure that a) the intended users regards the system controls as intuitive, b) the actions required to control operations follow a logical sequence, and c) complexity is minimized with respect to control panel signals.

The system shall achieve the following usability conditions:

a) suitable complexity and transparency;

b) self-descriptiveness and intuitive design (look-and-feel);

c) controllability;

d) conformity with user expectations; and

e) error tolerance.

The manual control elements (e.g., hand levers, pedals, switches) and indicators shall be chosen, designed, realized, and arranged, so that:

— they are easy to access and locate according to user expectations;

— neutral positions of the manual control elements are automatically reset after triggering;

— the movement of the manual control elements to activate the flush functions correspond to the intended effect or to common practice, whenever possible; and

— the activation forces are comfortable for the intended users.

### 6.2.2 Requirements for ease of cleaning

The frontend and connected installations that are accessible to the user (e.g., pipes and chutes), shall be designed and realized in such a way as to ensure that the degree of cleaning necessary after use is no greater than that of conventional flushing toilets.

Frontend surfaces shall have curves with a radius sufficient to allow thorough cleaning with common cleaning methods and without requiring the use of specialized chemical cleaning agents. If specialized cleaning tools are required, they shall be indicated and provided by the manufacturer.

### 6.2.3 Requirements for ease of operation

The design and realization of the non-sewered sanitation system shall minimize demands on the user with respect to the performance of periodically recurring operational activities (e.g. usage of rake, adding of bacteria) needed to keep the sanitation system safe and operational. These operational activities shall meet usability requirements defined in 6.2.1. If relevant, clear instructions for performing operational activities shall be provided by the manufacturer (see Annex C).

### 6.2.4 Cultural requirements

The design of the frontend shall anticipate and reflect cultural preferences and common practices. The design of the frontend should aim to accommodate preferences and practices prevalent in the cultural setting for which the sanitation system is designed, including:

a) mode of operation (water use, dry);

b) seating/squatting position; and

c) personal cleansing material (washers/wipers).

If changes to user practices are inevitable in order to ensure improved sanitation, these demands on the user should not exceed reasonable levels and should be clearly explained by user manuals provided by the manufacturer (see Annex C). Further details can be found in D.3.

## 6.3 Visibility of feces

The frontend squatting or WC pan shall ensure a visual barrier to prevent the user from seeing an accumulation of deposited feces from previous users when looking directly into the frontend squatting or WC pan with a viewing angle perpendicular to the floor. If the barrier is formed from a water seal, this seal should be of a minimum depth of 20 mm.

NOTE This requirement refers to the visibility of collected feces that has accumulated in the system as part of its normal operation, not to smudges or streaks within the squatting or WC pan.

## 6.4 Evacuation performance

Urinals, squatting pans, or WC pans applied as part of the frontend of non-sewered sanitation systems may employ evacuation mechanisms ranging from conventional flush (cistern/flush valve), pour flush, and dry flush, to novel evacuation mechanisms such as those employing mechanical forces.

Evacuation mechanisms that comply with relevant international or national standards are deemed to conform with the requirements specified in A.3.3.

Example standards are provided in Table 1; equivalent national standards may be applied.

Where there are no relevant international or national standards for the evacuation mechanism, requirements specified in A.3.3 shall be met. Following assembly of the non-sewered sanitation system, the flushing mechanism shall meet the requirements for the adapted flushing tests specified in A.3.3.

**Table 1 — Examples of applicable national standards for evacuation mechanisms**

| Frontend user interface | Evacuation mechanism | | | |
|---|---|---|---|---|
| | Conventional flushing mechanisms (cistern/ flush valve*) | Pour-flush | Dry | Novel evacuation mechanisms |
| WC pan | EN 997 | See A.3.3.4 and A.3.3.6 | | |
| Squatting pan | IS 2556-3 | See A.3.3.5 and A.3.3.6 | | |
| Urinal | EN 13407 | — | ASME A112.19.19 | — |



## 6.5 Integrity against external impacts

The frontend shall reliably resist mechanical loads incurred during transport, installation, normal operation, and maintenance. The requirements of NSF 41, Clause 5.2.1, or equivalent, shall be applied and a static load test shall be conducted.

## 6.6 Slipping, tripping or falling

Frontend areas of the non-sewered sanitation system in which users and/or service personnel are expected to move about, stand, or sit shall be designed and realized in such a way as to prevent slipping, tripping, or falling on or off these areas. Where appropriate, these areas shall be fitted with handholds that are fixed relative to the entrants and that enable them to maintain their stability.

# 7 Performance testing

## 7.1 General testing requirements

Non-sewered sanitation systems shall be tested for performance according to the classifications provided in Table 2.

If the product to be tested is limited to a backend component, then the backend shall be installed for testing purposes with the number and type of frontends specified for average and peak flow by the manufacturer. The distance between the frontend(s) and backend shall be the minimum distance specified by the manufacturer. The system as installed shall be classified as Class 1, Class 2, or Class 3 according to Table 2. Testing related to requirements specific to the frontend (Clause 6) need not be performed for backend-only products.

**Table 2 — Classification of non-sewered sanitation systems**

| Class | Testing Requirements |
|---|---|
| **Class 1:** Non-sewered sanitation systems – one frontend – backend non-biological | Controlled laboratory testing as outlined in 7.2 and field testing according to 7.3.1 |
| **Class 2:** Non-sewered sanitation systems – one frontend – backend includes one or more biological treatment processes | Controlled laboratory testing as outlined in 7.2 and field testing according to 7.3.2 |
| **Class 3:** Non-sewered sanitation systems – more than one frontend | Testing procedures as outlined in 7.2, which may be modified to account for alternative testing environment if the system cannot be installed in a laboratory; additional field testing procedures (see 7.3.2) for systems incorporating biological treatment processes.<br>For systems with 2 to 5 frontends, a minimum of 2 frontends (chosen randomly) shall be tested for all requirements involving the frontend including those of Clause 6 and odor (7.2.9.3), noise (7.2.9.4), and air emissions (7.2.9.5).<br>For systems with more than 5 frontends, a minimum of 3 frontends (chosen randomly) shall be tested for all requirements involving the frontend, including those of Clause 6 and odor (7.2.9.3), noise (7.2.9.4), and air emissions (7.2.9.5). |



## 7.2 Controlled laboratory testing

### 7.2.1 General

Class 1 and Class 2 systems, and Class 3 systems that can be installed in a laboratory (see Table 2) shall be subject to controlled testing in a laboratory. Requirements for laboratory testing as part of the certification process are specified in A.1.

### 7.2.2 Assembly, installation, operation, and maintenance

Assembly and installation of sanitation systems shall be conducted according to the manufacturer's instructions. Sanitation systems shall be started, loaded, operated, and maintained in accordance with the manufacturer's instructions.

If the manufacturer does not supply a superstructure as part of the manufactured product, then a superstructure shall be installed according to the manufacturer's recommendations (e.g., with regard to size and materials) prior to testing. For these sanitation systems that do not include superstructures as part of the manufactured product, the added superstructure shall be removed prior to odor testing (see A.3.5) and noise testing (see A.3.7) and the tests shall be adapted as described in A.3.5 and A.3.7. The presence or absence of a superstructure during odor and noise testing shall be clearly indicated on the test report.

### 7.2.3 Documentation of input

Tests shall be conducted with actual human urine and feces, where specified. For helminth spiking (see A.3.4.3.2), if human feces is not available, animal feces may be used. Feces and urine shall either be directly deposited by users defecating and urinating into the system or be separately collected and subsequently deposited into the system. If users directly use the system during testing, these users should document fecal and urinary events following each use of the sanitation system. For the privacy of those users, the recording document should be kept within the enclosed frontend area.

### 7.2.4 Generated output

During the tests, the generated output shall meet the solid and liquid requirements for the intended reuse or disposal defined in 7.2.9.2.1 and 7.2.9.2.2, and the odor, air, and noise emissions requirements defined in 7.2.9.3, 7.2.9.4 and 7.2.9.5. The manufacturer shall indicate the intended purpose of solid output and effluent designated for reuse.

### 7.2.5 Test observations

During and after testing, the tester shall observe and record

a) any fractures, cracks, and permanent deformations of the sanitation system,

b) any back flows, blockages, and surcharging of conveyance devices (see 5.7), and

c) any ruptures or leakages.

### 7.2.6 Laboratory conditions

Laboratory temperatures shall be between 18 °C and 29 °C.

### 7.2.7 Testing sequence and duration

The system shall be tested according to the testing sequence provided in Table 3. The tests shall be conducted in the order described. The duration of the testing period shall be no less than 35 days and may be extended beyond the suggested 35-day schedule to accommodate backend processes that require more time. The manufacturer and the testing organization shall agree on the testing schedule before testing commences.

The tests specified in 6.4, 6.5, A.3.1, A.3.2, and A.3.3 shall be conducted prior to commencing the testing sequence in Table 3.

Specifications for the testing procedures listed in Table 3 can be found in A.3.8.

**Table 3 — Test sequence of relevant testing procedures**

| Testing procedure | Loading pattern | Suggested schedule | Suggested timeframe (days) |
|---|---|---|---|
| Start-up: Follow start-up procedure according to the manufacturer's instructions | | Start-up duration specified by manufacturer | The timeframe depends on the duration of the start-up period required to achieve system operability and stability. This duration shall be specified by the manufacturer. |
| — Intentional stopping of sanitation system operation<br>— Intentional starting of sanitation system operation<br>— Emergency stop<br>— Intentional starting of system operation | Normal loading pattern | Day 1 and Day 2 | 2 days |
| [none] | Normal loading pattern | Day 3 | 1 day |
| — Solid output and effluent (environmental parameters) | Normal loading pattern | Day 4 | 1 day |
| [none] | Normal loading pattern, adding the specified daily capacity for further input as indicated in 4.3.2 | Day 5 and Day 6 | 2 days |
| [none] | Normal loading pattern | Day 7 | 1 day |
| — Solid output and effluent (environmental parameters) | Normal loading pattern | Day 8 | 1 day |
| — Non-usage of sanitation system | No load | Day 9 to Day 11 | 3 days |
| [none] | Normal loading pattern | Day 12 | 1 day |
| — Solid output and effluent (environmental parameters) | Normal loading pattern | Day 13 | 1 day |
| — Short-term shutdown of sanitation system | No load | Day 14 and Day 15 | 2 days |
| — Solid output and effluent (environmental parameters) | Normal loading pattern | Day 16 | 1 day |
| — Separation and isolation from energy sources<br>— Energy discharge<br>— Reliability | Normal loading pattern | Day 17 and Day 18 | 2 days |
| — Long-term shutdown | No load | Day 19 to Day 23 | 5 days |
| [none] | Normal loading pattern | Day 24 | 1 day |

**Table 3** *(continued)*

| Testing procedure | Loading pattern | Suggested schedule | Suggested timeframe (days) |
|---|---|---|---|
| — Solid output and effluent (human health parameters) | Normal loading pattern | Day 25 | 1 day |
| — Visibility of feces<br>— Discharge and cleaning<br>— Solid output and effluent (human health parameters) | Normal loading pattern | Day 26 | 1 day |
| — Diarrhea test | Diarrhea | Day 27 | 1 day |
| **Removal of superstructure if superstructure is not part of manufactured product (see 7.2.2)** | | | |
| [none] | Normal loading pattern | Day 28 | 1 day |
| — Normal odor day test | Normal loading pattern | Day 29 | 1 day |
| — Simulant odor day test | Simulant feces | Day 30 | 1 day |
| — Normal odor day test<br>— Noise and air emissions | Normal loading pattern | Day 31 and Day 32 | 2 days |
| — Normal odor day test | Normal loading pattern | Day 33 | 1 day |
| — Overload protection<br>— Noise and air emissions<br>— Normal odor day test<br>— Solid output and effluent (environmental parameters) | Overload | Day 33 to Day 35 | 3 days |

### 7.2.8 Normal loading pattern

Where the testing schedule (Table 3) indicates a normal loading pattern, the tester shall ensure the sanitation system is loaded according to its specified treatment capacity (see 4.3.2) with human feces and urine. Additionally, six sheets of toilet paper shall be added for each fecal event. The toilet paper shall comply with relevant national standards (e.g., EN 997), and the tester shall document which standard is applied.

### 7.2.9 Performance requirements during laboratory testing

#### 7.2.9.1 Testing input and output

Tests shall be performed in the order in which they are given in Table 3 using the corresponding loading pattern. If the design of the system limits the frequency of solid output to such a degree that solid output tests cannot be performed with the frequency given in Table 3 (e.g. the system only produces solid output once every several months), then the number of solid output tests may be reduced to a minimum of one occurrence covering all health parameters. If such a reduction is deemed necessary, the reasons for this reduction shall be explained and documented.

#### 7.2.9.2 Solid output and effluent

The test methods for solid output and effluent given in A.3.4 shall be followed.

The environmental requirements for effluent shall be met by achieving all of the thresholds indicated in Table 6, Table 7, and Table 8 in at least 4 out of 5 test runs, with no more than 20% variance from the threshold for any failed parameter. Results shall not be averaged.

The human health requirements for solid output and effluent shall be met by achieving all of the thresholds indicated in Table 4 and Table 5 in both of 2 test runs.

#### 7.2.9.3 Solid output requirements

Solid output performance thresholds addressing human health parameters for all reuse purposes are given in Table 4.

**Table 4 — Solid output performance thresholds for human health parameters**

| | Threshold for all reuse purposes |
|---|---|
| Thermo-tolerant coliforms (per g total solids) | <1000 |
| Helminth eggs (per g total solids) | <1 |

The prevalence of Helminth eggs in the sample shall be determined according to the method specified in Table A.3. If less than 1 Helminth egg is found per g total solids, then the threshold can be regarded as met.

If 1 or more Helminth eggs are found per g total solids, then the testing organization may, according to its discretion and upon request of the manufacturer, test the viability of the eggs using a proven test method. If it cannot be demonstrated that the Helminth eggs in the sample are not viable, then the threshold cannot be regarded as met.

#### 7.2.9.4 Effluent requirements

Effluent performance thresholds are given in Table 5, Table 6, Table 7, and Table 8.

If effluent from the sanitation system is intended to be used for hand washing, then the water shall meet the requirements of the WHO Guidelines for Drinking Water Quality, 4th Edition.

NOTE There is no reason to measure Helminth eggs if the TSS threshold (see Table 6) is not met. If the TSS threshold is not met, the system fails to meet the effluent parameters regardless of the number of Helminth eggs.

**Table 5 — Liquid output performance thresholds for human health parameters**

| | Threshold for all reuse purposes |
|---|---|
| Thermo-tolerant coliforms count (per 100 ml) | ≤10 (or non detectable) |
| Helminth eggs count (per litre) | ≤0,1 |

The prevalence of Helminth eggs in the sample shall be determined according to the method specified in Table A.3. If 0,1 or fewer Helminth eggs are found per litre, then the threshold can be regarded as met.

If more than 0,1 Helminth eggs are found per litre, then the testing organization may, according to its discretion and upon request of the manufacturer, test the viability of the eggs using a proven test method. If it cannot be demonstrated that the Helminth eggs in the sample are not viable, then the threshold cannot be regarded as met.

**Table 6 — Effluent performance thresholds for environmental parameters**

| | Category A usage:<br>Threshold for irrigation and other unrestricted urban uses | Category B usage:<br>Threshold for discharge into surface water or other restricted urban uses |
|---|---|---|
| COD (mg/l) | ≤50 | ≤150 |
| TSS (mg/l) | ≤10 | ≤30 |

NOTE 1 In accordance with EPA Guidelines for water reuse, Category A usage refers to unrestricted urban uses that comprise all uses where public access is not restricted (e.g. landscape irrigation, toilet flushing).

NOTE 2 In accordance with EPA Guidelines for water reuse, Category B usage refers to discharge into surface water and other restricted urban uses that comprise all uses where public access is controlled or restricted by physical or institutional barriers (e.g. fences, temporal access restriction).

**Table 7 — Effluent performance thresholds for nutrients**

| | Threshold for discharge into the environment |
|---|---|
| Total nitrogen (mg/l) | 15 |
| Total phosphorous (mg/l) | 2 |

**Table 8 — Effluent performance threshold for pH**

| | Threshold for all reuse purposes |
|---|---|
| pH | 6 to 9 |



### 7.2.9.5 Odor emissions requirements

Class 1, 2, and 3 sanitation systems for which the superstructure is provided as part of the manufactured product shall meet the requirements specified in Table 9 and Table 10. For Class 1 and 2 sanitation systems for which a superstructure is not part of the manufactured product, adjustments to the test methods described in Table A.5 shall be made and the requirements in Table 10 shall be met; for these systems, the requirements of Table 9 need not be met.

Within the sanitation system superstructure, when tested according to A.3.5, the percentage of observations during which odor is reported as unpleasant or unacceptable shall be lower than or equal to the maximum percentages indicated in Table 9.

NOTE 1 Unpleasant refers to odor that is not enjoyable and is mildly offensive, but does not meet the criteria of unacceptable.

NOTE 2 Unacceptable refers to odor that is severely offensive, nauseating and/or sufficiently revolting to cause one to avoid using the sanitation system.

**Table 9 — Maximum allowable percentage of observations reporting odor within system superstructure as unpleasant or unacceptable**

| | Maximum percentage of observations reported as "unpleasant" % | Maximum percentage of observations reported as "unacceptable" % |
|---|---|---|
| Normal odor day | 10 | 2 |
| Simulant odor day | 10 | 2 |

In the vicinity of the sanitation system, when tested according to A.3.5, the percentage of observations during which odor is reported as unpleasant or unacceptable shall be lower than or equal to the maximum percentages indicated in Table 10.

**Table 10 — Maximum allowable percentage of observations reporting odor in the vicinity of system as unpleasant or unacceptable**

| | Maximum percentage of observations reported as "unpleasant" % | Maximum percentage of observations reported as "unacceptable" % |
|---|---|---|
| Normal odor day | 10 | 2 |
| Simulant odor day | 10 | 2 |



#### 7.2.9.6 Noise requirements

When installed according to the manufacturer's instructions in a test site that meets the requirements of A.3.7.1, any noise source associated with system operation (such as treatment, evacuation mechanism, or mechanical components), measured at 1 m from the system according to A.3.7.4, shall not exceed an average of 70 dBA ($L_{EX,24h}$) over the course of 24 h, and shall not at any time exceed 90 dBA ($L_{pA,max}$) during testing according to A.3.7.3.

NOTE 1 $L_{EX,24h}$ represents daily system noise levels, equivalent to the system noise level averaged over a period of 24 h.

NOTE 2 $L_{pA,max}$ represents the maximum A-weighted sound pressure level.

#### 7.2.9.7 Air emissions requirements

Potential air emissions from non-sewered sanitation systems can be classified as pollutants or explosive gases. The monitoring of explosive gases during operation is addressed in 4.13.2. The following provision addresses air pollutants. The non-sewered sanitation system shall be designed and realized in such a way as to ensure that air pollutants released indoors and outdoors do not exceed the thresholds defined in Table 11 and Table 12 and when tested according to A.3.6.

CO, $CO_2$ and $NO_2$ shall be tested if the non-sewered sanitation system applies combustion in its treatment processes and need not be tested otherwise.

**Table 11 — Indoor air emission thresholds**

| Parameter | Emission thresholds (average levels over indicated timeframe) |
|---|---|
| CO (ppm) | 1 h: 28 |
| $NO_2$ (ppb) | 1 h: 99 |
| $SO_2$ (ppm) | 1 h: 6,8 |
| $CO_2$ (ppm) | 1 h:1 000 |
| $H_2S$ (ppb) | 30 min: 4,6 |
| VOCs (ppb) | 1 h: 187 |
| $PM_{2,5}$ ($\mu g/m^3$) | 1 h: 25 |
| NOTE 1 $NO_x$ as the sum of NO plus $NO_2$ is indicated as $NO_2$ for both indoor and ambient parameters. | |

**Table 12 — Ambient air emissions thresholds**

| Parameter | Emission thresholds (1 h average) |
|---|---|
| CO (ppm) | 80 |
| $SO_2$ (ppm) | 68 |
| $NO_2$ (ppm) | 195 |
| VOC (ppm) | 12 |
| $H_2S$ (ppm) | 1,9 |
| PAH (ppm) | 0,001 |
| $PM_{2,5}$ ($\mu g/m^3$) | 10 |
| NOTE 1 $NO_x$ as the sum of NO plus $NO_2$ is indicated as $NO_2$ for both indoor and ambient parameters. | |
| NOTE 2 There is no internationally recognized threshold value provided for ambient $PM_{2,5}$. The recognized percentage of total PM that is made up of $PM_{2,5}$ is approximately 15% (for combustion processes without the use of a dust filter technology). | |



## 7.3 Field testing

During field testing, the system shall be in use by the intended users at its specified treatment capacity (4.3.2). In order to pass field testing requirements, at least 80 % of all test results for environmental parameters (see Table 6, Table 7, Table 8) and 100 % of all test results for human health related parameters (see Table 4 and Table 5) shall meet the requirements defined in in 7.2.9.2.1 and 7.2.9.2.2. Results shall not be averaged.

Additionally, during and after testing, the tester shall observe and record

a) any fractures, cracks, and permanent deformations of the sanitation system,

b) any back flows, blockages, and surcharging of conveyance devices (see 5.7), and

c) any ruptures or leakages.

### 7.3.1 Class 1 sanitation systems

Class 1 sanitation systems (see Table 2) shall be subject to field testing for a minimum duration of 30 days. A minimum of one sanitation system identical to the model subjected to controlled laboratory testing shall be selected.

Environmental solid and liquid parameters (see Table 6, Table 7, and Table 8) shall be tested weekly, and human health related solid and liquid parameters (see Table 4 and Table 5) shall be tested bi-weekly. The number of solid samples may be reduced to a minimum of 1 if output is limited by the design of the system (see 7.2.9.1). The manufacturer shall document this limitation and the testing organization shall verify.

### 7.3.2 Class 2 and Class 3 sanitation systems

Class 2 and Class 3 sanitation systems (see Table 2) that incorporate biological treatment processes shall be subject to field testing as follows.

A minimum of one sanitation system, identical to the model subjected to controlled laboratory testing, shall be selected for field testing for a minimum duration of 5 months. If the defined operating conditions (see 4.9) cannot be achieved within 5 months using only one sanitation system, either several systems shall be tested under varying operating conditions simultaneously, or the timeframe of 5 months shall be extended.

Environmental solid and liquid parameters (see Table 6, Table 7, and Table 8) shall be tested weekly, and human health related solid and liquid parameters (see Table 4 and Table 5) shall be tested monthly. The number of solid samples may be reduced to a minimum of 1 if output is limited by the design of the system (see 7.2.9.1). The manufacturer shall document this limitation and the testing organization shall verify.



# 8 Sustainability

## 8.1 General

The following provisions relate to the sanitation system's use and recovery of resources.

NOTE This document does not attempt to comprehensively address sustainability concerns with respect to non-sewered sanitation systems. There are many aspects to sustainability that are not covered in this document.

## 8.2 Reuse of nutrients

The manufacturer of the sanitation system shall specify the type, subtypes, concentration, and amount of nutrients contained in the final solid output and/or effluent (in units such as mg/l or mg/kg dry mass and mg per user and day). The manufacturer shall specify the assumptions used for these calculations.

NOTE 1 The nutrients of interest are those that facilitate plant growth such as phosphorus, nitrogen, and potassium.

NOTE 2 This information can be used to determine the reasonable reuse of the final solid output and/or effluent.

## 8.3 Water consumption and reuse of effluent

### 8.3.1 Calculations

To facilitate comparison across systems as well as determination of suitability for a given location, sanitation system water use shall be calculated and indicated as both per-flush and per user per day, in units such as l/flush and l/user and day. Water use calculations need not consider related activities

such as hand washing that do not directly involve operation of the sanitation system. The manufacturer shall specify the assumptions used for these calculations.

### 8.3.2 Water consumption

The manufacturer shall indicate the amount of water required to operate the sanitation system (see 8.3.1). The water consumption of the sanitation system shall be minimized to a reasonably practical extent.

### 8.3.3 Reuse of effluent

The manufacturer shall indicate the proportion of the system's water requirements that can be met with effluent stemming from the sanitation system. If the system requires freshwater in addition to treated effluent, the manufacturer shall indicate the necessary amount and quality of freshwater (see 8.3.1). The reuse of treated effluent within the sanitation system shall be maximized to a reasonably practical extent.

## 8.4 Energy consumption and energy recovery

### 8.4.1 Calculations

To facilitate comparison across systems as well as determination of suitability for a given location, sanitation system energy consumption and recovery shall be calculated and indicated in units such as kJ or kWh per volume or mass and kJ or kWh per user per day.

### 8.4.2 Energy consumption

The manufacturer shall indicate the energy required to operate the sanitation system (see 8.4.1). The energy consumption of the sanitation system shall be minimized to a reasonably practical extent.

### 8.4.3 Direct and indirect energy recovery

Sanitation systems shall maximize direct energy recovery to a reasonably practical extent. The manufacturer shall indicate the quantity of energy directly recovered as energy supply for the operation of the sanitation system (see 8.4.1).

Indirect recovery of energy through output products that are not used for the operation of the sanitation system shall be maximized to a reasonably practical extent. The manufacturer shall indicate the energy content of these output products (see 8.4.1).

NOTE Examples of output products that can be directly or indirectly recovered are thermal energy (e.g. stemming from combustion), biogas generated through anaerobic digestion, and solid output used for later combustion or pyrolysis.

The manufacturer should indicate the relationship between energy consumption and direct/indirect energy recovery through an energy-balance diagram.

## 8.5 Life cycle assessment

A life cycle assessment of the sanitation system should be conducted based on ISO 14040 and ISO 14044.

NOTE Life cycle assessment includes end-of-life considerations.

## 8.6 Affordability

The sanitation system should be affordable for the intended users. In order to meet this requirement, system developers and manufacturers should consider both the capital expenditure (CAPEX) to acquire

and install the system and the operating expense (OPEX) of keeping the system in continuous working order. The manufacturer shall provide the relevant information specified in D.1.3, which serves as a basis for calculating OPEX.

Furthermore, D.1 should be considered to determine the suitability of a sanitation system for a given location and users regarding affordability.

# Annex A
(normative)

# Test methods and additional testing requirements

## A.1 Certification bodies

Where testing is performed for the purposes of certification, certifying bodies shall meet the requirements of ISO/IEC 17065:2012.

NOTE ISO/IEC 17065 requires that when testing is conducted as part of the certification process, the testing laboratory shall meet the applicable requirements in ISO/IEC 17025 (subclauses 6.2.1 and 6.2.2 of ISO/IEC 17065).

## A.2 Type tests

### A.2.1 Tests to be conducted

Type tests shall be performed according to Table A.1 to demonstrate conformity with this document. Type tests shall be conducted for at least one representative sample product. Tests shall be repeated following any product modification that is likely to alter safety-related, functional, or capacity-related properties of the finished product.

### A.2.2 Testing documentation

The results of the type tests shall be documented and made available for inspection.

Documentation of testing results shall be provided in the form of a report containing the following information:

a) statement that the test was conducted in accordance with this document, i.e IWA 24:2016;

b) description of the test unit, including its manufacturer, model, type, and design capacity, as well as a schematic or design drawing to indicate the integral components of the unit;

c) description of the test, including the operating conditions, testing apparatus, testing procedures, number and frequency of samples, date and time of sampling, and a sketch showing the test layout and locations of sampling;

d) expression of test results, either as data collected during the test or as calculated results, including method of calculation and precision of the test method, and the measurement uncertainty if applicable; and

e) evaluation and interpretation of results, including a statement indicating whether or not the test unit meets all the requirements contained in the document.

**Table A.1 — Means of obtaining type test results**

| Clause | Results to be obtained through:<br>— Documents<br>— Visual inspection<br>— Test method |
|---|---|
| 4.2 Metric system | Documents |
| 4.3.1 Treatable input | Documents |
| 4.3.2 Treatment capacity | Documents and visual inspection |
| 4.3.3 Menstrual hygiene products | Documents and visual inspection |
| 4.3.4 Overload protection | Testing according to 7.2 |
| 4.3.5 Operability following non-usage or short-term shutdown | Testing according to 7.2 |
| 4.3.6 Long-term shutdown | Testing according to 7.2 |
| 4.3.7 Continuous use | Documents and visual inspection |
| 4.4.2 Solid output and effluent requirements | Detailed requirements in 7.2.9.2.1 and 7.2.9.2.2; Testing according to A.3.4 |
| 4.4.3 Odor emissions requirements | Detailed requirements in 7.2.9.3; Testing according to A.3.5 |
| 4.4.4 Noise requirements | Detailed requirements in 7.2.9.4; Testing according to A.3.7 |
| 4.4.5 Air emissions requirements | Detailed requirements in 7.2.9.5; Testing according to A.3.6 |
| 4.5 Expected design lifetime | Documents and visual inspection |
| 4.6 Aspirational design | Documents and visual inspection |
| 4.7 Secure design | Documents and visual inspection |
| 4.8.1 Ambient temperature range | Documents |
| 4.8.2 Ambient air humidity | Documents |
| 4.8.3 Atmospheric pressure | Documents |
| 4.9.1 General | Documents |
| 4.9.2 Hygienic design | Documents and visual inspection |
| 4.9.3 Tightness | Testing according to A.3.1 |
| 4.9.4 Cleanability of surfaces | Testing and visual inspection |
| 4.9.5 Chemical and biological additives | Documents |
| 4.10.1 Durability of materials | Documents and visual inspection |
| 4.10.2 Fire resistance of material | Documents |
| 4.11 Connections and joining elements | Documents and visual inspection |
| 4.12.1 Safety of edges, angles and surfaces | Visual inspection |
| 4.12.2 Fire and explosion protection | Documents and visual inspection |

**Table A.1** (*continued*)

| Clause | Results to be obtained through:<br>— **Documents**<br>— **Visual inspection**<br>— **Test method** |
|---|---|
| 4.12.3 Structural integrity | Documents |
| 4.12.4 Reuse of effluent | Documents and visual inspection |
| 4.12.5 Underground systems | Documents and visual inspection |
| 4.12.6 External impacts | Documents and visual inspection |
| 4.13.1 Information and warnings | Documents (English version only) and visual inspection |
| 4.13.2 Marking and labeling | Visual inspection |
| 4.14.1 Reasonable configuration, adjustment, and maintenance activities | Documents and visual inspection – see D.2 |
| 4.14.2 Location and access of configuration, adjustment, and maintenance points | Visual inspection |
| 4.14.3 Discharge and cleaning | Testing according to 7.2 |
| 4.14.4 Tools and devices | Documents and visual inspection |
| 4.14.5 User manual | Documents |
| 4.14.6 Handling and transport of the sanitation system | Documents and visual inspection |
| 5.1 Safety assessment | Documents and visual inspection |
| 5.2.2 Intentional starting of sanitation system operation | Documents and testing according to 7.2 |
| 5.2.3 Intentional stopping of sanitation system operation | Documents and testing according to 7.2 |
| 5.2.4 Emergency stop | Documents and testing according to 7.2 |
| 5.3.1 Security of energy supply | Documents and testing according to 7.2 |
| 5.3.2.1 Separation and isolation | Documents and testing according to 7.2 |
| 5.3.2.2 Energy discharge | Documents and testing according to 7.2 |
| 5.3.3 Safety requirements for non-electric primary energy supply | Documents and functional testing according to 7.2 |
| 5.4.1 Pressurized equipment | Documents |
| 5.4.2 Pipes, hoses and tanks | Documents and visual inspection |
| 5.4.3 Moving and rotating parts | Documents and visual inspection |
| 5.4.4 Backflow prevention | Documents and visual inspection |
| 5.5.1 High temperatures of parts and surfaces | Visual inspection |

**Table A.1** (*continued*)

| Clause | Results to be obtained through:<br>— **Documents**<br>— **Visual inspection**<br>— **Test method** |
|---|---|
| 5.5.2 Low temperatures of parts and surfaces | Visual inspection |
| 5.5.3 Other sources of radiation | Documents and visual inspection |
| 5.6.1 Safety and reliability of electrical and electronic equipment | Documents and visual inspection |
| 5.6.2 Control system | Documents and testing according to A.3.2 |
| 5.6.3 Safety-related function of the control system | Documents and testing according to A.3.2 |
| 5.7 Reliability of conveyance devices | Testing according to 7.2 |
| 5.8 Transitions from the backend | Testing according to ISO 10816-1 |
| 6.2.1 General usability requirements | Documents and functional testing according to 7.2. |
| 6.2.2 Requirements for ease of cleaning | Documents and visual inspection |
| 6.2.3 Requirements for ease of operation | Documents and visual inspection |
| 6.2.4 Cultural requirements | Documents and visual inspection – see D.3 |
| 6.3 Visibility of feces | Testing according to 7.2 |
| 6.4 Evacuation performance | Testing according to A.3.3 |
| 6.5 Integrity against external impacts | Testing (see 6.4) |
| 6.6 Slipping, tripping or falling | Visual inspection |
| 8 Sustainability | Documents and see D.1 for 8.6 Affordability |



## A.3 Test methods

### A.3.1 Tightness

Where applicable, system tightness shall be tested through a hydraulic test applying 1.5 MOP. Where a hydraulic test applying 1.5 MOP is not applicable, the requirements of EN 12566-3, 6.4, or equivalent, shall be applied and vacuum tests or pneumatic tests shall be conducted.

### A.3.2 Control system

#### A.3.2.1 General requirements

Control system testing protocols are adapted from IEC 61511 and based on industrial best practice.

Functions of the control system shall be tested by means of document verification, visual inspection, and functional testing. If the test coverage of functional testing does not incorporate all functions, then an explanation shall be given that definitively justifies the exclusion of those functions from testing requirements.

Based on the visual inspection and the relevant technical documentation of the sanitation system, a systematic test plan shall be developed that incorporates test cases enabling each control system function to be tested independently.

The testing shall be performed by a tester who is not involved with the design process; the control system designer shall not conduct control system testing. The test results shall be documented and made available for inspection.

### A.3.2.2 Test plan and protocol

The test plan and protocol shall include, at a minimum:

a) formal identification of the tested system, including software release if relevant;

b) identification of measuring equipment, including calibration information if applicable;

c) verification by visual inspection of consistency between technical documentation and the system as built, including:

   1) suitability of labeling;

   2) correct installation;

   3) correct IP classification;

   4) proof of the signal circuits, including short-circuit testing, potential level testing, and continuity testing;

   5) transition resistance testing;

   6) insulation testing;

   7) earth conductor testing; and

   8) reliability-centered design (RCD) testing;

d) control system function and description of the test cases used to evaluate control system function;

e) description of the expected modes of the sanitation system for testing the control functions, including (where applicable):

   1) preparation for use, including setting and adjustment;

   2) start up;

   3) configuration;

   4) automatic, manual, or semi-automatic process control;

   5) steady state of operation;

   6) re-setting;

   7) shut down;

8) maintenance; and

9) reasonably foreseeable abnormal conditions;

f) description of the test criteria, (i.e. expected conditions or results after each test case is performed), including qualitative criteria (e.g., indication mechanisms, change in system modes or conditions) and quantitative criteria (e.g., reaction times, transition times, temperatures);

g) determination of whether the observed control system activity meets the test criteria, and documentation of any unmet criteria;

h) name and signature of the test engineer; and

i) date of testing.

#### A.3.2.3 General test cases

Test cases shall be incorporated into the test plan verifying that:

a) devices of conveyance and treatment processing do not start unexpectedly;

b) all system startups are indicated on the control display;

c) automatic or manual stopping is unimpeded in all relevant operational conditions including test of the emergency stop;

d) protective devices remain fully effective or issue a stop command;

e) the signaling system indicates all relevant system states and failure modes to the user by means of a corresponding alarm, such as failures of electrical and mechanical components critical to the treatment processes and the system's overall availability or unavailability for use; and

f) the system remains safe and operational following reasonably foreseeable misuse and user errors.

All test measurement equipment used for validation shall be calibrated against a proven standard. All test equipment shall be verified for proper operation.

#### A.3.2.4 Additional requirements for safety-related functions

In addition to testing according to A.3.2.1, A.3.2.2, and A.3.2.3, safety-related functions of the control system shall also be verified through:

a) review and evaluation of the safety integrity requirements determined through the safety assessment (see 5.1);

b) review and verification of the safety requirements specifications, safety provisions of the user manual (see Annex C), and design documents, as well as available test protocols;

c) functional review and analysis of system circuit diagrams, as well as qualification of hardware and software used for the safety function according to the safety requirement specifications and safety provisions of the user manual;

d) verification of appropriate mitigation of potential common cause failures (for an example of a scoring table see ISO 13849-1:2015, Annex F);

e) formal verification by calculations indicating whether the required safety integrity is achieved; and

f) test cases based on the safety requirement specifications.

### A.3.3 Evacuation mechanism

#### A.3.3.1 General

Evacuation mechanism test protocols are adapted from EN 997 and IS 2556-3 and IS 2556-14 based on industrial best practice.

#### A.3.3.2 Test object

Frontends incorporating the following evacuation mechanisms shall be tested:

a) flushing cistern;

b) pour flush;

c) dry toilet; and

d) novel evacuation mechanisms.

The evacuation mechanism shall be activated as specified by the manufacturer.

#### A.3.3.3 Flushing volume

The test shall be conducted with the flushing volume specified by the manufacturer.

For non-sewered sanitation systems using cisterns or novel evacuation mechanisms requiring water, all tests shall be conducted with the specific "full flush" flushing volume as indicated by the manufacturer.

For non-sewered sanitation systems using pour-flush mechanisms, the water shall be poured as close to the WC or squatting pan as possible, in a continuous and even stream. The amount of water used in the test shall approximate the normal flushing volume amount indicated by the manufacturer.

For non-sewered sanitation systems using dry toilets or novel evacuation mechanisms requiring no water, no flush water shall be applied.

#### A.3.3.4 Generalized test methods and functional requirements for WC pan

##### A.3.3.4.1 Wash of bowl

The test shall be conducted using 20 g of fine dry wood sawdust.

The testing procedure is as follows:

a) Moisten the entire inner surface of the WC pan below the rim.

b) Immediately afterwards, sprinkle the sawdust as evenly as possible over the moistened surface.

c) Activate the evacuation mechanism and measure any unwashed area.

d) Repeat steps 1 through 3 for a total of 5 tests.

The arithmetic average of the results of the 5 tests (unwashed area below the rim) shall not exceed 50 $cm^2$.

#### A.3.3.4.2 Evacuation of toilet paper

The tester shall document the toilet paper standard used as specified in 7.2.8.

The testing procedure is as follows:

a) Working with one sheet at a time, loosely crumple 12 individual sheets of toilet paper and drop them separately, one after the other, into the WC pan, completing the task within a time span of 14 s to 18 s.

b) Activate the evacuation mechanism within 2 s of the last sheet being dropped into the WC pan.

c) Document and remove any paper not flushed out of the bowl.

d) Repeat this test for a total of 5 tests.

All 12 sheets of toilet paper shall be flushed out of the pan a minimum of 4 times out of 5 tests.

#### A.3.3.4.3 Evacuation of solid waste

The test shall be conducted using balls of non-absorbent material, each having a mass of (3,7 ± 0,1) g and a diameter of (20 ± 0,1) mm.

The testing procedure is as follows:

a) For each evacuation operation, place 50 balls into the WC pan and activate the evacuation mechanism.

b) Document and remove any balls left in the pan.

c) Repeat this test for a total of 5 tests.

The average of the results of the 5 tests shall meet or exceed the threshold of 85% of the balls flushed out of the WC pan.

#### A.3.3.4.4 Over-splashing

The over-splashing test applies to systems that incorporate water in their evacuation mechanisms, with the exception of pour-flush systems.

The test shall be conducted using paper of a type that exhibits a clearly visible change when wet.

The testing procedure is as follows:

a) Lay sheets of paper on the floor encircling the WC pan to be tested, projecting 200 mm beyond the circumference of the bowl projected onto the floor.

b) Activate the flushing mechanism and document evidence of water seen on the paper.

The flushing water shall not splash beyond the rim of the bowl and wet the paper. Only a few small drops may reach the paper.

#### A.3.3.5 Functional requirements and generalized test methods for squatting pan

##### A.3.3.5.1 Wash of bowl

The test shall be conducted using 20 g of dry sawdust sifted through a 2 mm sieve.

The testing procedure is as follows:

a) Moisten the entire internal surface of the squatting pan below the rim.

b) Sprinkle 20 g of fine dry sawdust on the inside of the squatting pan below the rim as completely and evenly as possible.

c) Activate the evacuation mechanism and document any sawdust left on the squatting pan.

The sprinkled saw dust shall be cleared below 40 mm of the rim of the squatting pan.

##### A.3.3.5.2 Evacuation of toilet paper

The tester shall document the toilet paper standard used as specified in 7.2.8.

The testing procedure is as follows:

a) Loosely crumple 6 pieces of the toilet paper or polythene sheet and drop them into the squatting pan.

b) Activate the evacuation mechanism.

c) Document and remove any paper not flushed out of the bowl.

d) Repeat the test for a total of 4 tests.

All 6 pieces of toilet paper shall be flushed out of the squatting pan a minimum of 3 times out of 4 tests.

##### A.3.3.5.3 Smudge test

The test shall be conducted using quartz powder of a color that contrasts with that of the squatting pan, passed through a 1,18 mm sieve.

The testing procedure is as follows:

a) Smudge the entire interior surface of the squatting pan with the quartz powder up to 40 mm below the rim.

b) Active the evacuation mechanism.

c) Document any smudge left on the squatting pan.

Immediately after evacuation, there shall be no smudge left on the squatting pan.

##### A.3.3.5.4 Splash test

The splash test applies to systems that incorporate water in their evacuation mechanisms, with the exception of pour-flush systems.

The test shall be conducted using colored dye to tint the water.

The testing procedure is as follows:

a) Ensure that the floor is clean and dry in the testing area.

b) Tint the flushing water to be used with the colored dye.

c) Activate the flushing mechanism.

d) Observe and document whether flushing water splashes over the rim onto the floor, counting any droplets that reach the floor.

e) Repeat the test 5 times.

The flushing water shall not splash over the rim onto the floor. The sum of the results of the 5 tests shall not exceed 10 droplets.

#### A.3.3.6 Holding capacity test

The holding capacity test applies to systems that incorporate water in their evacuation mechanisms, including pour-flush systems.

The pan, when sealed at the outlet and vent (if provided), shall be capable of holding a minimum of the specified "full flush" flushing volume as indicated by the manufacturer, up to the highest possible water level of the pan as installed.

### A.3.4 Solid output and effluent test method

#### A.3.4.1 General

The following sampling and test methods pertain to the solid output and effluent requirements given in 7.2.9.2.

#### A.3.4.2 Sampling

##### A.3.4.2.1 Sampling point

The manufacturer and testing organization shall agree on a suitable point from which to draw solid output and effluent samples. The sampling point shall be chosen to ensure that a representative sample is obtained (e.g., the point in the system immediately preceding or following discharge of treated output).

##### A.3.4.2.2 Sampling type and frequency

Samples shall be taken according to the sample types and sampling frequency described in Table A.2. Sampling equipment and procedures shall comply with relevant national and international standards, and the equipment, procedures, and standards used shall be documented in the testing report. Samples shall be preserved using proven, parameter-specific preservation methods and, if relevant, shall be delivered to the testing organization.

**Table A.2 — Sampling type and frequency**

| | Parameters | Sample type – grab/composite | Minimum sampling frequency |
|---|---|---|---|
| Effluent | Total nitrogen | Composite | 1 sample per day |
| Effluent | Total phosphorus | Composite | |
| Effluent | pH | Grab | |
| Effluent | COD | Composite | |
| Effluent | TSS | Composite | |
| Effluent | Thermo-tolerant coliforms | Composite | |
| Solid output | | Grab | |
| Effluent | Helminth eggs | Composite | |
| Solid output | | Grab | |

### A.3.4.3 Test methods

#### A.3.4.3.1 General

To ensure representative and accurate results, the procedures for analysis of solid output and effluent shall follow internationally accepted and recognized test methods. Recommended test methods for solid output and effluent are given in Table A.3. For testing of Thermo-tolerant coliforms and Helminth eggs, spiking of input shall be performed (A.3.4.3.2).

**Table A.3 — Recommended test methods for solid output and effluent**

| | Parameters | Test methods | |
|---|---|---|---|
| Effluent | Total nitrogen | APHA 4500-N C, APHA 4120 or 4130 | |
| Effluent | Total phosphorus | APHA 4500-P | EN ISO 6878 |
| Effluent | pH | APHA 4500-$H^+$ A | |
| Effluent | COD | APHA 5220 B | |
| Effluent | TSS | APHA 2540D | EN 872 |
| Effluent and solid output | Thermo-tolerant coliforms | APHA 9221, 9222 and 9223 | |
| Effluent and solid output | Helminth eggs | — Methods for microbiological analysis of sewage sludges, EPA, 1993, Section F. Ascaris Ova, [page III-36]<br>— SOP Helminth Test (Ascaris, Trichuris and Taenia), University of Kwazulu-Natal, 2015 | |

#### A.3.4.3.2 Spiking input for human health parameter testing

To ensure meaningful results for human health related parameters, solid and liquid input into the system shall be spiked with thermo-tolerant coliforms and Helminth eggs in accordance with Table A.4.

Spiking shall be performed prior to the relevant tests, allowing sufficient time for the input to be fully processed to ensure that the sampled output corresponds to the spiked input.

**Table A.4 — Spiking input with thermo-tolerant coliforms and Helminth eggs**

| | Liquid | Solid |
|---|---|---|
| Thermo-tolerant coliforms (TTC) | Option 1: If the concentration of TTC in the liquid input can be measured, then the liquid input shall be spiked to reach a concentration of $10^{10}$ TTC per litre.<br><br>Option 2: If the concentration of TTC in the liquid input cannot be measured, then the excretion rate of thermo-tolerant coliforms within the feces of the test persons shall be measured. The concentration in the feces shall then be spiked to reach a concentration of $10^7$ TTC per gram. | The excretion rate of thermo-tolerant coliforms within the feces of the test persons shall be measured. The concentration in the feces shall then be spiked to reach a concentration of $10^7$ TTC per gram. |
| Helminth eggs | The liquid input to the system shall be spiked with $10^4$ Helminth eggs (Ascaris) per litre. | The solid input to the system shall be spiked with $10^4$ Helminth eggs (Ascaris) per gram. |

### A.3.5 Odor test method

#### A.3.5.1 General

The specifications for the odor test method assume that sanitation systems have only one frontend (Class 1 and Class 2, see Table 2) and a superstructure included as part of the manufactured product. For Class 3 systems and systems for which a superstructure is not part of the manufactured product, the test method adjustments described in Table A.5 shall be made for the corresponding systems.

**Table A.5 — Adjustments to odor test methods for Class 3 and superstructureless systems**

| | |
|---|---|
| **Class 1 and Class 2 sanitation systems for which a superstructure is not part of the manufactured product** | Odor emissions shall be tested only "in the vicinity of the sanitation system" (see A.3.5.8) and 4 panelists shall participate in each testing event (2 panelists positioned 2 m from the frontend, 2 at the backend). If no observation is missed, the compilation of all assessments provides 2 160 individual observations after completion of 3 normal odor day tests and 720 individual observations after completion of 1 simulant odor day test. Odor requirements shall be regarded as met if the odor emissions meet the thresholds given in Table 10. |
| **Class 3 sanitation systems with 2 to 5 frontends** | Odor emissions shall be tested "within the sanitation system superstructure" (see A.3.5.7) for only 2 of the frontends, which shall be chosen randomly. Odor emissions "in the vicinity of the sanitation system" shall be conducted as described in A.3.5.8. |
| **Class 3 sanitation systems with more than 5 frontends** | Odor emissions shall be tested "within the sanitation system superstructure" (see A.3.5.7) for only 3 frontends, which shall be chosen randomly. Odor emissions "in the vicinity of the sanitation system" shall be conducted as described in A.3.5.8. |

### A.3.5.2 Test site

Within the laboratory where the controlled test is conducted (see 7.2.7), background odor sources should be contained to prevent interference with the assessment. The ventilation rate of the laboratory shall be between 6 and 12 air exchanges per hour.

### A.3.5.3 Panel composition

The panel shall be composed of 4 panelists that have been screened (see A.3.5.5) and selected (see A.3.5.4).

### A.3.5.4 Selection of panelists

Selection of panelists shall incorporate the following requirements and recommendations (modified from EN 13725:2003-07, 6.7.2):

a) In order to obtain a reliable panel, assessors with specific qualities shall be selected from the general population to serve as panelists.

b) In order to ensure repeatability of panelists' observations, their olfactory responses should be as constant as possible from day to day, and within a day.

c) In order to ensure repeatability, the olfactory sensitivity of the panelists shall be within a defined bandwidth. To achieve this aim, candidates for the panel shall be screened to ensure a specific range of sensitivity to the reference odorant hydrogen sulfide ($H_2S$) (see A.3.5.5).

d) To familiarize panelists with the olfactometric procedures, they shall first be trained by performing the screening assessment. These results shall be discarded.

Panelists shall be selected from among those whose screening assessment results (see A.3.5.5) comply with the criteria given in Table A.6.

**Table A.6 — Screening assessment results required for panel selection**

| Bag contents | Panelist perceptions |
|---|---|
| Neutral gas | Correctly perceive no odor in all 3 instances |
| 0,01 $ppb_v$ $H_2S$ | Perceive no odor in 4 or 5 of the 5 instances |
| 2 $ppb_v$ $H_2S$ | Perceive odor in all 3 instances |
| NOTE If odor is systematically perceived in neutral gas by multiple panelists, this may be a sign of a problem with the neutral gas or with the gas bags. | |

### A.3.5.5 Screening of panelists

The screening assessment procedure is as follows:

a) Present each panelist with a bag filled with neutral gas as defined in Section 6.4.1 of EN 13725. The bag should have a volume ranging from 1 l to 5 l, and comply with Section 6.3 of EN 13725. The bag should have a port to allow direct smelling of the undiluted bag content.

b) Instruct the panelists to smell the neutral gas and indicate whether they perceive an odor. If the panel perceives an odor (or a change in the perceived odor) in the neutral gas, proceed with systematic testing to trace and eliminate the source of the odor.

c) Instruct the panelists to smell, in a randomly generated sequence of 11 total assessments:

   1) neutral gas, a total of 3 times within the sequence;

   2) 0,01 $ppb_v$ $H_2S$ in neutral gas, a total of 5 times within the sequence;

   3) 2 $ppb_v$ $H_2S$ in neutral gas, a total of 3 times within the sequence.

   Ensure the bags have no identification that would allow the panelists to recognize the bags or identify their contents. For the bags with the reference odorant $H_2S$, the concentration should be within ±5% and be prepared following similar quality measures as in EN 13725:2003-07, 6.4.

   4) Instruct each panelist to indicate, after smelling each bag's contents, whether he/she perceives an odor. Do not communicate results to the panelists during the screening.

   5) Repeat the screening a second time on a separate day, allowing at least 24 h to pass between the 2 screenings.

   6) Allow no more than 6 months to pass before repeating the screening procedure for each panelist.

### A.3.5.6 Odor emissions assessment procedures

#### A.3.5.6.1 General

Panelists should follow the code of behavior for assessors given in EN 13725:2003-07, 6.7.1.

After defining assessment frequency and timing (see A.3.5.7.1 and A.3.5.8.1), odor assessment shall be conducted using direct observation as follows:

a) Assign 4 panelists (2 panelists for odor assessment within the sanitation system superstructure; 2 panelists for odor assessment in the vicinity of the sanitation system) to conduct both assessments

simultaneously. The panelists should alternate between the assessment within the sanitation system superstructure and in the vicinity of the sanitation system after each odor assessment event.

b) Ensure that panelists understand the odor coding system for reporting odors and the associated terms and concepts.

c) Instruct the panelists to inhale the surrounding air and smell its odor at 10-second intervals, for a total assessment duration of 3 min.

d) Instruct the panelists to record their observations for each interval consisting of a) an indication of the presence or absence of odor, and b) if an odor is detected, the odor type and hedonic tone (pleasant, unpleasant, or unacceptable). A sample assessment report sheet is given in Figure A.1.

e) Ensure that panelists do not talk or otherwise communicate with one another in a way that could reveal their assessment during the odor observation.

Panel member: Joe Doe
Date: March 26, 2016
Start time: 14:25
Stop time: 14:28
Measurement round: After fecal, round 2
Measurement point and notes: comments appear here

**Odor Codes**
Type of Odor
0 – No odor
F – Fecal odor
X – Other odor
Odor attributes
1 – Pleasant
2 – Acceptable
3 – Unpleasant
4 – Unacceptable

1st minute

| | | | | | |
|---|---|---|---|---|---|
| F4 | F3 | X3 | X2 | X2 | X3 |

2nd minute

| | | | | | |
|---|---|---|---|---|---|
| X2 | X2 | X2 | X2 | X2 | X2 |

3rd minute

| | | | | | |
|---|---|---|---|---|---|
| X2 | F2 | F2 | X2 | 0 | 0 |

Key
- fecal = odor that can easily be attributed to feces and/or urine
- other odor = non-fecal odor (e.g., perfume, cleaning products, process odor)
- pleasant = enjoyable odor
- acceptable = mild odor, not offensive, easily tolerated
- unpleasant = odor that is not enjoyable, mildly offensive, but does not meet the criteria of unacceptable
- unacceptable = severely offensive, nauseating and/or sufficiently revolting to cause one to avoid using the sanitation system

**Figure A.1 — Sample odor assessment report sheet**

#### A.3.5.6.2 Validity of assessments

Panelists should be trained to a level of proficiency in the observational method that ensures they do not miss individual observations during an assessment event. For each assessment event to achieve validity, no more than 2 individual observations shall be missed. For the odor assessment as a whole to achieve validity, no more than a total of 4 individual observations shall be missed per day of testing. Odor assessment events shall be repeated if the number of missing observations exceeds these thresholds. Additionally, if there is evidence that misuse of the sanitation system has occurred, a new measurement event shall be scheduled.

#### A.3.5.6.3 Normal odor day test

During a normal odor day test, the sanitation system shall be used according to the specified testing procedure and loading pattern indicated for the given day according to 7.2.

#### A.3.5.6.4 Simulant odor day test

##### A.3.5.6.4.1 General

For the simulant odor day test, simulant feces infused with odorant shall be used.

NOTE The simulant feces does not attempt to match all properties of feces, but rather to simulate the consistency and the odor of feces and urine combined.

##### A.3.5.6.4.2 Simulant feces preparation

Required materials:

— pan with tight-fitting lid;

— fork or spatula for stirring;

— cook stove;

— water;

— white rice;

— firm tofu;

— peanut or vegetable oil;

— butyric acid;

— *p*-cresol;

— indole;

— dimethyl trisulfide;

— triacetin;

— trimethylamine;

— hermitically sealable glass containers; and

— refridgerator.

The procedure for preparing simulant feces is as follows:

a) Place 150 g of white rice with 0,5 l water in a pan covered with a tight lid, and bring to boil.

b) Once the water boils, cook for an additional 30 min at low heat (gentle boil).

c) Allow the rice to cool slightly and mix vigorously with a fork or spatula for 1 minute.

d) Cover and allow to cool to room temperature.

e) In a separate container, mix 1 kg of firm tofu with a fork or spatula for 30 s so as to break it in smaller chunks (as smooth paste is not required).

f) Add 100 ml glycerin, the 600 g of cooked rice prepared in steps a) to d), 50 ml of peanut or vegetable oil, and mix for 30 s with a fork or spatula until the different ingredients are mixed.

g) Add odorants at the following amounts per kg of wet mass:

   — Butyric acid: 1000 mg/kg;

   — *p*-cresol: 300 mg/kg;

   — Indole: 30 mg/kg;

   — Dimethyl trisulfide: 6 mg/kg (best added as 0,5 ml of a 12 mg/ml solution in triacetin);

   — Trimethylamine: 5 mg/kg;

h) Mix the odorants into the paste until homogenously distributed.

i) Store the simulant feces in hermetically sealed glass containers and keep refrigerated.

j) Use the simulant feces within 1 month.

#### A.3.5.6.4.3 Simulant odor day test procedures

Equipment needed for each test event:

— 300 g simulant feces, at room temperature in a hermetically sealed container allowing rapid transfer to the toilet and resealing of the container after use;

— container with 200 ml of water; if an electrically conductive liquid is important to the proper functioning of the sanitation system, up to 10 g/l urea, 8 g/l NaCl, and 2 g/l KCl may be added to the water; and

— odor assessment report sheet (see Figure A.1)

The procedure for conducting each simulant feces test event is as follows:

a) Instruct laboratory personnel to load the system as follows:

   1) Enter the sanitation system superstructure and close the door (if relevant).

   2) Rapidly transfer first the 300 g simulant feces and then the 200 ml water to the WC or squatting pan.

   3) Rapidly seal the empty simulant feces container and activate the evacuation mechanism.

   4) Exit the superstructure (if relevant).

b) Instruct the panelists to perform the test as follows:

   1) Approach the system (entering the superstructure if relevant) 5 min after the evacuation mechanism has been activated.

   2) Begin the odor assessment (see A.3.5.6.1).

   3) Conduct the odor assessment for a total assessment duration of 3 min.

The 2 panelists in the vicinity of the system shall conduct their assessment simultaneously.

### A.3.5.7 Odor emissions assessment procedures within the sanitation system superstructure

#### A.3.5.7.1 Assessment frequency and timing

For each normal odor day test (see A.3.5.6.3), odor shall be assessed

a) 5 min after fecal and urinary events, measured from the point in time when the evacuation mechanism has been activated,

b) when process operations are expected to release the most odors, and

c) randomly during the test day, according to the frequency indicated in Table A.7.

During a simulant odor day test (see A.3.5.6.4), odor shall be assessed

— 5 min after a simulated fecal event (see A.3.5.6.4.3), measured from the point in time when the evacuation mechanism has been activated,

— when process operations are expected to release most odors, and

— randomly during the test day according to the frequency indicated in Table A.8.

**Table A.7 — Frequency and timing for odor assessment for normal odor day test within the sanitation system superstructure**

| | 5 min after a fecal event | 5 min after a urinary event | When process operations are expected to release the most odors | Randomly during the test day |
|---|---|---|---|---|
| Normal odor day test – number of tests to be conducted | 4 | 2 | 2 | 2 |

**Table A.8 — Frequency and timing for odor assessment for simulant odor day test within the sanitation system superstructure**

| | 5 min after a simulated fecal event | When process operations are expected to release most odors | Randomly during the test day |
|---|---|---|---|
| Simulant odor day test – number of tests to be conducted | 4 | 4 | 2 |



### A.3.5.7.2 Assessment procedures

For each assessment event as defined in Table A.7 and Table A.8, 2 panelists shall enter the sanitation system superstructure and close the door to begin the assessment.

If the superstructure cannot accommodate 2 panelists at one time, the sampling frequencies indicated in Table A.7 and Table A.8 shall be doubled.

A.3.5.6.1 provides the detailed assessment procedure.

### A.3.5.7.3 Validity of assessments

If no observation is missed, the compilation of all assessments following Table A.7 and Table A.8 provides 1080 individual observations per frontend tested (18 individual observations per event × 2 panelists × 10 events per day × 3 normal odor day tests) after completion of 3 normal odor day tests and 360 individual observations per frontend tested (18 individual observations per event × 2 panelists × 10 events per day) after completion of 1 simulant odor day test.

A.3.5.6.2 provides the general validity requirements.

### A.3.5.8 Odor emissions assessment procedures in the vicinity of the sanitation system

#### A.3.5.8.1 Assessment frequency and timing

For each normal odor day test, odor shall be assessed

a) 5 min after a fecal and urinary event, measured from the point in time when the evacuation mechanism has been activated,

b) when process operations are expected to release the most odors, and

c) randomly during the test day, according to the frequency indicated in Table A.9.

**Table A.9 — Frequency and timing for odor assessment for normal odor day test in the vicinity of the sanitation system**

| | 5 min after a fecal event | 5 min after a urinary event | When process operations are expected to release the most odors | Randomly during the test day |
|---|---|---|---|---|
| Normal odor day test – number of tests to be conducted | 4 | 2 | 2 | 2 |

For each simulant odor day test, odor shall be assessed a) 5 min after a simulated fecal event, measured from the point in time when the evacuation mechanism has been activated; b) when process operations are expected to release the most odors; and c) randomly during the test day, according to the frequency indicated in Table A.10.

**Table A.10 —Frequency and timing for odor assessment for simulant odor day test in the vicinity of the sanitation system**

| | 5 min after a simulated fecal event | When process operations are expected to release the most odors | Randomly during the test day |
|---|---|---|---|
| Simulant odor day test – number of tests to be conducted | 4 | 4 | 2 |



#### A.3.5.8.2 Assessment procedures

For each assessment event as defined in Tables A.9 and A.10, 2 panelists shall assess the odor.

Panelist positioning is as follows:

a) Because the panel is composed of 4 members, the panelists will alternate between smelling odors in the vicinity of the sanitation system and within the sanitation system superstructure at each event.

b) For the panelists positioned in the vicinity of the system, position one panelist standing in front of the sanitation system, 2 m away from the sanitation system door. Position the second panelist standing at the backend of the sanitation system, 2 m away from the point designated by the manufacturer and approved by the testing organization as the point at which backend odor emissions are highest. If the configuration of the system or test site does not allow the prescribed 2

m, the distance may be reduced. Good engineering judgment should be used when selecting the odor observation point.

A.3.5.6.1 provides the detailed assessment procedure.

#### A.3.5.8.3 Validity of assessments

If no observation is missed, the compilation of all assessment following Table A.9 provides 1080 individual observations per frontend tested (18 individual observations per event × 2 panelists × 10 events per day × 3 normal odor day tests) after completion of 3 normal odor day tests and assessment following Table A.10 provides 360 individual observations per frontend tested (18 individual observations per event × 10 events per day × 2 panelists) after completion of 1 simulant odor day test.

A.3.5.6.2 provides the general validity requirements.

### A.3.6 Air emissions test method

#### A.3.6.1 Equipment

#### A.3.6.1.1 Specification

Analyzers used for the air emissions test shall be proven capable of measuring the emissions of interest with appropriate sensitivity. Equipment shall be operated according to the manufacturer's instructions. Testers shall ensure their familiarity with the characteristics of their analyzer for their particular application.

Instrumental analyzers shall be assessed prior to use with respect to the following performance characteristics:

a) response time;

b) zero and span drift;

c) detection limit;

d) effect of interfering substances;

e) effect of temperature and pressure on instrument; and

f) stability.

#### A.3.6.1.2 Calibration

For semi-continuous emission monitors, a zero and span check on the entire sampling system shall be performed immediately prior to the on-site test (within 2 h of analyzer stabilization). A final zero and span check shall be performed after site measurements have been completed.

Additional calibrations should be performed at regular intervals throughout the day.

### A.3.6.2 Air emission measurement procedures

#### A.3.6.2.1 Measuring event

Each measuring event shall include measurement of emissions from the most significant sources of air pollutants within the non-sewered sanitation system (i.e. those producing the highest concentrations of air pollutants), including treatment unit operation as well as any other sources of air emissions involved in system operation.

#### A.3.6.2.2 Test methods

##### A.3.6.2.2.1 General

To ensure representative and accurate results, the procedures for analysis of air emissions shall follow internationally accepted and recognized test methods.

##### A.3.6.2.2.2 Indoor air emissions

Recommended test methods for indoor air emissions are indicated in Table A.11. Equivalent national standards may be applied. The manufacturer and testing organization shall jointly determine whether to conduct grab sampling or continuous analysis.

**Table A.11 — Recommended test methods for analysis of indoor air emissions**

| Component | Test method | Analytical method |
|---|---|---|
| CO | 1) ISO 4224<br>2) NIOSH 6604 | 1) Continuous analysis<br>2) Grab sampling |
| $NO_2$ | ISO 7996; NIOSH 6700: Nitrogen Dioxide | Continuous analysis |
| $CO_2$ | 1) ISO 16000-26<br>2) NIOSH 6603 | 1) Continuous analysis<br>2) Grab sampling |
| $H_2S$ | NIOSH 6013; OSHA6 ID 141, 1008 | Grab sampling |
| VOC | ISO 16000-5 Part 5 | Grab sampling |
| $SO_2$ | NIOSH 6004 | Grab sampling |
| $PM_{2.5}$ | NIOSH 0500 | Grab sampling |



##### A.3.6.2.2.3 Ambient air emissions

Internationally accepted and recognized test methods for ambient air emissions are indicated in Table A.12. Either the ISO/EN/VDI guideline or the U.S. EPA method may be used. Equivalent national standards may be applied.

**Table A.12 — Recommended test methods for analysis of ambient air emissions**

| Component | ISO/EN/VDI guideline | U.S. EPA test methods |
|---|---|---|
| CO | EN 15058 | Method 10 |
| $SO_2$ | EN 14791 | Method 6C |
| $NO_2$ | EN 14792 | Method 7E |
| VOC | EN 12619 | Method 25A |

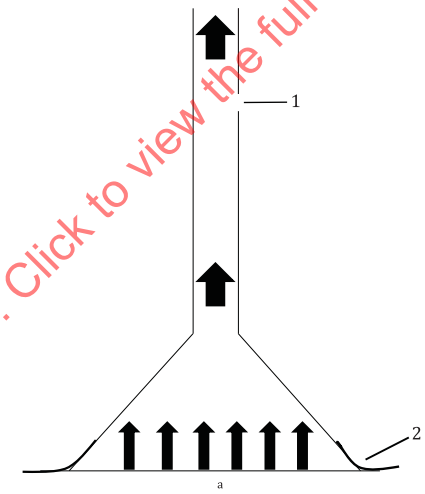
**Table A.12** (*continued*)

| Component | ISO/EN/VDI guideline | U.S. EPA test methods |
|---|---|---|
| PAH | VDI 3874 | Compendium method TO-13A |
| $H_2S$ | VDI 3486 Bl. 2 | NIOSH 6013; OSHA6 ID 141, 1008 - |
| $PM_{2,5}$ | VDI 2066 Bl. 10 | Method 5I; Method 201A |
| $O_2$ | EN14789 | Method 3A |
| Volume flow | ISO 16911- 1 | Method 2 |
| Moisture Content | EN 14790 | Method 4 |
| Requirements for measuring sections | EN 15259 | Method 1A |

### A.3.6.3 Sampling points

#### A.3.6.3.1 Indoor air emissions

Single-point sampling shall be carried above the squatting or WC pan of the frontend. A hood shall be used to collect the sample. The hood shall be made of an inert material (e.g. stainless steel), so that there is no risk of chemical reactions or other interactions with the samples. The hood shall be sealed at its base. The seal can take the form of a continuous apron.






**Key**

1 sampling/measuring orifice

2 continuous apron

[a] Air.

**Figure A.2 — Recommended sampling arrangement for indoor air emissions**

#### A.3.6.3.2 Ambient air emissions

The measurement shall be carried out in the external gas vent as outlined in the EPA Method 1A – Sample and Velocity Traverses for Stationary Sources with Small Stacks or Ducts.

### A.3.6.4 Number of samples and sampling duration

#### A.3.6.4.1 Indoor air emissions

A sampling shall consist of a minimum of 2 test runs per parameter. Each run shall cover the full measuring event (see A.3.6.2.1).

The minimum sampling duration for each run shall be 30 min for $H_2S$ and 60 min for all other parameters, apart from exceptions given in A.3.6.4.3. These run times apply to both grab and continuous sampling.

#### A.3.6.4.2 Ambient air emissions

The sampling program shall consist of a minimum of 2 test runs per pollutant. The minimum sampling time for each run shall be 60 min for each of the components indicated in Table 12, apart from exceptions given in A.3.6.4.3.

#### A.3.6.4.3 Shorter sampling time

If the non-sewered sanitation system cannot be operated under a full load for 60 min (e.g., due to low seasonal demand), then a shorter sampling time (e.g. 30 min) may be used if the mean emission value can be calculated with sufficient certainty. For very short-term emission events for batch processes, several similar emission events may be combined in one sampling in order to enable the evaluation of the operating state. Pollutant detection limits should be considered in assessing whether shorter sampling times are appropriate, particularly with respect to grab sampling.

### A.3.6.5 Air emission measurement calculation procedures

#### A.3.6.5.1 Normalizing ambient measurements

Ambient air emission measurements shall be normalized by converting the raw values indicated on the instrument to the standard conditions prevalent in the test location.

The conversion formula is given in Formula A.1.

$$C_N = C \times \frac{1}{1 - \frac{H_2O\left[\%\right]}{100}} \times \frac{21 - 7\left[\text{Vol.}\%\right]}{21 - O_{2,\text{measured}}} \times \frac{1013}{p\left[\text{hPa}\right]} \times \frac{273,15 + T}{273,15} \quad \text{(A.1)}$$

where

$C_N$ is the concentration normalized;

$C$ is the raw value;

$H_2O$ is the humidity measured;

$O_{2,\text{measured}}$ is the $O_2$ concentration of the exhaust gas;

$p$ is the pressure of the exhaust gas; and

$T$ is the temperature of the exhaust gas.

#### A.3.6.5.2 Calculations

##### A.3.6.5.2.1 Indoor air emissions

After both test runs have been conducted, the following calculations shall be performed:

a) Calculate the average amount of emissions over 60 min ($H_2S$: 30 min) for each test run.

b) Take the higher average amount of both test runs.

   1) If the average is below the indicated threshold for 60 min ($H_2S$: 30 min) (see Table 11), then the relevant requirements of 7.2.9.5 shall be regarded as met.

   2) The relevant requirements of 7.2.9.5 shall be regarded as unmet if the average is higher than the indicated threshold for 60 min.

##### A.3.6.5.2.2 Ambient air emissions

After both test runs have been conducted, the following calculations shall be performed for each pollutant:

a) Calculate the average amount of emissions over 60 min for each test run.

b) Take the higher average amount of both test runs.

   1) If the average is below the indicated threshold for 60 min (see Table 12), then the relevant requirements of 7.2.9.5 shall be regarded be met.

   2) The relevant requirements of 7.2.9.5 shall be regarded as unmet if the average is higher than the indicated threshold for 60 min.

### A.3.7 Noise test method

#### A.3.7.1 Test site and superstructure

Within the laboratory where the controlled test is conducted (see 7.2), at least one sound-reflecting plane should be present on or near the location at which the non-sewered sanitation system is mounted. The laboratory should be adequately isolated from background noise and provide acoustic conditions closely approximating a free field above a reflecting ground. For laboratories that do not meet these recommendations, procedures for applying corrections are given in A.3.7.5.

If the sanitation system includes a superstructure as part of the manufactured product, then noise shall be measured both within the superstructure (see A.3.7.4.1.1) and at the external measurement points (see A.3.7.4.1.2).

If the sanitation system does not include a superstructure as part of the manufactured product, then noise measurements shall be taken without a superstructure installed and only at the external measurement points (see A.3.7.4.1.2).

#### A.3.7.2 Instrumentation

##### A.3.7.2.1 General

The instrumentation system, including the microphones, cables, and windscreen, if used, shall meet the requirements of IEC 61672-1:2013, class 1, and the filters shall meet the requirements of IEC 61260-1:2014, class 1.

##### A.3.7.2.2 Calibration

Before and after each series of measurements is taken, a sound calibrator meeting the requirements of IEC 60942:2003, class 1 shall be applied to each microphone to verify the calibration of the entire measuring system at one or more frequencies within the frequency range of interest. Without any adjustment, the difference between the readings made before and after each series of measurements shall be less than or equal to 0,5 dB. If this value is exceeded, the results of the series of measurements shall be discarded.

#### A.3.7.3 Operation of non-sewered sanitation system during test

The noise level of non-sewered sanitation systems shall be tested under conditions that are

a) reproducible, and

b) representative of the loudest operations involved in typical usage.

#### A.3.7.4 Noise measurement procedures

##### A.3.7.4.1 Measurement points

###### A.3.7.4.1.1 Within superstructure

For non-sewered sanitation systems that include a superstructure as part of the manufactured product, noise shall be measured within the superstructure at a single measurement point. The measurement point shall be centered above the squatting or WC pan of the frontend at a height of 1,2 m.

###### A.3.7.4.1.2 External

The external measurement points shall be determined relative to a reference parallelepiped, which shall be determined as the smallest imaginary rectangular parallelepiped that could spatially enclose



the system (see Figure A.3). If a superstructure is provided as part of the manufactured product, then the reference parallelepiped shall enclose the superstructure. Minor projections from the system shall be disregarded in determining the size of the reference parallelepiped.

The measurement points shall be positioned on the surface of a measurement parallelepiped whose planes are each 1 m outward (relative to the system) from those of the reference parallelepiped. Key measurement points shall be determined at the midpoint along the 1) width and 2) length of the measurement parallelepiped at a height of 1,2 m. Remaining measurement points shall be determined at 1 m intervals along the measurement planes, starting from the key measurement points (see Figure A.3), at a height of 1,2 m. If the shortest distance between two measurement points at a corner of the measurement parallelepiped is less than 1 m, then the measurement point nearest to the corner shall be discarded. The total number of points on the measurement parallelepiped is N.

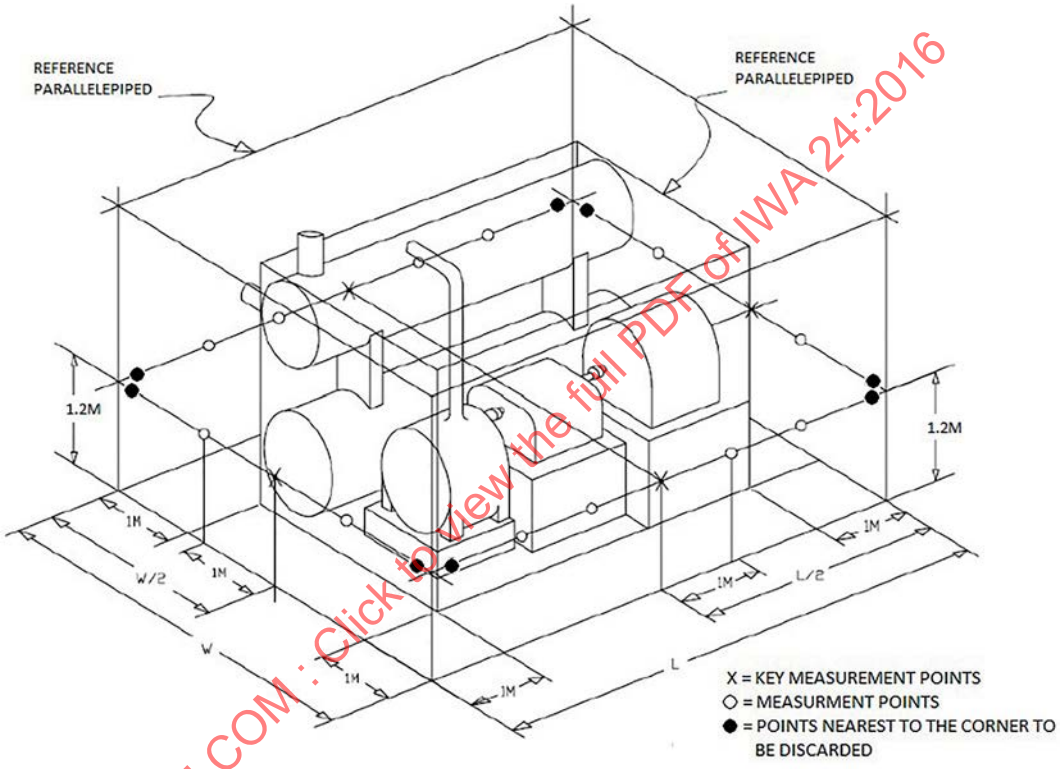



**Figure A.3 — Test unit measurement points**
(Source: ANSI/AHRI Standard 575 – modified)



#### A.3.7.4.2 Sound level meter setting

The sound level meter shall be set to A-weighting and slow time weighting and shall record the average and maximum noise level for each measuring event.

#### A.3.7.4.3 Microphone orientation

The microphone should be oriented to achieve maximum sensitivity to the incident sound from the noise source, to the exclusion of other noises. The microphone shall be oriented so that the reference direction of the microphone is normal to the measurement surface. The instrument manufacturer's recommendations shall be followed in using the meter and in determining the correct microphone orientation for the flattest frequency response.

#### A.3.7.4.4 Measuring event and data to be collected

Both maximum and average A-weighted sound pressure level measurements shall be taken at all N measurement points for each measuring event. The measuring events shall ensure measurement of all noise sources within the non-sewered sanitation system, including evacuation and treatment unit operation as well as any other sources of noise involved in system operation. In order to establish background noise levels, a further measuring event shall be conducted with the non-sewered sanitation system test unit switched off and all other test conditions preserved, including the continued operation of any other equipment present in the test room.

If all measuring events ensuring measurement of all noise sources can be completed in fewer than 24 h, then the test need not run a full 24 h.

### A.3.7.5 Sound measurement calculation procedures

#### A.3.7.5.1 Correction for background noise and reflecting surfaces in test environment

Two possible corrections can be determined to improve the measurement uncertainty of noise levels:

a) the correction, $K1$, in dB, to account for background noise; and

b) the correction, $K2$, in dB, to account for the reflecting surfaces in the test site.

#### A.3.7.5.2 Uncertain measurements due to background noise

If an A-weighted sound pressure level taken with the test unit operating fails to measure at least 6 dB above background noise levels (as measured according to A.3.7.4.4), then the measurement shall be marked uncertain by the use of an asterisk (*). The number of uncertain measurement points due to background noise is $N_{K1}$.

#### A.3.7.5.3 Uncertain measurements due to test environment

If an external measurement point (see A.3.7.4.1) is located within 1 m of a wall, window, or other reflecting surface, measurements shall not be recorded at that measurement point. The number of uncertain measurement points due to reflective surfaces in the test environment is $N_{K2}$.

#### A.3.7.5.4 Representative A-weighted sound pressure level

The number of valid measurement points shall be calculated by subtracting the uncertain measurement points identified in A.3.7.5.2 and A.3.7.5.3 from the total number of measurement points determined in A.3.7.4.1. If at least half of the measurement points remain (that is, if $N - N_{K1} - N_{K2} \geq N/2$), then the representative A-weighted sound pressure level ($L$) shall be calculated using Formula A.2.

$$L = 10\text{Log}10\left[\sum_{i=1}^{n} 10^{Li/10}\right] - 10\text{Log}10n \qquad \text{(A.2)}$$

where

$L$ is the representative or high-limit sound pressure level logarithmic average rounded off to the nearest 0,5 dB for a measuring event

$Li$ is the sound pressure level at the measured points; and

$n$ is the number of points to be averaged = ($N - N_{K1} - N_{K2}$).

The daily system noise levels, $L_{EX,\ 24h}$ are equivalent to the highest representative A-weighted sound pressure level among all measuring events. The maximum A-weighted sound pressure level, $L_{pA,max}$, is equivalent to the highest A-weighted sound pressure level measured from all measuring events.

### A.3.8 Laboratory testing procedures

#### A.3.8.1 Intentional stopping, starting, and activation of emergency stop

The following test procedure measures compliance with 5.2.

a) Stop the sanitation system operation by activating the stop control device or following the sequence of stop control actions. If a transition period is required, record its duration and note how it compares with the transition period indicated by the manufacturer (see 5.2.3).

b) Following at least 4 h of stoppage, start the sanitation system operation by activating the start control device or following the sequence of start control actions. If the starting of the sanitation system operation requires the application of mechanical force, measure the strength of this force by a proven measurement device and note how it compares with the force indicated by the manufacturer (see 5.2.2).

c) Following at least 4 h of operation, activate the emergency stop. If the system is equipped with more than one emergency stop device, test each device independently. Observe and record whether all mechanical and electrical processes and operations have been halted (see 5.2.4).

d) Subsequently, start sanitation system operation as described in Step 2.

#### A.3.8.2 Non-usage of sanitation system

The following test procedure measures compliance with the non-usage requirements of 4.3.5.

a) Without shutting down the system, allow 2 days to pass during which the sanitation system is not used (i.e. no load enters the system).

b) On the 3rd day, resume the normal loading pattern.

c) Record any malfunctions and efforts required to resume operation.

### A.3.8.3 Short-term shutdown of sanitation system

The following test procedure measures compliance with the short-term shutdown requirements of 4.3.5.

a) Prepare the system for short-term shutdown according to the manufacturer's instructions.

b) Shut down the system as specified in the manufacturer's instructions for short-term shutdown.

c) Allow 1 day to pass.

d) On the 2nd day, resume operation according to the manufacturer's instructions for resuming operation after short-term shutdown.

e) Record the duration required for the system to stop and to resume operation and compare with the duration indicated by the manufacturer.

### A.3.8.4 Reliability and safety for energy supply

#### A.3.8.4.1 Electrical energy supply

If electric energy serves as the primary energy source, the following test procedure shall be conducted to measure compliance with 5.3.1 and 5.3.2.

If the system relies on photovoltaic energy, it may be simulated through an alternative energy source for the purpose of the test. The alternative energy source shall reproduce the characteristic behavior of the photovoltaic energy supply.

a) Separate and isolate the sanitation system from its electrical energy supply through the specific safety device (see 5.3.2.1).

NOTE 1 If the system is powered by electricity, this separation can be achieved by unplugging the system.

NOTE 2 Systems in compliance with 5.3.1 will now be in either a safe state or powered by a redundant source or energy (see 5.3.1).

b) If the energy remaining or stored in the system poses a potential hazard (see 5.3.2.2), record whether all energy remaining or stored in the system is discharged, using an appropriate measuring device.

c) If a redundant source of energy is provided, check and record the capacity of the redundant source of energy (see 5.3.1).

#### A.3.8.4.2 Non-electrical energy supply

If the primary energy source is non-electrical, test the functioning of reliability and safety measures according to their intended use (see 5.3.3).

### A.3.8.5 Long-term shutdown

The following test procedure measures compliance with 4.3.6.

a) If the system is in a safe state following the testing procedure described in A.3.8.3, resume operation under the normal loading pattern (7.2.8) for at least 4 h before proceeding to long-term shutdown. If the system is powered by a redundant source of energy following the testing procedure described in A.3.8.3, proceed directly to long-term shutdown.

b) Follow the manufacturer's instructions for long-term shutdown. Record the duration of the transition to long-term shutdown.

c) After 3 days of shutdown, follow restart procedures and record the duration of the restart process.

#### A.3.8.6 Overloading

The following test procedure measures compliance with 4.3.4.

a) Load the system with the intended treatment capacity (4.3.2) plus twice the defined safety factor (4.3.4).

b) Record whether the overload indicator mechanism performs as intended. If the system is overloaded and the overload indicator mechanism is not performing as intended, record whether the system enters into a safe state.

#### A.3.8.7 Visibility of feces

The following test procedure measures compliance with 6.3.

a) Ensure sufficient lighting and a viewing angle directly into the frontend squatting or WC pan (perpendicular to the floor).

b) Activate the evacuation mechanism.

c) Once the frontend has resumed a ready state, observe and record whether an accumulation of deposited feces from previous users is visible.

d) If the visibility barrier is formed from a water seal, measure the depth of the water in the seal. Record whether the water seal reaches a depth of at least 20 mm.

#### A.3.8.8 Discharge and cleaning

The following test procedure measures compliance with 4.15.3.

a) Initiate the process of discharging all liquids, gases and aerosols, and solids from the system, following the manufacturer's instructions.

b) Record whether the system enters into a safe state for this purpose.

c) Record whether all contents have been discharged and whether the system clearly indicates to the user that the discharge process is complete.

#### A.3.8.9 Usability requirements

The following test procedure measures compliance with 6.2.1. applying recognized ergonomic and anthroprometric data:

a) Compare the use of the sanitation system with the usability requirements (suitable complexity and transparency; self-descriptiveness and intuitive design (look-and-feel); controllability; conformity with user expectations; error tolerance) specified in 6.2.1.

b) Record whether the related controls (e.g., hand levers, pedals, switches) and indicators are easy to access and located according to user expectations;

c) When using the sanitation system according to manufacturer's instructions, record whether:

1) neutral positions of the controls are automatically reset after triggering;

2) the movement of the controls to activate the flush functions correspond to the intended effect or to common practice; and

3) the activation forces are comfortable for the intended users.

### A.3.8.10 Diarrhea test day

For the diarrhea test day 50% of the specified users per day shall add diarrhea input instead of solid feces. Simulated diarrhea suitable for the specific backend may be used if actual diarrheal use is impractical.

# Annex B
(normative)

# Risk assessment and list of significant hazards

## B.1 Risk assessment requirements

If a manufacturer elects to conduct a risk assessment (see 5.1), the following provisions apply (adapted from ISO 12100 and based on industrial best practice).

### B.1.1 General

The manufacturer or his or her authorized representative shall process a risk assessment in order to ensure and to document that the fundamental requirements for the protection of health and safety are met by the design and realization of the non-sewered sanitation system. The non-sewered sanitation system shall be designed and realized so that it is fit for its function, and can be operated and maintained without putting persons at risk when the system's operations are carried out under the anticipated conditions of use.

### B.1.2 Risk assessment process within design process

A systematic evaluation process shall be included in the product design process that follows and documents risk assessment steps (see Figure B.1) in order to:

a) determine the relevant hazards that are reasonably expected to emerge from the design and realization of the specific sanitation system (e.g. by means of a hazard identification study or what-if-study);

b) evaluate the identified hazards and determine the related health and safety requirements that apply to the design and realization of the non-sewered sanitation system;

c) evaluate the probability of occurrence of harm and the severity of that harm associated with each hazard, and determine the related risk potential;.

d) determine whether the risk is acceptable or additional risk mitigation is required;

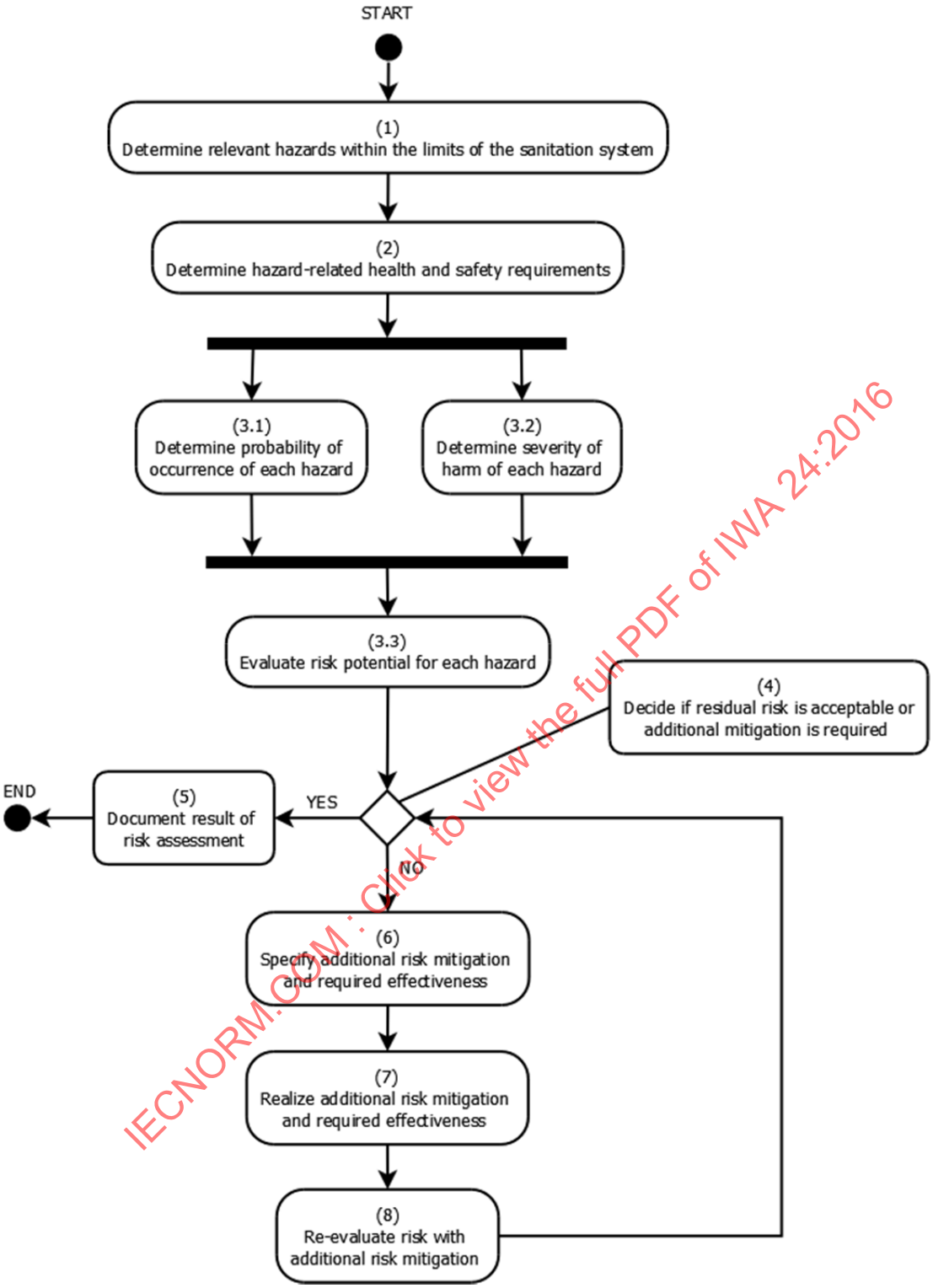
e) document the risk assessment result if the risk is deemed acceptable; or

f) specify additional risk mitigation measures and the results to be achieved if additional risk mitigation is required;

g) design and realize additional risk mitigation if needed; and

h) re-evaluate the risks following risk mitigation and determine whether the resulting residual risk is acceptable or further risk mitigation is required.

By incorporating the risk assessment process into the design process, the non-sewered sanitation system shall be designed and realized in such a way as to iteratively respond to the results of the risk assessment.






NOTE Numbered steps correspond to those described in B.1.2.

**Figure B.1 — Flow chart of iterative risk assessment**

### B.1.3 Limits of the system

The process of risk assessment and risk reduction shall consider the limits of the non-sewered sanitation system, which include:

a) characteristics of the intended users and service personnel and their levels of training, experience, and ability;

b) operating modes and their associated user intervention procedures;

c) system malfunctions and failures that do not result in the system entering safe state mode;

d) intended use and any reasonably foreseeable misuse;

e) power supply interface and power supply storage; and

f) expected lifetime of the system and/or its components, taking into account recommended service intervals.

### B.1.4 Relevant life cycle

The risk assessment shall include hazards that can be generated by the non-sewered sanitation system in all relevant phases of the non-sewered sanitation system life cycle, i.e.:

a) transport;

b) assembly and installation;

c) use and malfunction;

d) standby;

e) service and maintenance;

f) shut-down and storage; and

g) dismantling and scrapping.

### B.1.5 Risk mitigation principles

Risks shall be evaluated in order to determine whether additional risk reduction is required, in accordance with the provisions of this document and following the common principles of safety integration:

In selecting the most appropriate design solution for risk mitigation, the manufacturer or his or her authorized representative shall apply the following order of priority, proceeding to a lower-order solution only if a higher-order solution cannot be achieved:

a) inherently safe design and construction;

b) protective measures in relation to risks that cannot be eliminated by inherently safe design and construction;

c) information provided to users and service personnel concerning residual risks.

### B.1.6 Documentation requirements

The procedure and results of the risk assessment shall be comprehensively documented in a risk assessment report.

This risk assessment report shall include, at a minimum:

a) the sanitation system under consideration and its intended use on which the risk assessment is based;

b) technical documentation, test results, information, and data as well as identification of any standards or other technical specifications referred to or used for the assessment;

c) the risk reduction targets to be achieved by the risk mitigation measures;

d) a risk assessment form including the relevant hazards and hazardous situations identified and their risk-based evaluation;

e) each risk reducing measure considered and the related risk reducing effectiveness, separately indicating the reduction of probability of occurrence and the reduction of the severity of potential harm;

f) indication of the residual risks, and related instructions or warnings to incorporate into the user manual and/or necessary warning signs;

g) a final statement that confirms that all relevant risks emerging from the sanitation systems are mitigated to an acceptable level in accordance with the risk reduction targets.

## B.2 List of significant hazards

Table B.1 lists the significant hazards and hazardous situations and events addressed in this document and indicates the relevant subclause corresponding to each hazard. Hazards relevant to a particular sanitation system shall be identified through a safety assessment (5.1). ISO 12100 can indicate additional relevant hazards for the particular sanitation system.

**Table B.1 — Significant hazards addressed**

| No. | Significant hazard | Relevant subclause |
|---|---|---|
| **1** | **Mechanical hazards** due to parts and components, respectively due to their shape, location, mass and stability, mass and velocity, mechanical strength or accumulation of mechanical energy inside the system, liquids and gases under pressure, effects of vacuum. | 5.3.3; 6.4 |
| 1.1 | Crushing hazard | 5.4.3 |
| 1.2 | Shearing hazard | 5.4.3 |
| 1.3 | Cutting or severing hazard | 4.13.1 |
| 1.4 | Drawing-in or trapping hazard | 5.4.3 |

**Table B.1** (*continued*)

| No. | Significant hazard | Relevant subclause |
|---|---|---|
| 1.5 | Impact hazard | 4.13.3 |
| 1.6 | Stabbing or puncture hazard | 4.13.1 |
| 1.7 | Friction or abrasion hazard | 4.13.1 |
| 1.8 | High pressure fluid injection or ejection hazard | 5.4.1; 5.4.2 |
| 1.9 | Slipping, tripping and falling | 6.6 |
| **2** | **Electrical hazards** | 5.3.2.2; 5.6.1 |
| 2.1 | Contact with live parts, electrocution | 5.3.2.1; 5.3.2.2; 5.6.1 |
| 2.2 | Effects from short circuits, overloads, etc. e.g. fire | 5.3.2.1; 5.6.1 |
| **3** | **Thermal hazards** resulting in burns, scalds and other injuries through possible contact with objects or surfaces of a high or low temperature. | 5.5.1; 5.5.2 |
| **4** | Hazards generated by **noise** resulting in discomfort, Interference with speech communication, acoustic, signals etc. | 4.4.3, 6.5 |
| **5** | **Vibration** hazards resulting in discomfort due to whole body vibration, particularly when combined with poor postures. | 6.5 |
| **6** | Hazards generated by **radiation** due to ionizing radiation sources, low frequency electromagnetic Radiation, optical radiation or radio frequency electromagnetic radiation. | 5.5.3; 5.6.1 |
| **7** | **Material and substance hazards** | |
| 7.1 | Hazards from contact with harmful substances, fluids, gases, mists, fumes and dusts causing infections, sensitizations. | 4.4.1; 4.4.4; 4.10.1; 4.10.2; 4.10.3; 4.10.4; 4.10.5; 4.11.1; 4.12; 4.13.4; 4.15.3; 6.1.2 |
| 7.2 | Fire or explosion hazard | 4.10.3; 4.11.2; 4.13.2; 5.6.1 |
| **8** | **Ergonomic hazards** resulting in discomfort, stress, human error | 4.1; 4.4.2; 4.7; 4.14.1; 4.14.2; 6.2.1; 6.2.3; 6.2.4; 6.3; 6.6 |
| 8.1 | Unhealthy postures or excessive effort | 4.15.2; 5.2.2; 6.2.1 |
| 8.2 | Deficiencies in usability | 4.3.7; 4.15.1; 4.15.4; 4.15.5; 6.2.1; 6.2.2; 6.4 |
| 8.3 | Neglecting principles of safety integration guards and protection devices. | 5.1; 5.2.4; 5.4.3 |
| 8.4 | Inadequate design of adjustment and maintenance places and access to these places. | 4.15.2 |
| **9** | Hazards associated with the **environment** in which the sanitation system is used. | 4.8; 4.9.1; 4.9.2; 4.9.3;4.13.4; 4.13.6 |

**Table B.1** (*continued*)

| No. | Significant hazard | Relevant subclause |
|---|---|---|
| **10** | **Process hazards** as unexpected start-up, overloads or insufficient process etc. | 5.2.2; 5.2.3; 5.2.4; 5.6.3 |
| 10.1 | Failure of control system | 5.2.4; 5.6.2; 5.6.3 |
| 10.2 | Restoration of energy supply in case of interruption | 5.3.1 |
| 10.3 | Erroneous control actions of the user or service personnel | 4.12; 4.15.1; 5.6.2 |
| 10.4 | Deficient treatment process | 4.3.1; 4.3.2; 4.3.3; 4.3.4; 4.3.5; 4.3.6; 4.10.5; 5.3.1; 5.6.2; 5.7; 6.4 |
| **11** | **Loss of stability or overturning** | 4.13.3; 4.13.5; 4.13.6; 6.5 |
| **12** | **Hazards due to transporting the sanitation system** | 4.15.6 |

## B.3 Product Safety Life Cycle (PSLC)

If a PSLC is conducted, the following requirements apply.

Following the entry of the sanitation system into the market, the PSLC enables the systematic observation and documentation of experiences and events from sanitation system operation by users and maintenance personnel. The data shall be systematically evaluated with respect to implications for product safety improvement and product performance improvement. Thus, the PSLC provides a means for the manufacturer to ensure that the expected functional and safety-related requirements (e.g., capacity, thresholds, availability) are continuously met by the sanitation system.

A typical generic PSLC shall be included in the product design process that follows and documents the following process steps (see Figure B.2):

a) Perform technical product analysis that determines distinctive subsystems and functional units of the sanitation system including their interdependent interfaces.

b) Determine standards and regulations relevant for design and later operation of the sanitation system.

c) Identify relevant hazards through risk assessment (B.1) or equivalent safety assessment (5.1) to realize and maintain the safety of the sanitation system.

d) Determine course of action concerning required additional risk mitigation through technical, organizational, or person-related measures achieving the expected safety of the sanitation system.

e) Prepare the required user manuals and information for the user to allow safe operation of the sanitation system (see requirements in 4.15.5 and specifications in Annex C).

NOTE Steps 3, 4 and 5 correspond to the risk assessment procedure detailed in B.1.

f) Conduct review, verification, and testing of performance capacities and safety requirements of the sanitation system according to Clause 7.

g) Prepare and consolidate the sanitation system's documentation with respect to technical specification and design, verification, and testing as well as risk assessment (B.1) or equivalent safety assessment (5.1) and user documentation. The resulting technical file should be archived for