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Non-sewered sanitation systems — Prefabricated integrated treatment units — General safety and performance requirements for design and testing

Systèmes d'assainissement autonomes — Unités de traitement intégrées préfabriquées — Exigences générales de performance et de sécurité pour la conception et les essais

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Foreword

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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 of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Project Committee ISO/PC 305, *Sustainable non-sewered sanitation systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

It is estimated that 2,3 billion people do not have access to basic sanitation systems. The devastating consequences of the lack of sanitation facilities include an estimated 1,8 billion people globally using a source of drinking water that is faecally contaminated and 361 000 children under 5 years of age dying per year, primarily from dysentery-like diarrhoeal diseases.

In March 2013, the United Nations (UN) issued a global call to action to eliminate the practice of open defecation by 2025. The UN and regional sanitation leaders have concluded that areas where open defecation is common have the highest levels of child death and disease, as a result of ingesting human faecal matter that has entered the food or water supply. 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.

On 1st January 2016, the 17 UN Sustainable Development Goals (SDG) were launched, including SDG 6: ensure access to water and sanitation for all. The SDGs are a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of the new UN sustainable development agenda.

Targets 6.2 and 6.3 of SDG 6 state:

— by 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations;

— by 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

In this context, the purpose of this document is to support the development of stand-alone sanitation systems designed to address basic sanitation needs and promote economic, social, and environmental sustainability through strategies that include minimizing resource consumption (e.g. water, energy) and converting human excreta to safe output.

This document is intended to promote the implementation of sanitation systems where increased sustainability is desired, or where traditional sanitary sewer systems are unavailable or impractical and thus, to ensure human health and safety as well as protecting of the environment.

However, this document does not attempt to exhaustively address sustainability concerns with respect to non-sewered sanitation systems (NSSS). There are many aspects to sustainability that are not covered in this document.

The concept of a NSSS is indicated in Figure 1, showing the integration of the frontend(s) and backend(s) along with the input and output. Inputs entering the NSSS primarily comprise of human faeces and urine, menstrual blood, bile, flushing water, anal cleansing water, toilet paper, other bodily fluids/ solids. Outputs substances exiting the NSSS include the products of the backend treatment process such as solid output and effluent, as well as noise, air, and odour emissions.

By design, such sanitation systems operate without connection to any sewer or drainage network. The NSSS can be either manufactured as one package or manufactured as a set of prefabricated elements designed to be assembled without further fabrication or modification that influences the system function. The prefabricated components of NSSS are intended to require minimal work to be integrated and quickly provide fully functioning sanitation systems.

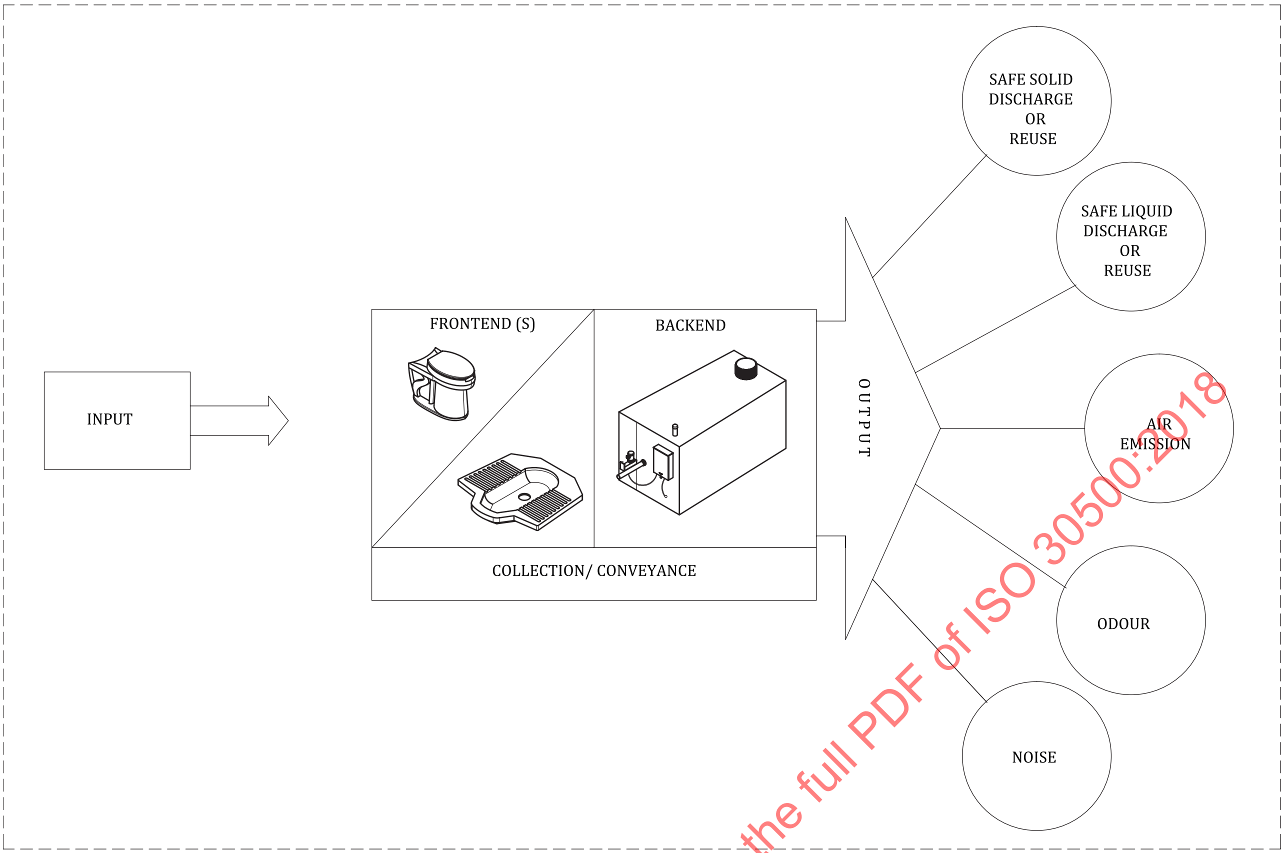


Figure 1 — Concept of a non-sewered sanitation system

In NSSS, the frontend includes user interfaces such as a urinal, squatting pan, or sitting 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 may be combined with urine diversion applications (e.g. urine diversion flush toilet, urine diversion dry toilet). Backend treatment technologies and processes of NSSS range from biological or chemical to physical unit processes (e.g. anaerobic and aerobic digestion, combustion, electrochemical disinfection, membranes). Some systems use only one of these technologies or processes while others apply various unit processes in combination through several treatment units.

Non-sewered sanitation systems — Prefabricated integrated treatment units — General safety and performance requirements for design and testing

1 Scope

This document specifies general safety and performance requirements for design and testing as well as sustainability considerations for non-sewered sanitation systems (NSSS). A NSSS, for the purposes of this document, is a prefabricated integrated treatment unit, comprising frontend (toilet facility) and backend (treatment facility) components that

a) collects, conveys, and fully treats the specific input within the system, to allow for safe reuse or disposal of the generated solid, liquid, and gaseous output, and

b) is not connected to a networked sewer or networked drainage systems.

This document is applicable to sanitation systems that are either manufactured as one package, or manufactured as a set of prefabricated elements designed to be assembled in one location without further fabrication or modification that influences the system function. The plane or surface (e.g. flooring, concrete pad) upon which a fully assembled NSSS is situated is beyond the scope of this document. This document is not applicable to sanitation systems constructed *in situ*.

This document also covers NSSS backend components that are designed to be integrated with one or more specified frontends.

Although this document is primarily applicable to the development of sanitation systems that are not connected to water and electricity networks, it can also be applied to systems that can utilize water mains and/or electricity.

This document defines the basic treatable input as primarily human excreta and gives options for extending the range of input substances. Requirements for the quality of the outputs from the sanitation system are given for solid and liquid discharges as well as odour, air, and noise emissions.

It contains criteria for the safety, functionality, usability, reliability, and maintainability of the system, as well as its compatibility with environmental protection goals.

This document does not encompass the following aspects:

— guidelines for selection, installation, operation and maintenance, and management of sanitation systems;

— transportation of treated output outside of the sanitation system (e.g. manual transport, transportation by truck or trunk pipes) for further processing, reuse, or disposal;

— treatment processes taking place at another location separate from that of the frontend and backend components;

— reuse and disposal of sanitation system output.

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 20816-1, *Mechanical vibration — Measurement and evaluation of machine vibration — Part 1: General guidelines*

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

IEC 60942:2017, *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 — Part 1: Specifications*

EN 997:2012, *WC pans and WC suites with integral trap*

EN 13725:2003, *Air quality — Determination of odour concentration by dynamic olfactometry*

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

NSF/ANSI 41:2011, *Non-liquid saturated treatment systems*

WHO Guidelines for Drinking Water Quality, 4th edition

3 Terms, definitions and abbreviated terms

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 https://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
NSSS
system that is not connected to a networked sewer, 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* (3.1.2.7)

Note 1 to entry: For the purposes of this document, a NSSS that fully treats the specific input is a NSSS that meets the performance testing requirements specified in Clause 7.

3.1.1.2
evacuation mechanism
mechanism that delivers energy/movement to convey the *input* (3.1.2.1) from the *frontend* (3.1.1.3) 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
any user interface such as urinal, squatting or seat 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 to or integrated with the *non-sewered sanitation system* (3.1.1.1) in order to provide shelter or privacy 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 *faeces* (3.1.2.4) and *urine* (3.1.2.3), menstrual blood, bile, flushing water, anal cleansing water, toilet paper, other bodily fluids/solids and, in some systems, additional input as defined by the manufacturer

EXAMPLE Examples of additional input may include water from hand washing, menstrual hygiene products, organic household waste.

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* (3.1.2.7)] as well as noise, air, and odour emissions

Note 1 to entry: The output can be reusable product, a direct output to the environment, or a residual waste.

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
faeces
excreta products of the human digestive system, including microorganisms

3.1.2.5
excreta
waste products of human metabolism, in solid or liquid form, generally *urine* (3.1.2.3) and/or *faeces* (3.1.2.4)

[SOURCE: ISO 24521:2016, 3.3]

3.1.2.6
diarrhoea
loose, watery *faeces* (3.1.2.4), often resulting from viral, parasitic protozoan, bacterial, or helminth infection

3.1.2.7
effluent
treated liquid discharged from the *backend* (3.1.1.4)

3.1.2.8
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 and/or biological agents

EXAMPLE Deodorants, bactericides, bacteriostats, microbiocides, chemical reactants, surfactants, or enzymatic agents.

3.1.2.9
energy supply
energy from electrical grid, photovoltaic, or other sources (e.g. mechanical storages, pressurized air reservoirs or windmills) that powers the *non-sewered sanitation system* (3.1.1.1)

3.1.2.10
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
source or situation with a potential for harm in terms of human injury or ill health (both short and long term), damage to property, environment, soil and vegetation, or a combination of these

[SOURCE: ISO 30000:2009, 3.4, modified — "soil and vegetation" has been added.]

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
systematic use of available information to identify *hazards* (3.1.3.1) and to estimate the *risk* (3.1.3.2)

[SOURCE: ISO/IEC Guide 51:2014, 3.10]

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 — The word "machine" has been replaced by "non-sewered sanitation system".]

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 — The word "system" has been replaced by "non-sewered sanitation system", "for users and professional service personnel "and the note have been added.]

3.1.3.8
exposed material
material used within the *non-sewered sanitation system* (3.1.1.1) that comes into contact with human *urine* (3.1.2.3) or *faeces* (3.1.2.4), or intermediate products and residual waste 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 and prevent leakage

[SOURCE: ISO 15821:2007, 3.6, modified — The term "test specimen" has been replaced by "non-sewered sanitation system", "and prevent leakage" has been added.]

3.1.3.10
technical tightness
inherent characteristics of a *non-sewered sanitation system* (3.1.1.1) that prevents hazardous fluids, gases, or suspended particulate matter from passing from the external environment through to the processing/treatment internal environment, or from the processing/treatment internal environment to the external environment, or both

Note 1 to entry: The sanitation system or components thereof are considered technically tight if the leakage rate does not exceed 0,001 Pa·l/s.

Note 2 to entry: Subsystems, components, or boundaries that require technical tightness are to be identified in the safety assessment (see 5.1).

3.1.3.11
strength safety factor
ratio between the load or pressure limit 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.

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 use

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 behaviour

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

[SOURCE: ISO/IEC Guide 51:2014, modified — The term "product or system" has been replaced by "non-sewered sanitation system", Notes have been deleted and a new Note 1 to entry has been added.]

3.1.4.3
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 82:2014, 3.1]

3.2 Abbreviated terms

BL	Batch liquid
BS	Batch solid
CAPEX	Capital expenditure
CFU	Colony-forming units
COD	Chemical oxygen demand
EMC	Electromagnetic compatibility
EPA	US Environmental Protection Agency
GHG	Greenhouse gas
HACCP	Hazard analysis and critical control point
HAZOP	Hazard and operability study
IP	Ingress protection
LRV	Log reduction values
MOP	Maximum operating pressure
NIOSH	National Institute of Occupational Safety and Health
NPV	Net present value
OPEX	Operating expense
OSHA	Occupational Safety and Health Administration
PFU	Plaque-forming units
PL	Periodic liquid
PS	Periodic solid
PSLC	Product safety life cycle
SSF	Strength safety factors
TSS	Total suspended solids
UN	United Nations

UNICEF	United Nations Children's Emergency Fund
VOC	Volatile organic compound
WHO	World Health Organization

4 General requirements

4.1 User requirements

The NSSS shall be designed in such a way as to ensure that the users can use the system safely and in the manner intended by the manufacturer. The design and implementation of the system shall ensure that users with little or no literacy or those who do not have technical expertise are able to safely and effectively use the system frontend and perform routine user maintenance as intended by the manufacturer.

NOTE Additional requirements for specific users, such as persons with disabilities and small children, are provided, for example, in Reference [26], Reference [33] and Reference [40].

4.2 Metric system

Design and construction of NSSS shall be specified in International System of Units of measurement.

4.3 Design capacity

4.3.1 Treatable input

NSSS shall be capable of treating, at a minimum, human faeces and urine, menstrual blood, bile, flushing water, anal cleansing water, toilet paper, and other bodily fluids/solids. Manufacturers may identify additional categories of input as acceptable for treatment, such as water from hand washing, menstrual hygiene products, and/or organic household waste.

4.3.2 Treatment capacity

The design capacity with regard to human faeces and urine shall be indicated as expected uses per day (faecal uses/day and urine uses/day). The average amount of faeces (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 Reference [75] measured the average faecal 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 1,0 l/person/day to 1,3 l/person/day.

4.3.3 Menstrual hygiene products

If the system is intended to accept menstrual hygiene products separately from other system inputs, then the provisions and instructions for the safe operation and maintenance of the disposal mechanism or device shall be provided. Cultural norms, existing practices and aspirations regarding the disposal of menstrual hygiene products shall be considered (see D.4 and E.4).

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 visual and/or audible 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 (see A.3.8.6).

4.3.5 Operability following non-usage

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

Non-usage is when there is no intentional shut down of the system by the user. In addition, the system is not used nor has any human interaction for a period of 60 h.

4.3.6 Operability following short-term shut down

Following restart after a short-term shut down (i.e. 60 h or less) specified by the manufacturer, the system shall be able to immediately accept input and return to normal operating state.

4.3.7 Operability following long-term shut down

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

The manufacturer shall clearly indicate the duration of time necessary to complete the long-term shut down process. The long-term shut down process should not require more than 10 h for completion. Required user interaction during shut down should be minimized.

Following restart after long-term shut down, the sanitation system shall be able to immediately accept input and be capable to return to normal operating state within the time specified by the manufacturer.

4.3.8 Continuous use

The sanitation system shall allow continuous use without unreasonable waiting times between uses. The manufacturer shall specify the minimum wait time between uses in the user manual or as part of the equipment label or data plate.

4.3.9 Safe state

Means of indication (visual or audible) or instruction to determine if the system is in a safe state (see 3.1.3.7) shall be provided by the manufacturer.

4.4 Performance requirements

4.4.1 General

The sanitation system shall be such that when operated, maintained and used, the requirements in 4.4.2 to 4.4.5 are met under all operating conditions (see 4.8).

4.4.2 Solid output and effluent requirements

Solid output and effluent shall be fully treated within the sanitation system allowing for safe reuse or disposal. Solid output and effluent shall meet the requirements specified in 7.2.9.3 and 7.2.9.4 at all times including the start-up period when tested in accordance with A.3.4.

4.4.3 Odour emissions requirements

In order to minimize odour emissions from the sanitation system, the requirements in 7.2.9.5 shall be met when tested in accordance with A.3.5.

NOTE Potential origins of odour emissions from the sanitation system include faecal odours (faeces and urine, and aging of faeces and urine), and process odours such as those emerging during drying, pyrolysis, combustion, and discharge of output.

4.4.4 Noise requirements

Noise emissions from the NSSS shall not pose risks to the health and psychological wellbeing of the user. When tested in accordance with A.3.7, the sanitation system shall meet the requirements specified in 7.2.9.6.

4.4.5 Air emissions requirements

Potential air emissions from NSSS may be classified as pollutants or explosive gases. The monitoring of explosive gases during operation is addressed in 4.12.2. Air pollutants from the NSSS released indoors and outdoors shall not exceed a level that poses risks to the health of the user. When tested in accordance with A.3.6, the sanitation system shall meet the requirements specified in 7.2.9.7.

The design of the NSSS (frontend and backend) shall be such that emissions of bioaerosols and endotoxins are minimized. For NSSS with a backend that discharges directly in the indoor environment, and where bioaerosol and/or endotoxins can reasonably be expected, testing for pathogenic bioaerosols and for endotoxins is recommended.

At the time of publication of this document, no performance requirements are specified for bioaerosols or endotoxins. This may change in the future e.g. as occupational health standards are established for these hazards.

4.5 Expected design lifetime

NSSS shall be designed for a serviceable life of a minimum of 10 years, at the loading rates or frequency stipulated by the manufacturer, assuming use and maintenance according to the manufacturer's specifications. Maintenance requirements are specified in 4.14 and user manual requirements are specified in Annex C.

4.6 Aspirational and ergonomic design

NSSS should be designed not only for functionality but also for comfort. NSSS 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 (see E.2).

4.7 Secure design

In order to prevent theft or tampering, critical accessible components of the NSSS shall be assembled or affixed in such a way as to deter removal or dismantling by unauthorized parties.

NOTE Design requiring the use of tools for removal or dismantling of any components can help to deter theft.

4.8 Operating conditions

4.8.1 Ambient temperature range

NSSS shall operate safely and reliably in environments with ambient temperatures at a minimum range from 5 °C to 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 outside this range shall additionally demonstrate their capability to operate safely and reliably in these expanded ambient temperature ranges.

4.8.2 Ambient air humidity

NSSS shall operate safely and reliably in ambient air humidity conditions at a minimum range from 20 % to 100 %. Technologies designed for use in environments with ambient air humidity below 20 % shall additionally demonstrate their capability to operate safely and reliably in these expanded ambient air humidity ranges.

4.8.3 Atmospheric pressure

NSSS shall operate safely and reliably under atmospheric pressure conditions at a minimum range from sea level (101 kPa) to 2 500 m altitude (76 kPa). Technologies designed for use in environments with atmospheric pressure outside this range shall additionally demonstrate their capability to operate safely and reliably in these expanded atmospheric pressure ranges.

4.9 Requirements for sanitation system components

4.9.1 General

Critical materials, equipment, components, connections, and joining elements of the NSSS that are indispensable to the proper operation of the system shall be selected based on their suitability for sanitation applications.

Documentation of the performance adequacy shall be provided for any essential materials, equipment, components, connections, or joining elements that are not explicitly designed, commonly used or approved for use in sanitation systems. Performance adequacy can be demonstrated through risk assessments or other commonly accepted methods (e.g. failure mode and effects analysis, material testing, material safety data sheets).

When testing is conducted as part of the product certification process, the laboratory performing material testing shall meet the requirements in A.1.

4.9.2 Hygienic design

NSSS shall be designed in such a way as to mitigate any risk of infection due to potential pathogens from human urine or faeces or the intermediate and residual products of the sanitation system.

NSSS shall 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 where 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 Resistance to the effects of flooding, such as inundation and the lateral force of floodwater, is an additional consideration for NSSS in flood-prone areas.

Related testing procedures are provided in A.3.1.

4.9.4 Cleanability of surfaces

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

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

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

Visibly exposed materials shall be designed in such a way as to ensure that faeces and residual substances can be removed by domestic household cleaning methods and without requiring the use of specialized chemical cleaning agents. Overall cleanability should have a minimum value equivalent to 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

NSSS should minimize 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, handling and storage of any additives necessary for system function (e.g. safety data sheets from the manufacturer of the relevant additives) (see Annex C).

4.10 Material requirements

4.10.1 Durability of materials

Materials used for NSSS shall be structurally stable, durable, and, where relevant, water tight, and shall be resistant to the effects of local conditions for the intended use (see 3.1.4.1) and reasonably foreseeable misuse (see 3.1.4.2).

Durability shall be achieved either through the use of materials inherently resistant to corrosion or through the application of a 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) on such components shall be prevented (see E.3.3.3).

4.10.2 Fire resistance of materials

NSSS shall be resistant to fire. Materials shall not ignite, progressively glow, smoulder, or show evidence of being functionally impaired when exposed to a source of ignition. Materials should conform to ISO 10295 (all parts) or equivalent.

4.11 Connections and joining elements

Connections (e.g. welds, joints) within NSSS 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 and 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 via the safety assessment (see 5.1) shall not require regular maintenance activity. Location, type, and specification of such connections shall 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 NSSS with which users or service personnel can come into contact shall be free from rough or sharp edges or unnecessarily sharp points.

4.12.2 Fire and explosion protection

NSSS shall be designed in such a way as to avoid any risk of fire or overheating caused by operation or malfunctions of the NSSS itself, or by gases, liquids, dust, vapours, or other substances generated or used in the process of the system's operation.

NSSS shall be designed 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, vapours, or other substances produced. Hazardous accumulations of potentially explosive gases, liquids, dust, vapours 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 ≥ 3;

— for hazards that halt backend operations, SSF ≥ 2;

— for hazards that cause inconvenience, SSF ≥ 1,5.

4.12.4 Prevention of contact with unsafe effluent and reuse

Sanitation systems that do not meet effluent requirements for flushing or handwashing (see 7.2.9.4) shall prevent this type of internal (or within the system) reuse in the design of the system through reasonably practicable means.

Sanitation systems that are designed for intentional effluent reuse (rather than safe discharge to the environment) shall meet the necessary requirements for the type of reuse (e.g. irrigation, flushing, handwashing) (see 7.2.9.4).

4.12.5 Underground systems

Components of NSSS that are designed to be 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; and

— should allow for easy monitoring to prevent leakages and groundwater and/or soil pollution.

4.12.6 External impacts

NSSS and their components and fittings shall be stable enough 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 4.14.5). 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 NSSS shall be provided through clear and unambiguous symbols or pictograms to ensure the user's comprehension (see E.3.2). In addition, information and warnings on NSSS shall also take into account user requirements (see 4.1).

A data plate or label 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) and manufacturer defined wait time between uses (see 4.3.8);

b) expected daily capacity for additional 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;

d) instructions for obtaining service and contact information;

e) minimum and maximum operating temperature.

When a backend is supplied without a frontend, a data plate or label, consisting of the information listed in a) through to e), shall be provided by the manufacturer such that it can be placed securely in the vicinity of the frontend by the site owner or operator.

If the effluent of the system does not meet drinking water requirements (see 7.2.9.4), a data plate or label 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.

Additionally, if the system is designed to produce treated output suitable for reuse, the manufacturer shall:

— specify the intended purpose/application of solid output, effluent and/or off-gas;

— provide information on the quality of the reusable output (e.g. nutrient content).

This information shall be in the form of a data plate or label placed in a location visible to the user in the vicinity of the backend.

Plates and labels shall be permanent and clearly legible.

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

4.13.2 Marking and labelling

NSSS shall have permanent and legible data plates. The information shall be provided in the official language(s) of the country of use.

Data plates shall include, at a minimum:

a) manufacturer's name and address;

b) model number;

c) serial number;

d) date of manufacture;

e) total unit mass when operational;

f) parameters of primary electric circuits, including voltage and amperage.

4.14 Maintenance

4.14.1 Reasonable configuration, adjustment, and maintenance activities

NSSS shall be designed 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 users.

See D.3 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

To prevent contamination and minimize the risk of infection, configuration, adjustment, and maintenance points should be located separate from any hazardous areas. Removal of system blockages, when necessary, should be processed from the outside of the sanitation system and should not necessitate any disassembly.

NSSS shall be designed in such a way as to ensure that components requiring service can be accessed and if sanitation system access is required, re-configuration can be performed safely. Configuration, adjustment, and maintenance should not unnecessarily involve contact with input materials, intermediate process products, or residual products.

4.14.3 Discharge and cleaning

Cleaning and regular maintenance activities conducted by the user shall not require discharge of partially treated materials. Discharge of partially treated materials may be necessary for maintenance activities conducted through service personnel. If maintenance activities require discharging partially treated materials, either solid, liquid, or gas, these partially treated materials need not meet the requirements for outputs to the environment specified in this document. The service personnel shall be responsible for appropriate disposal of the partially treated material. Discharge of partially treated material for maintenance shall not be a substitute for treatment by the system.

It is understood that the volume of in-process or partially treated material remaining after shut down for a service interval will vary due to the prior loading conditions, treatment approach (batch, continuous, other) and timing of shut down procedure. It is intended to ensure that systems deliver full on-site treatment (as far as practicable) and as such the partially treated materials needing to be disposed of should be minimized.

The manufacturer should provide clear instructions to service personnel to deposit discharged partially treated material in a way that minimizes risk for health, safety and environment.

4.14.4 Tools and devices

If specialized tools are required for emptying and maintaining the NSSS, then these specialized tools shall be described 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 NSSS 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 specified in Annex C.

4.14.6 Handling and transport of the sanitation system

NSSS, including primarily mobile 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 properly secured 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.

5 Technical requirements

5.1 Safety assessment

The manufacturer of a NSSS 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;

c) demonstrate the safety of the product by documenting the results of the safety assessment.

This assessment should be carried out during the design process; however, 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 foreseeable misuse.

Additional requirements for risk assessments are specified in Annex B.

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). If a PSLC is conducted, the requirements specified in B.3 apply.

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 25 N.

5.2.3 Intentional stopping of sanitation system operation

The NSSS 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 NSSS shall be equipped with one or more emergency stop devices that safely halt all mechanical and electrical processes as well as operations and cut off energy supply. Manufacturers of NSSS should refer to 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 backup 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 shut down (see 4.3.7). The amount of energy supplied by the redundant source shall be indicated to the user.

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 NSSS is plugged into an electrical outlet, removal of the plug may be 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 NSSS 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.

Subsystems of the sanitation system that 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

NSSS 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 or vacuum equipment

Pressurized equipment with a nominal operation gauge pressure higher than 50 kPa or vacuum equipment with a nominal operation gauge pressure lower than 50 kPa vacuum shall be designed 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 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.

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.

NSSS shall be designed 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. The test method should be 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 −20 °C shall be equipped with protection measures or fixed guards sufficient to prevent injuries due to low temperatures.

5.5.3 Other radiation emissions

Undesirable radiation emissions from the sanitation system shall be suitable to meet safe levels.

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.

Safety requirements shall include 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);

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 NSSS 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.

If a control system is incorporated, it 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 start-up 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 from the safety assessment (see 5.1) shall remain fully effective or issue a stop command;

d) the signalling 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.

If a control system exists, it shall be capable of detecting, at a minimum:

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

— the overall availability for use, and shall deliver a visible 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 in such a 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 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 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 in accordance with ISO 20816-1, the vibration level in the XYZ-axis at any possible area of the frontend user interface of NSSS shall not exceed 0,5 m/s^2.

6 Additional requirements for the frontend

6.1 General

Requirements specific to the frontend apply to NSSS 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 users. Anthropometric data of the users should be used for the design of all areas and parts accessed by the users, in accordance with ISO 7250 (all parts).

The sanitation system shall be easy to use. The frontend shall meet the usability needs of the users. Designers shall ensure that:

a) the users regard the system controls as intuitive;

b) the actions required to control operations follow a logical sequence;

c) complexity is minimized with respect to control panel signals.

The system shall achieve the following usability conditions:

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

— controllability;

— conformity with user expectations;

— user or maintenance 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;

— the activation forces are comfortable for the 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 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 addressed in the user manual (see 4.14.5) and supplied with the system.

6.2.3 Requirements for ease of operation

The design and realization of the NSSS 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 addressed in the user manual, (see 4.14.5 and 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;

c) personal cleansing material (washers/wipers).

If changes to common practices of users 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.4.

6.3 Visibility of faeces

The frontend shall ensure a visual barrier to prevent the user from seeing an accumulation of deposited faeces from previous users when looking directly into the frontend squatting or seat pan with a viewing angle perpendicular to the floor.

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

6.4 Evacuation performance

Urinals, squatting pans, or seat pans applied as part of the frontend of NSSS 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 to the requirements specified in A.3.3.

Examples of applicable standards are provided in Table 1

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 NSSS, the flushing mechanism shall meet the requirements for the adapted flushing tests specified in A.3.3.

Table 1 — Examples of applicable standards for evacuation mechanisms

Frontend user interface	Evacuation mechanism			
	Conventional flushing mechanisms (cistern/ flush valve)	Pour-flush	Dry	Novel evacuation mechanisms
Seat 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. A static load test shall be conducted based on the requirements of NSF/ ANSI 41:2011, 5.2.1.

6.6 Slipping, tripping or falling

Frontend areas of the NSSS in which users and/or service personnel are expected to move about, stand, or sit shall be designed 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.

6.7 Water seal

If input is evacuated from the frontend through a trap with a water seal, this seal shall be a minimum depth of 20 mm.

7 Performance testing

7.1 General testing requirements

NSSS shall be tested for performance according to the classifications provided in Table 2.

The test methods and additional testing requirements listed in Annex A shall be followed to ensure conformity with this document.

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: NSSSs – one frontend – backend non-biological	Controlled laboratory testing as outlined in 7.2 and field testing in accordance with 7.3.2.
Class 2: NSSSs – one frontend – backend includes one or more biological treatment processes	Controlled laboratory testing as outlined in 7.2 and field testing in accordance with 7.3.3.
Class 3: NSSSs – more than one frontend	Controlled laboratory testing as outlined in 7.2 (may be modified to account for alternative testing environment if the system cannot be installed in a laboratory) and field testing according to 7.3.3. 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 odour (7.2.9.5), noise (7.2.9.6), and air emissions (7.2.9.7). 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 odour (7.2.9.5), noise (7.2.9.6), and air emissions (7.2.9.7).

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 product certification process are specified in A.1.

7.2.2 Assembly, installation, operation, and maintenance

Assembly and installation of NSSS 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. The superstructure should satisfy the requirements of A.3.6.6. The specifications of the superstructure shall be clearly indicated in the test report. For sanitation systems that do not include superstructures as part of the manufactured product, the added superstructure shall be removed prior to noise testing (see A.3.7). The tests shall be adapted as described in A.3.7. The presence or absence of a superstructure during noise testing shall be clearly indicated in the test report.

7.2.3 Documentation of input

Tests shall be conducted with actual human urine and faeces, where specified. For helminth spiking (see A.3.4.4.1), if suitable human faeces is insufficient for spiking, pig faeces and required microbial cultures to achieve required minimum concentration, may be used. Faeces 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 faecal 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, or where required by ethics board of testing facilities or the country where testing is conducted.

7.2.4 Generated output

During the tests, the generated output shall meet the solid output and effluent requirements for the intended reuse or disposal defined in 7.2.9.3 and 7.2.9.4, and the odour, air, and noise emissions requirements defined in 7.2.9.5, 7.2.9.6 and 7.2.9.7. 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 following elements shall be observed and recorded:

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

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

c) any ruptures or leakages;

d) all safety or overload shut downs and process malfunctions.

7.2.6 Laboratory conditions

Laboratory temperatures shall be between 15 °C and 30 °C. The laboratory shall report humidity and atmospheric pressure in accordance with good laboratory practices.

7.2.7 Testing sequence and duration

The system shall be tested according to the testing sequence provided in Table 3, columns 1 (testing procedure) and 2 (pattern). The duration of the testing period shall be no less than 32 days and may be extended beyond the suggested 32-day schedule to accommodate backend processes that require more time. Due to the test methods and required pathogen spiking for human health parameters, factors such as residence time, treatment cycles, breakthrough etc. should be taken into consideration in the testing schedule. The testing schedule shall be determined before testing commences.

The tests specified in 6.4, 6.5, 6.6, 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	Pattern	Suggested schedule	Suggested timeframe
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 NSSS operation — Intentional starting of NSSS operation — Emergency stop — Restart	Normal	Day 1 and Day 2	2 days
[none]	Normal	Day 3	1 day
— Solid output and effluent (health and environmental parameters)	Normal	Day 4	1 day

Table 3 *(continued)*

Testing procedure	Pattern	Suggested schedule	Suggested timeframe
[none]	Diarrhoea	Day 5	1 day
— Solid output and effluent (health and environment parameters)	Diarrhoea	Day 6	1 day
[none]	Normal	Day 7	1 day
— Non-usage of NSSS	No load	Day 8 to Day 10	3 days
[none]	Normal	Day 11	1 day
— Short-term shut down of NSSS	No load	Day 12 to 14	3 days
[none]	Normal	Day 15	1 days
— Solid output and effluent (health and environmental parameters)	Normal	Day 16	1 day
— Separation and isolation from energy sources — Energy discharge (Reliability and safety of energy supply, A.3.8.4)	No load	Day 17	1 day
[none]	Normal	Day 18	1 day
— Long-term shut down of NSSS	No load	Day 19 to Day 21	3 days
[none]	Normal	Day 22	1 day
— Solid output and effluent (health and environment parameters)	Normal	Day 23	1 day
— Visibility of faeces	Normal	Day 24	1 day
— Normal odour day test	Normal	Day 25	1 day
— Simulant odour day test	Simulant faeces	Day 26	1 day
— Noise and air emissions	Normal	Day 27	1 day
— Normal odour day test	Normal	Day 28	1 day
— Overload protection and continuous use	Overload (use of simulant faeces acceptable, see A.3.8.6)	Day 29	1 day
— Noise and air emissions	Stress	Day 30	1 day
— Normal odour day test — Solid output and effluent (health and environmental parameters)	Stress	Day 31	1 day
— Discharge and cleaning	No load	Day 32	1 day

7.2.8 Loading pattern

7.2.8.1 Normal loading pattern

Where the testing schedule (Table 3) indicates a normal load, it shall be ensured that the sanitation system is loaded according to its specified treatment capacity with all additional system input specified by the manufacturer.

The loading of the system shall be performed as a percentage of daily load (kg/day of faeces, l/day of urine), derived from capacity calculations as stated in 4.3.2.

Daily load is determined through multiplying:

a) uses per day (faecal uses/day and urine uses/day); by

b) the average amount of faeces (kg/use) and urine (l/use).

Loading shall be conducted at the corresponding timing:

— 35 % from 6 am to 9 am;

— 25 % from 11 am to 2 pm;

— 40 % from 5 pm to 8 pm.

7.2.8.2 Stress loading pattern

Where the testing schedule (Table 3) indicates "Stress", it shall be ensured that the sanitation system is loaded with treatment capacity (see 4.3.2) + "Sn", where Sn is 80 % of the difference between maximum capacity (see 4.3.4) and treatment capacity (see 4.3.2).

Loading shall be conducted at the corresponding timing:

— 35 % from 6 am to 9 am;

— 25 % from 11 am to 2 pm;

— 40 % from 5 pm to 8 pm.

7.2.9 Performance requirements during laboratory testing

7.2.9.1 Testing input and output

Tests shall be performed in the order 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 and environmental parameters. If such a reduction is deemed necessary, the reasons for this reduction shall be explained and documented.

All NSSS shall be loaded using an input pattern in a manner representative of typical user habits and system loading patterns (see 7.2.8). It shall be a reasonable representation of typical usage by user input patterns. Inputs shall be measured as needed.

Output or discharge patterns will be dependent on the nature of the system, and may be batch, intermittent, or continuous. Batch systems are those in which input is collected for a specified duration, treated, and completely discharged from the system. Intermittent systems are those in which a fraction of the system contents is discharged from the system at specified times. Continuous systems are those in which discharge from the system occurs continuously.

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 events, 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 each of the test events.

7.2.9.3 Solid output requirements

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

Table 4 — Solid output validation thresholds and log reduction values (LRVs) for human health protection

Parameter (Pathogen class)	Human enteric bacterial pathogens	Human enteric viruses	Human enteric Helminths	Human enteric Protozoa
Surrogate	using *E. coli*[b] as surrogate, measured in CFU or MNP	using MS2 Coliphage as surrogate, measured in PFU	using *Ascaris suum* viable ova as surrogate	using viable *Clostridium perfringens* spores as surrogate, measured in CFU
Max. concentration in solids [number/g (dry solids)]	100	10	< 1	< 1
Overall LRV for solid[a]	≥ 6	≥ 7	≥ 4	≥ 6

[a] Log-reduction values (LRVs) were derived from a quantitative microbial risk assessment (QMRA) as described by WHO 2016, assuming 1 g of faecal solids contains approximately the same range of reference pathogens as in 1 l of liquid effluent (for LRVs derived in Table 5). For further information, see Reference [61] and Reference [72].

[b] *E. coli* strain KO11 (ATCC 55124) is selected because it is chloramphenicol resistant. Therefore, this antibiotic may be added to the plating medium to suppress the growth of other, interfering bacteria.

The prevalence of Helminth eggs (using *Ascaris suum* viable ova as surrogate) in the sample shall be determined according to the method specified in Table A.3. If < 1 Helminth egg (using *Ascaris suum* viable ova as surrogate) is found per g total solids, then the threshold can be regarded as met.

If ≥ 1 Helminth eggs (using *Ascaris suum* viable ova as surrogate) are found per g total solids, it may be decided to test the viability of the eggs using a proven test method. If it cannot be demonstrated that the Helminth eggs (using *Ascaris suum* viable ova as surrogate) 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 or anal cleansing, then the water shall meet the requirements of the WHO Guidelines for Drinking Water Quality, 4th Edition, Clauses 7 to 10.

It is not necessary to measure Helminth eggs (using *Ascaris suum* viable ova as surrogate) if the TSS threshold (see Table 6) is not met. If the TSS threshold is not met in at least 4 out of 5 test cases, the system fails to meet the effluent parameters.

Table 5 — Liquid effluent validation thresholds and log-reduction values (LRVs) for human health protection

Parameter (Pathogen class)	Human enteric bacterial pathogens	Human enteric viruses	Human enteric Helminths	Human enteric Protozoa
Surrogate	using *E. coli*[b] as surrogate, measured in CFU or MPN	using MS2 Coliphage as surrogate, measured in PFU	using *Ascaris suum* viable ova as surrogate	using viable *Clostridium perfringens spores* as surrogate, measured in CFU
Max. concentration in liquids (number/l)	100	10	< 1	< 1
Overall LRV for liquid[a]	≥ 6	≥ 7	≥ 4	≥ 6

[a] Log-reduction values (LRVs) were derived from a quantitative microbial risk assessment (QMRA) as described by WHO 2016. For further information, see Reference [61] and Reference [72].

[b] *E. coli* strain KO11 (ATCC 55124) is used because it is chloramphenicol resistant. Therefore, this antibiotic may be added to the plating medium to suppress the growth of other, interfering bacteria.

The prevalence of Helminth eggs (using *Ascaris suum* viable ova as surrogate) in the sample shall be determined according to the method specified in Table A.3. If < 1 Helminth eggs (using *Ascaris suum* viable ova as surrogate) are found per litre, then the threshold can be regarded as met.

If ≥ 1 Helminth eggs (using *Ascaris suum* viable ova as surrogate) are found per litre, it may be decided to test the viability of the eggs using a proven test method. If it cannot be demonstrated that the Helminth eggs (using *Ascaris suum* viable ova as surrogate) 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: Threshold for unrestricted urban uses	**Category B usage: 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 Reference [81], 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 Reference [81], 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).

NOTE 3 COD refers to total COD unfiltered.

Table 7 — Effluent performance load reduction percentage for nutrients (Environmental requirement)

	Minimum load reduction percentage %
Total nitrogen	70
Total phosphorus	80

Table 8 — Effluent performance range for pH (Environmental requirement)

	Range for all reuse purposes
pH	6 to 9

7.2.9.5 Odour emissions requirements

Class 1, 2, and 3 sanitation systems shall meet the requirements specified in Table 9 and Table 10. Sanitation systems for which a superstructure is not part of the manufactured product shall be tested with a superstructure satisfying the requirements of A.3.6.6

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

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

	Maximum percentage of observations reported as "unpleasant" %	Maximum percentage of observations reported as "unacceptable" %
Normal odour day	10	2
Simulant odour day	10	2

In the vicinity of the sanitation system, when tested in accordance with A.3.5, the percentage of observations during which odour 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 odour in the vicinity of system as unpleasant or unacceptable

	Maximum percentage of observations reported as "unpleasant" %	Maximum percentage of observations reported as "unacceptable" %
Normal odour day	10	2
Simulant odour day	10	2

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

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

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 in accordance with A.3.7.4, shall not exceed an average of 60 dBA ($L_{EX,24h}$) over the course of 24 h, and shall not at any time exceed 85 dBA ($L_{pA,max}$) during testing in accordance with 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 NSSS can be classified as pollutants or explosive gases. The monitoring of explosive gases during operation is addressed in 4.12.2. The NSSS shall be designed 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 when tested in accordance with A.3.6.

CO and CO_2 shall be tested if the NSSS applies combustion in its treatment processes and need not be tested otherwise.

The manufacturer shall document the GHG emissions (CO_2, methane, and N_20).

Table 11 — Indoor air emission thresholds

Parameter	Emission thresholds (average levels over indicated timeframe)
CO (ppmv)	1 h: 28
NO_x (ppbv)	1 h: 99
SO_2 (ppbv)	1 h: 6,8
CO_2 (ppmv)	1 h: 1 000
H_2S (ppbv)	30 min: 4,6
VOCs (ppbv)	1 h: 187
$PM_{2,5}$ (µg/m^3)	1 h: 25
NH_3 (ppmv)	1h: 25

NOTE 1 NO*x* is the sum of NO and NO_2. Measurement values are given as NO_2.

NOTE 2 ppmv is parts per million by volume, ppbv is parts per billion by volume.

Table 12 — Outdoor exhaust or vent air emissions thresholds

Parameter	Emission thresholds (1 h average)
CO (ppmv)	80
SO_2 (ppmv)	68
NO_x (ppmv)	195
VOC (ppmv)	12
H_2S (ppmv)	1,9
PAH (ppmv)	0,001
$PM_{2,5}$ (mg/m^3)	10
NH_3 (ppmv)	50

NOTE 1 NO*x* is the sum of NO and NO_2. Measurement values are given as NO_2.

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).

NOTE 3 See Table 11 for the meaning of ppmv.

7.3 Field verification of performance

7.3.1 General

During field testing, the system shall be in use by the users at its specified treatment capacity (4.3.2). In order to pass field testing requirements, at least 75 % of all test results for environmental parameters (see Table 6, Table 7, Table 8) and 100 % of all test results for maximum bacterial, viral, helminth, and protozoa human health related parameters (maximum concentrations in solid output and effluent, see Table 13), using surrogates (*E. coli*, somatic coliphages, and spores of *Clostridium perfringens* respectively) shall satisfy the requirements defined. Results shall not be averaged.

Percentage load reduction (see Table 7) can be derived by comparing the total nitrogen and total phosphorus in the input samples against that in the treated output samples. In field validation, as systems are being utilized as per actual intended application, input samples may not be readily obtained for laboratory analysis. In this regard, prior to commencing field validation, input samples are to be collected and analysed daily for a period of 1 week. The collection point is to be upstream of any treatment section of the sanitation system.

The input data collected will be used as the input reference data in deriving the total nitrogen and total phosphorus throughout the field validation process.

Table 13 — Solid output and liquid effluent field verification of performance thresholds

Parameter (Pathogen class)	Human enteric bacterial pathogens	Human enteric viruses	Human enteric Protozoa
Surrogate	using *E. coli* as surrogate, measured in CFU or MPN	using somatic coliphage as surrogate, measured in PFU	using *viable Clostridium perfringens* spores as surrogate, measured in CFU
Max. concentration in solids [number/g, (dry solids)]	100	10	< 1
Max. concentration in liquids (number/l)	100	10	< 1

NOTE 1 Recommended test methods for solid output and effluent are given in Table A.3.

NOTE 2 In field testing, testing for human enteric Protozoa (using viable *Clostridium perfringens* spores as surrogate) also validates treatment efficiency for human enteric Helminths.

Additionally, during and after testing, the following elements shall be observed and recorded:

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

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

c) any ruptures or leakages;

d) all safety or overload shut downs and process malfunctions.

7.3.2 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 output and effluent parameters (see Table 6, Table 7, and Table 8) and human health related solid and liquid parameters (maximum concentrations in solid output and effluent, see Table 13) shall be tested weekly. The number of solid output samples may be reduced to a minimum of one if output is limited by the design of the system (see 7.2.9.1). The manufacturer shall document this limitation and it shall be verified as part of the testing.

7.3.3 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 4.8) 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 (maximum concentrations in solids and liquids, see Table 13) shall be tested monthly. The number of solid samples may be reduced to a minimum of one if output is limited by the design of the system (see 7.2.9.1). The manufacturer shall document this limitation and it shall be verified as part of the testing.

8 Sustainability

8.1 General

Provisions of 8.2 to 8.6 relate to the sanitation system's use and recovery of resources.

8.2 Recovery of nutrients

The manufacturer of the sanitation system shall specify the type, subtypes, concentrations, 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 per day. Water use calculations do not need to 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 and the quality of water required to operate the sanitation system (see 8.3.1). The water consumption of the sanitation system shall be minimized.

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 dilution of the treated effluent before reuse, the manufacturer shall indicate the necessary amount and quality of the freshwater (see 8.3.1) and any water reused. The reuse of treated effluent within the sanitation system shall be maximized to a reasonably practicable extent.

NOTE Reuse of effluent within systems may not be protective of public health unless saprozoic pathogens are considered, treated, and monitored.

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 practicable extent.

For systems using renewable energy, references for more information are provided in E.3.3.

8.4.3 Direct and indirect energy recovery

Sanitation systems shall maximize direct energy recovery to a reasonably practicable 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 practicable 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 Recurring operational requirements

The manufacturer shall convey along with the product the relevant information specified below for the NSSS, taking into account the treatment capacity of the system as determined in 4.3.2.

a) Recommended configuration, adjustment, and maintenance activities, including the identification of parts and components expected to require periodic replacement and the estimated frequency within which such parts and components will be replaced. The information shall be provided in a summarizing table. An example for such a table is shown as Table 14. The complexity of the task should be described as indicated in Table 15.

b) Estimated annual net energy consumption (in units such as kWh/year).

c) Estimated annual freshwater input, if any (in units such as l/year).

d) Estimated annual consumption (amount/number) of other resources such as chemical and biological additives and specialized cleaning and maintenance tools.

Table 14 — Manufacturer's recommended configuration, adjustment, and maintenance activities

Who is to perform activity (user/professional service personnel)	**Type of activity**	**Complexity of task** (as per Table 15)	**Frequency**	**Expected duration per activity** (person hours)	**Required parts, components or consumables**

Table 15 — Complexity of configuration, adjustment, and maintenance activities

Complexity	Technical competence
Very low	No skills (background education, experience) and no training required
Low	Basic skills and less than 1 h training required
Medium	Requires certain skills that can be acquired by training lasting no more than 1 day
High	Requires high technical skills (e.g. technical education in the field related to the activity), more than 1 day of training, and at least 6 months of work experience
Very high	Requires very high and specialized technical skills (e.g. advanced technical education in the field related to the activity), extensive training, and at least 1 year of work experience

This information should enable the user to quantify the likely operational expenditures for the NSSS. Further information and explanations related to this point can be found in D.1.

Annex A
(normative)

Test methods and additional testing requirements

A.1 General

When testing is done as part of the product certification process, the certification body shall meet the requirements of ISO/IEC 17065.

NOTE ISO/IEC 17065 requires that when testing is conducted as part of the conformity assessment process, the testing laboratory shall meet the applicable requirements in ISO/IEC 17025 (see ISO/IEC 17065:2012, 6.2.1 and 6.2.2).

A.2 Type tests

A.2.1 Tests to be conducted

To demonstrate conformity with this document, type tests shall be performed according to Table A.1. 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, performance, 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. ISO 30500;

b) description of the test unit, including its manufacturer, model, type, tolerance/accuracy 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, as well as the measurement uncertainty if applicable;

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

Table A.1 — Means of obtaining type test results

Clause/subclause	Results to be obtained through: — Documents — Visual inspection — 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 A.3.8.6
4.3.5 Operability following non-usage	Testing according to A.3.8.2
4.3.6 Operability following short-term shut down	Testing according to A.3.8.3
4.3.7 Long-term shut down	Testing according to A.3.8.5
4.3.8 Continuous use	Documents and visual inspection
4.4.2 Solid output and effluent requirements	Detailed requirements in 7.2.9.3 and 7.2.9.4; testing according to A.3.4
4.4.3 Odour emissions requirements	Detailed requirements in 7.2.9.5; testing according to A.3.5
4.4.4 Noise requirements	Detailed requirements in 7.2.9.6; testing according to A.3.7
4.4.5 Air emissions requirements	Detailed requirements in 7.2.9.7; testing according to A.3.6
4.5 Expected design lifetime	Documents and visual inspection
4.6 Aspirational and ergonomic 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	Documents 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 and visual inspection
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
4.12.3 Structural integrity	Documents
4.12.4 Prevention of contact with unsafe effluent and reuse	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 and visual inspection
4.13.2 Marking and labelling	Visual inspection
4.14.1 Reasonable configuration, adjustment, and maintenance activities	Detailed requirements in D.3. documents and visual inspection – see D.2
4.14.2 Location and access of configuration, adjustment, and maintenance points	Visual inspection

Table A.1 *(continued)*

Clause/subclause	Results to be obtained through: — Documents — Visual inspection — Test method
4.14.3 Discharge and cleaning	Testing according to A.3.8.8
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 A.3.8.1
5.2.3 Intentional stopping of sanitation system operation	Documents and testing according to A.3.8.1
5.2.4 Emergency stop	Documents and testing according to A.3.8.1
5.3.1 Security of energy supply	Documents and testing according to A.3.8.4
5.3.2.1 Separation and isolation	Documents and testing according to A.3.8.4
5.3.2.2 Energy discharge	Documents and testing according to A.3.8.4
5.3.3 Safety requirements for non-electric primary energy supply	Documents and testing according to A.3.8.4.2
5.4.1 Pressurized or vacuum 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
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.3.2.4
5.7 Reliability of conveyance devices	Testing throughout the test sequence (Table 3)
5.8 Transitions from the backend	Testing in accordance with ISO 20816-1
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.4
6.3 Visibility of faeces	Testing according to A.3.8.7
6.4 Evacuation performance	Testing according to A.3.3
6.5 Integrity against external impacts	Testing (see 6.5)
6.6 Slipping, tripping or falling	Visual inspection
6.7 Water Seal	Testing according to A.3.8.11
Clause 8 Sustainability	Documents and see Annex D

A.3 Test methods

A.3.1 Tightness

A.3.1.1 Water tightness

A.3.1.1.1 General

The water tightness of the system shall be tested as appropriate for the component parts. All tests should be conducted in as stable temperature conditions as possible. Where this is not possible, calculations to take account of the expansion of the test fluid or the pipework materials shall be included in the test results.

For water or wastewater containers, the containers may need to be supported, depending upon their material and construction, before testing. A simple water test of filling the container to the brim and checking for leaks will be appropriate for free-standing containers. For lightweight containers that will rely upon the supporting ground or an additional structure for integrity, air tests (with either positive or negative pressure) may be more appropriate.

Sanitation systems which operate at atmospheric pressure or gauge pressure levels lower than 50 kPa g do not require hydraulic testing at 1,5 MOP. Tightness of these sanitation systems is tested by appropriate visual inspection methods [see 7.2.5 c)], unless the need for tests is specifically identified from the risk assessment.

The tests outlined in A.3.1.1.2 and A.3.1.1.3 shall be undertaken, as applicable to the system.

A.3.1.1.2 Water supply system test

The pipework to be tested shall be charged with potable water and all air removed. The pipework is then pressurized to 1,5 MOP. The test pressure is maintained by additional pumping if required, for 30_{-0}^{+10} min and the pressure recorded. The pipework is isolated and left for another 30_{-0}^{+10} min and the pressure recorded. During this time the pressure shall not fall more than 60 kPa or show any visible leakage.

NOTE This test is adapted from EN 805. This is a simplified specification that does not differentiate between materials.

A.3.1.1.3 Container tests

A.3.1.1.3.1 Container water test

The container is placed on an open elevated grid, for support but also to enable any leaks to be identified. The container should have any connections sealed or isolated and then be filled with water to the brim.

After 30_{-0}^{+5} min, the water level shall be observed. If the water level has dropped and the material of the container is likely to have absorbed water, the container should be topped-up, as required, with water and the additional volume of water required shall be recorded. Up to 2 h can be allowed for water absorption, after which no more water shall be added. The container shall not leak.

NOTE This test is adapted from EN 12566-3.

A.3.1.1.3.2 Container air test — Vacuum

The container is placed on a level surface and supported laterally. All orifices are to be sealed or isolated, apart from one that is to be connected to a suitable vacuum pump and gauge. A pressure of −(10 ± 2) kPa is applied for 180^{+10}_{-0} s and then the container is isolated from the vacuum pressure supply. After (60 ± 1) s the pressure within the container is measured. It shall not have increased by more than 10 kPa.

NOTE This is a simplified test based upon EN 12566-3.

A.3.1.1.3.3 Container air test — Pressure

The container is placed on a level surface and supported laterally. All orifices are to be sealed or isolated, apart from one that is to be connected to a suitable air pump and gauge. A pressure of +(30 ± 2) kPa is applied for 180^{+10}_{-0} s and then the container is isolated from the vacuum supply. After 60^{+10}_{-0} s the pressure within the container is measured. It shall not have dropped by more than 10 kPa.

NOTE This test is adapted from EN 12566-3.

A.3.1.2 Technical tightness

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. Documentary evidence of compliance is to be submitted for review and verification.

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 testing does not incorporate all functions, then a justification shall be given to exclude 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 labelling;

2) correct installation;

3) correct International Protection Marking 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;
8) residual current device 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;
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, qualifications, and signature of the person performing the test;

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 start-ups 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 signalling 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;

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;

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, 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) evacuation mechanism for a dry toilet; or

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 NSSS 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 NSSS using pour-flush mechanisms, the water shall be poured according to manufacturer’s instructions. The amount of water used in the test shall approximate the normal flushing volume amount indicated by the manufacturer.

For NSSS 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 seat pan

A.3.3.4.1 Wash of bowl

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

The testing procedure is as follows.

a) Moisten the entire inner surface of the seat 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 a) through c) 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

Testing shall be carried out using toilet paper material that is in accordance with EN 997:2012, 5.7.2.4.1.

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 seat 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 seat 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 excreta

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 ± 1) mm.

The testing procedure is as follows.

a) For each evacuation operation, place 50 balls into the seat 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 seat 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 seat 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 sawdust shall be cleared below 40 mm of the rim of the squatting pan.

A.3.3.5.2 Evacuation of toilet paper

Testing shall be carried out using toilet paper material that is in accordance with EN 997:2012, 5.7.2.4.1.

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 colour 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) Activate 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 coloured 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 coloured 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

A sampling point from which to draw solid output and effluent samples shall be chosen so that it ensures 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 test report. Samples shall be preserved using proven, parameter-specific preservation methods.

Table A.2 — Sampling type and frequency

	Parameters	Sample type — grab/ composite	Minimum sampling frequency
Effluent	Total nitrogen	12 h composite	1 per designated day of sampling
Effluent	Total phosphorus	12 h composite	
Effluent	pH	Grab	
Effluent	COD	12 h composite	
Effluent	TSS	12 h composite	

For sampling related to human health parameters, refer to Table A.5.

A.3.4.3 Test methods

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 human enteric pathogen surrogates, spiking of input shall be performed (see A.3.4.4).

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

	Parameters	Test methods	
Effluent	Total nitrogen	APHA 4500-N C	
Effluent	Total phosphorus	APHA 4500-P	ISO 6878
Effluent	pH	APHA 4500-H+ A	
Effluent	COD (total COD unfiltered)	APHA 5220 B	
Effluent	TSS	APHA 2540D	EN 872
Effluent and solid output	Human enteric bacterial pathogen (using *E. coli* as surrogate, measured in CFU or MPN)	APHA 9221, APHA 9222 and APHA 9223	
Effluent and solid output	Human enteric Helminths (using *Ascaris suum* viable ova as surrogate)	— Methods for microbiological analysis of sewage sludges[83] — SOP Helminth Test (Ascaris, Trichuris and Taenia)[73] — Reference [95]	
Effluent and solid output	Human enteric viruses — using MS2 coliphage as surrogate in laboratory testing, measured in PFUs	EPA 1602 For large samples use EPA 1601	ISO 10705-1
	— using somatic coliphage as surrogate in field testing, measured in PFU	EPA 1602 For large samples use EPA 1601	ISO 10705-1
Effluent and solid output	— Using spores of *Clostridium perfringens* as surrogate in field testing, measured in CFU	Solids: ISO 7937 Liquid: ISO 14189	
For APHA methods, see Reference [55].			

A.3.4.4 Input spiking and output sampling for human health parameter testing (for laboratory testing)

A.3.4.4.1 General

To ensure meaningful results for human health related parameters, faecal and urine input into the system shall be spiked with human enteric pathogen surrogates in accordance with Table A.4 and Table A.5.

It is necessary to spike and measure input liquid and solids with indicator organisms at recommended concentrations such that load reductions due to the disinfecting treatment processes within systems can be detected and quantified.

Spiked faeces and urine input transit through the system is based on residence time distribution characteristic of the system. It is therefore necessary to spike inputs for a long enough duration to ensure that discharge streams correspond to spiked inputs. Sampling and testing of input and output streams shall encompass at least 24 h to capture the loading patterns of a 24 h cycle, and longer if system discharge is less frequent than once a day. Additionally, residence time for liquid and solid streams through a system may not be the same, and shall be independently characterized. Furthermore, some systems will operate in a way that solids and liquid interact significantly, and such interactions shall be considered in spiking and sampling procedures.

Table A.4 — Spiking input with human enteric pathogen surrogates

Parameter (Pathogen class)	Human enteric Bacterial pathogens	Human enteric viruses	Human enteric Helminths	Human enteric Protozoa
Surrogate	using *E. coli* as a surrogate, measured in CFU or MPN	using MS2 Coliphage as surrogate, measured in PFU	using *Ascaris suum* viable oval as surrogate	using viable *Clostridium perfringens* spores as surrogate, measured in CFU
Min. faeces spike [number/g, (dry solids)]	10^8	10^8	10^4	10^6
Min. urine spike (number/l)	10^8	10^8	10^4	10^6

Relevant references for spiking are given in Table F.1.

A.3.4.4.2 Definition of time scales for different types of systems

For systems in which urine and/or faeces input are collected, processed and completely discharged from the system in a batch fashion, parameters BL and BS are defined as the time it takes to process liquid and solid batches, respectively.

For systems in which liquid and/or solid streams are discharged continuously or periodically, the parameters T95L and T95S are defined as the system residence time of liquid and solid streams, respectively. These parameters are used to ensure that output stream sampling correspond to input streams that have been spiked with marker organisms. Further explanations and possible methods for determining T95L and T95S are described in Annex F.

For systems in which fractions of the liquid and/or solid contents of a system are discharged intermittently, the parameters PL and PS are defined as the periodicity or the time between consecutive discharges for the liquid and solid streams, respectively.

The manufacturer shall define the values of the following variables: BL, BS, T95L, T95S, PL and PS, as applicable, and provide evidence. Evidence may be in the form of documentation or obtained through carrying out tests. In addition, if applicable, the manufacturer shall provide documentation regarding the methods, measurements and calculations used to determine T95L and/or T95S.

A.3.4.4.3 Spiking and sampling for systems in which solid and liquid streams do not significantly interact

A.3.4.4.3.1 General

Some systems may involve separate disinfections methods for solids and liquids, and thus the two streams can be considered independently. The manufacturer shall provide documentation to demonstrate that the system falls within this category. For such systems, spiking and sampling times for liquid and solid streams are summarized in Table A.5.

Table A.5 — Spiking and sampling times and duration for liquid and solid streams

Type of liquid discharge (characterization parameters)	Urine spiking duration	Liquid sampling time and duration
Batch (BL) BL < 24 h	Urine input for all batches within a 24 h period	Liquid output of all spiked batches within 24 h.
Batch (BL) BL > 24 h	Urine input for a single batch	Liquid output of the spiked batch.
Continuous (T95L)	T95L + 24 h	Starting at T95L after liquid spiking begins; sample and test every 4 h for 24 h.
Periodic liquid discharge (T95L, PL) PL < 24 h	T95L + 24 h	Starting at T95L after liquid spiking begins; for 24 h. Sample and test each periodic discharge stream within the 24 h period.
Periodic liquid discharge (T95L, PL) PL > 24 h	T95L + PL	Starting at T95L after liquid spiking begins. Sample the first discharge stream after T95L.
Type of solid discharge (characterization parameters)	**Faeces spiking duration**	**Solid sampling time and duration**
Batch (BS) BS < 24 h	Faeces input for all batches within a 24 h period	Output of all spiked batches within 24 h.
Batch (BS) BS > 24 h	Faeces input for a single batch	Output of the spiked batch.
Continuous solid discharge (T95S)	T95S + 24 h	Starting at T95S after spiking begins; sample and test every 4 h sample for 24 h.
Periodic solid discharge (T95S, PS) PS < 24 h	T95S + 24 h	Starting at T95S after solid spiking begins; for 24 h. Sample and test each periodic discharge stream within the 24 h period.
Periodic solid discharge (T95S, PS) PS > 24 h	T95S + PS	Starting at T95S after solid spiking begins. Sample the first discharge stream after T95S.

For systems for which the duration of liquid and/or solids spiking determined following Table A.5 is excessively long (e.g. greater than 1 week), alternative spiking and sampling protocols may be developed. Alternative protocols, including possible shorter spiking durations are acceptable if the duration of the spiking of the liquid and/or solids inputs can be demonstrated to be sufficient to ensure representative sampling of the liquid effluent and solids discharged and for statistically significant calculation of the LRVs in the liquid and the solids. Evidence and rationale to support the statistical validity of the alternative protocols, including consideration of residence time distributions, shall be documented.

A.3.4.4.3.2 Alternative spiking and sampling frequency

Some systems may have multiple liquid and/or solid discharge streams. The protocols described in A.3.4.4.3 may be adapted to the specific characteristics of these systems. Evidence and rationale to support the statistical validity of the adapted protocols, and including consideration of residence time distributions, shall be documented.

A.3.4.4.4 Spiking and sampling for systems in which solid and liquid streams interact

A.3.4.4.4.1 General

Some systems may involve contact between solid and liquid streams for significant amounts of time during transit through the system, or may involve joint treatment of solids and liquids during some or all parts of the process. Solids and liquids in such systems may be discharged concurrently or separately. If discharge occurs concurrently, both streams are discharged in the same manner, i.e. both batch, both continuous, or both periodic. The two streams may also be discharged in different ways (e.g. liquid is discharged continuously, solid is discharged periodically). In all cases, each stream has a characteristic residence time/processing time as characterized by the time scale described in A.3.4.4.2.

If the applicable spiking and sampling times for the liquid and solid streams are both less than one week, both streams will be spiked and sampled for the duration of the longer spiking/sampling time.

If at least one of the streams has spiking/sampling time longer than one week, (e.g. a system with periodic discharge that occurs once every few weeks or months), alternative spiking and sampling protocols may be developed.

A.3.4.4.4.2 Alternative protocols

Alternative protocols, including possible shorter spiking durations are acceptable if the duration of the spiking of the liquid and/or solids inputs can be demonstrated to be sufficient to ensure representative sampling of the liquid effluent and solids discharged and for statistically significant calculation of the LRVs in the liquid and the solids. Evidence and rationale to support the statistical validity of the alternative protocols, including consideration of residence time distributions, dilution, and/or partition between phases shall be documented.

A.3.4.4.4.3 Alternative spiking and sampling durations

Some systems may have multiple liquid and/or solid discharge streams. The protocols described in A.3.4.4.4 may be adapted to the specific characteristics of these systems. Evidence and rationale to support the statistical validity of the adapted protocols, including consideration of residence time distributions, shall be documented.

A.3.4.4.5 Other

If a system does not fall under one of the above categories, the means to demonstrate the system treatment effectivity shall be defined and determined by modifying the methodology for spiking and sampling of liquid and solid streams, providing calculations or supporting data if needed to consider solids residence time in the system, dilution, and/or partition of the indicator organisms.

A.3.5 Odour test method

A.3.5.1 General

The specifications for the odour 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, the test method adjustments described in Table A.6 shall be made for the corresponding systems.

Table A.6 — Adjustments to odour test methods for Class 3 and superstructure-less systems

System	Description
Class 3 sanitation systems with 2 to 5 frontends	Odour 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. Odour 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	Odour emissions shall be tested "within the sanitation system superstructure" (see A.3.5.7) for only 3 of the frontends, which shall be chosen randomly. Odour 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 odour 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 selected (see A.3.5.4) and screened (see A.3.5.5).

A.3.5.4 Selection of panelists

Selection of panelists shall incorporate the following requirements and recommendations.

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 odourant 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.7.

Table A.7 — Screening assessment results required for panel selection

Bag contents	Panelist perceptions
Neutral gas	Correctly perceive no odour in all 3 instances
0,01 ppbv H_2S	Perceive no odour in 4 or 5 of the 5 instances
2 ppbv H_2S	Perceive odour in all 3 instances
NOTE 1 If odour 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.	
NOTE 2 See Table 11 for the meaning of ppbv.	

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 EN 13725:2003, 6.4.1. The bag should have a volume ranging from 1 l to 5 l and comply with EN 13725:2003, 6.3. 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 odour. If the panel perceives an odour (or a change in the perceived odour) in the neutral gas, proceed with systematic testing to trace and eliminate the source of the odour.

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 ppbv H_2S in neutral gas, a total of 5 times within the sequence;

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

   NOTE See Table 11 for the meaning of ppbv.

   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 odourant H_2S, the concentration should be within ±5 % and be prepared following similar quality measures as in EN 13725:2003, 6.4.

   4) Instruct each panelist to indicate, after smelling each bag's contents, whether he/she perceives an odour. 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 Odour emissions assessment procedures

A.3.5.6.1 General

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

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

a) Assign 4 panelists (2 panelists for odour assessment within the sanitation system superstructure; 2 panelists for odour 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 odour assessment event.

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

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

d) Instruct the panelists to record their observations for each interval consisting of i) an indication of the presence or absence of odour, and ii) if an odour is detected, the odour type and hedonic tone (pleasant, acceptable, 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 odour observation.

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

Odour codes
Type of odour
0 – No odour
F – Faecal odour
X – Other odour
Odour 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

faecal odour	odour that can easily be attributed to faeces and/or urine
other odour	non-faecal odour (e.g. perfume, cleaning products, process odour)
pleasant	enjoyable odour
acceptable	mild odour, not offensive, easily tolerated
unpleasant	odour 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 odour 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 odour assessment as a whole to achieve validity, no more than a total of 4 individual observations shall be missed per day of testing. Odour 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 odour day test

During a normal odour 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 odour day test

A.3.5.6.4.1 General

For the simulant odour day test, simulant faeces infused with odourant shall be used.

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

A.3.5.6.4.2 Preparation of simulant faeces for odour testing

Required materials:

— cook stove;

— fork or spatula for stirring;

— hermetically sealable glass containers;

— pan with tight-fitting lid;

— refrigerator.

Required ingredients:

— butyric acid;

— dimethyl trisulfide;

— firm tofu;

— glycerine;

— indole;

— p-cresol;

— peanut or vegetable oil;

— triacetin;

— trimethylamine;

— water;

— white rice.

The procedure for preparing simulant faeces 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 min.

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 (a 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 odourants at the following amounts per kg of wet mass:

— butyric acid: 1 000 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 odourants into the paste until homogenously distributed.

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

j) Use the simulant faeces within 1 month.

A.3.5.6.4.3 Simulant odour day test procedures

The following equipment is needed for each test event.

— 300 g simulant faeces, 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 as urine surrogate. If electrically conductive liquid is required for 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.

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

The procedure for conducting each simulant faeces 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 faeces and then the 200 ml water to the seat or squatting pan.

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

4) Exit the superstructure.

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 odour assessment (see A.3.5.6.1).

3) Conduct the odour 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 Odour emissions assessment procedures within the sanitation system superstructure

A.3.5.7.1 Assessment frequency and timing

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

— 5 min after faecal and urinary events, measured from the point in time when the evacuation mechanism has been activated;

— when process operations are expected to release the most odours;

— randomly during the test day;

according to the frequency indicated in Table A.8.

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

— 5 min after a simulated faecal 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 odours;

— randomly during the test day;

according to the frequency indicated in Table A.9.

Table A.8 — Frequency and timing for odour assessment for normal odour day test within the sanitation system superstructure

	5 min after a faecal event	5 min after a urinary event	When process operations are expected to release the most odours	Randomly during the test day
Normal odour day test – number of tests to be conducted	4	2	2	2

Table A.9 — Frequency and timing for odour assessment for simulant odour day test within the sanitation system superstructure

	5 min after a simulated faecal event	When process operations are expected to release most odours	Randomly during the test day
Simulant odour day test – number of tests to be conducted	4	4	2

NOTE “When process operations are expected to release the most odours” is likely to be just before or just after the flush or evacuation mechanism is activated.

A.3.5.7.2 Assessment procedures

For each assessment event as defined in Table A.8 and Table A.9, 2 panelists shall enter the sanitation system superstructure and close the door to begin the assessment immediately.

If the superstructure cannot accommodate 2 panelists at one time, the sampling frequencies indicated in Table A.8 and Table A.9 shall be doubled.

The detailed assessment procedure is provided in A.3.5.6.1.

A.3.5.7.3 Validity of assessments

If no observation is missed, the compilation of all assessments following Table A.8 and Table A.9 provides 1 080 individual observations per frontend tested (18 individual observations per event × 2 panelists × 10 events per day × 3 normal odour day tests) after completion of 3 normal odour day tests and 360 individual observations per frontend tested (18 individual observations per event × 2 panelists × 10 events per day) after completion of one simulant odour day test.

The general validity requirements are provided in A.3.5.6.2.

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

A.3.5.8.1 Assessment frequency and timing

For each normal odour day test, odour shall be assessed:

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

— when process operations are expected to release the most odours;

— randomly during the test day;

according to the frequency indicated in Table A.10.

Table A.10 — Frequency and timing for odour assessment for normal odour day test in the vicinity of the sanitation system

	5 min after a faecal event	5 min after a urinary event	When process operations are expected to release the most odours	Randomly during the test day
Normal odour day test – number of tests to be conducted	4	2	2	2

For each simulant odour day test, odour shall be assessed:

— 5 min after a simulated faecal event, measured from the point in time when the evacuation mechanism has been activated;

— when process operations are expected to release the most odours;

— randomly during the test day;

according to the frequency indicated in Table A.11.

Table A.11 — Frequency and timing for odour assessment for simulant odour day test in the vicinity of the sanitation system

	5 min after a simulated faecal event	When process operations are expected to release the most odours	Randomly during the test day
Simulant odour 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 Table A.10 and Table A.11, 2 panelists shall assess the odour.

Panelist positioning is as follows.

a) Because the panel is composed of 4 members, the panelists will alternate between smelling odours 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 as the point at which backend odour 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 odour observation point.

The detailed assessment procedure is provided in A.3.5.6.1.

A.3.5.8.3 Validity of assessments

If no observation is missed, the compilation of all assessments following Table A.10 provides 1 080 individual observations per NSSS tested (18 individual observations per event × 2 panelists × 10 events per day × 3 normal odour day tests) after completion of 3 normal odour day tests and assessment following Table A.11 provides 360 individual observations per NSSS tested (18 individual observations per event × 10 events per day × 2 panelists) after completion of one simulant odour day test.

The general validity requirements are provided in A.3.5.6.2.

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 capable of measuring the emissions of interest with appropriate sensitivity. Equipment shall be operated according to the manufacturer's instructions.

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;

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 analyser 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 NSSS (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.12. Equivalent national standards may be applied. The method for conducting the analysis shall be determined i.e. grab sampling or continuous analysis.

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

Component	Test method	Sampling method
CO	1) ISO 4224 2) NIOSH 6604	1) Continuous analysis 2) Grab sampling
NO_x	ISO 7996	Continuous analysis
CO_2	1) ISO 16000-26 2) NIOSH 6603	1) Continuous analysis 2) Grab sampling
H_2S	NIOSH 6013; OSHA6 ID 141, 1008	Grab sampling
VOC	ISO 16000-5	Grab sampling
SO_2	NIOSH 6004	Grab sampling
$PM_{2.5}$	NIOSH 0500	Grab sampling
NH_3	1) NIOSH 6015 2) NIOSH 6016	Grab sampling
NOTE 1 NO_x is the sum of NO and NO_2. Measurement values are given as NO_2.		
NOTE 2 For NIOSH methods, see Reference [63].		

A.3.6.2.2.3 Outdoor exhaust or vent air emissions

Internationally accepted and recognized test methods for outdoor exhaust or vent air emissions are indicated in Table A.13. Equivalent national standards may be applied.

Table A.13 — Recommended test methods for analysis of outdoor exhaust or vent air emissions

Component	Recommended test methods
CO	EN 15058, US EPA, Method 10
SO_2	EN 14791, US EPA, Method 6C
NO_x	EN 14792, US EPA, Method 7E
VOC	EN 12619, US EPA, Method 25A
PAH	VDI 3874, US. EPA Compendium method TO-13A
H_2S	VDI 3486 Bl. 2, NIOSH 6013; OSHA6 ID 141, 1008
$PM_{2,5}$	VDI 2066 Bl. 10, US EPA, Method 5I; Method 201A
O_2	EN 14789, US EPA, Method 3A
NH_3	US EPA CTM-027
Volume flow	ISO 16911-1, US EPA, Method 2
Moisture content	EN 14790, US EPA, Method 4
Requirements for measuring sections	EN 15259, US EPA, Method 1A
NOTE For US EPA methods, see Reference [82].	

A.3.6.3 Sampling points

A.3.6.3.1 Indoor air emissions

The measurement shall be carried out inside the superstructure, about 1 m to 1,5 m above the squatting or seat pan of the frontend. The door of the superstructure shall remain closed before and during sampling.

A.3.6.3.2 Outdoor exhaust or vent air emissions

The measurement shall be carried out in the external gas vent as outlined in the EPA Method 1A.

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 Outdoor exhaust or vent 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 required by the process (e.g. short processing time, discontinuous emissions, etc.) 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

Outdoor exhaust or vent air emissions measurements shall be normalized by converting the raw values indicated on the instrument to the standard conditions prevalent in the test location.

In systems in which combustion/incineration processes are applied, the conversion formula is given by Formula (A.1):

$$C_N = C \times \frac{1}{1 - H_2O} \times \frac{21 - 7}{21 - O_{2,\text{measured}}} \times \frac{101{,}3}{p} \times \frac{273{,}15 + T}{273{,}15} \qquad \text{(A.1)}$$

NOTE Formula (A.1) has a reference O_2 concentration of 7 % by volume.

In systems in which non-combustion/non-incineration processes are applied, the conversion formula is given by Formula (A.2):

$$C_N = C \times \frac{1}{1 - H_2O} \times \frac{101,3}{p} \times \frac{273,15 + T}{273,15} \qquad (A.2)$$

where

C_N	is the normalized concentration, in ppmv, ppbv, or µg/m^3;
C	is the measured concentration, in the same units as C_N;
H_2O	is the humidity measured in volume fraction of water vapour $\frac{m^3 H_2O}{m^3 gas}$;
$O_{2, measured}$	is the O_2 concentration of the exhaust gas, measured in $\frac{m^3 O_2}{m^3 \text{exhaust gas}} \times 100$;
p	is the pressure of the exhaust gas, measured in kPa;
T	is the temperature of the exhaust gas, measured in °C.

NOTE See Table 11 for the meaning of ppmv and ppbv.

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 7.2.9.7 shall be regarded as met.

   2) The relevant requirements of 7.2.9.7 shall be regarded as unmet if the average is higher than the indicated threshold for 60 min.

A.3.6.5.2.2 Outdoor exhaust or vent 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 7.2.9.7 shall be regarded as met.

   2) The relevant requirements of 7.2.9.7 shall be regarded as unmet if the average is higher than the indicated threshold for 60 min.

A.3.6.6 Specification of superstructure for laboratory testing

If the superstructure is not part of the manufactured product, then a superstructure shall be installed for the laboratory testing. If the superstructure is a prefabricated integral to the product, the superstructure is not modified.

The superstructure should consider the manufacturer's recommendations and shall meet the criteria below. Class 3 sanitation systems shall include 2 or 3 superstructures depending on the number of frontends (see Table A.6).

The superstructure is intended to mimic a typical application; it shall meet the following criteria.

a) The superstructure shall completely surround and enclose the user interface. It shall have a door to access the user interface and isolate the user when utilizing the toilet.

b) The materials of construction exposed to the inside of the superstructure shall not significantly absorb odours nor shall they produce odours. Recommended materials of construction for the inside surfaces include galvanized steel and stainless steel. Suitable materials include plastic panels (e.g. PVC, HDPE and similar) if they do not release odours, dry wall, and cement-based products (preferably painted with a washable coating). Wood-based panels are only acceptable if painted with a washable coating.

c) The superstructure, for each frontend, shall have a minimum size of 1 m in width × 2 m in length × 2,3 m in height and a maximum size of 2,5 m × 2,5 m × 2,5 m.

d) A ventilation fan shall be installed on the ceiling above the user interface, and provide a minimum of 5, and a maximum of 10 air exchanges per hour.

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 NSSS 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 60942:2017, 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 NSSS shall be tested under conditions that are:

a) reproducible;

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

A.3.7.4 Noise measurement procedures

A.3.7.4.1 Measurement points

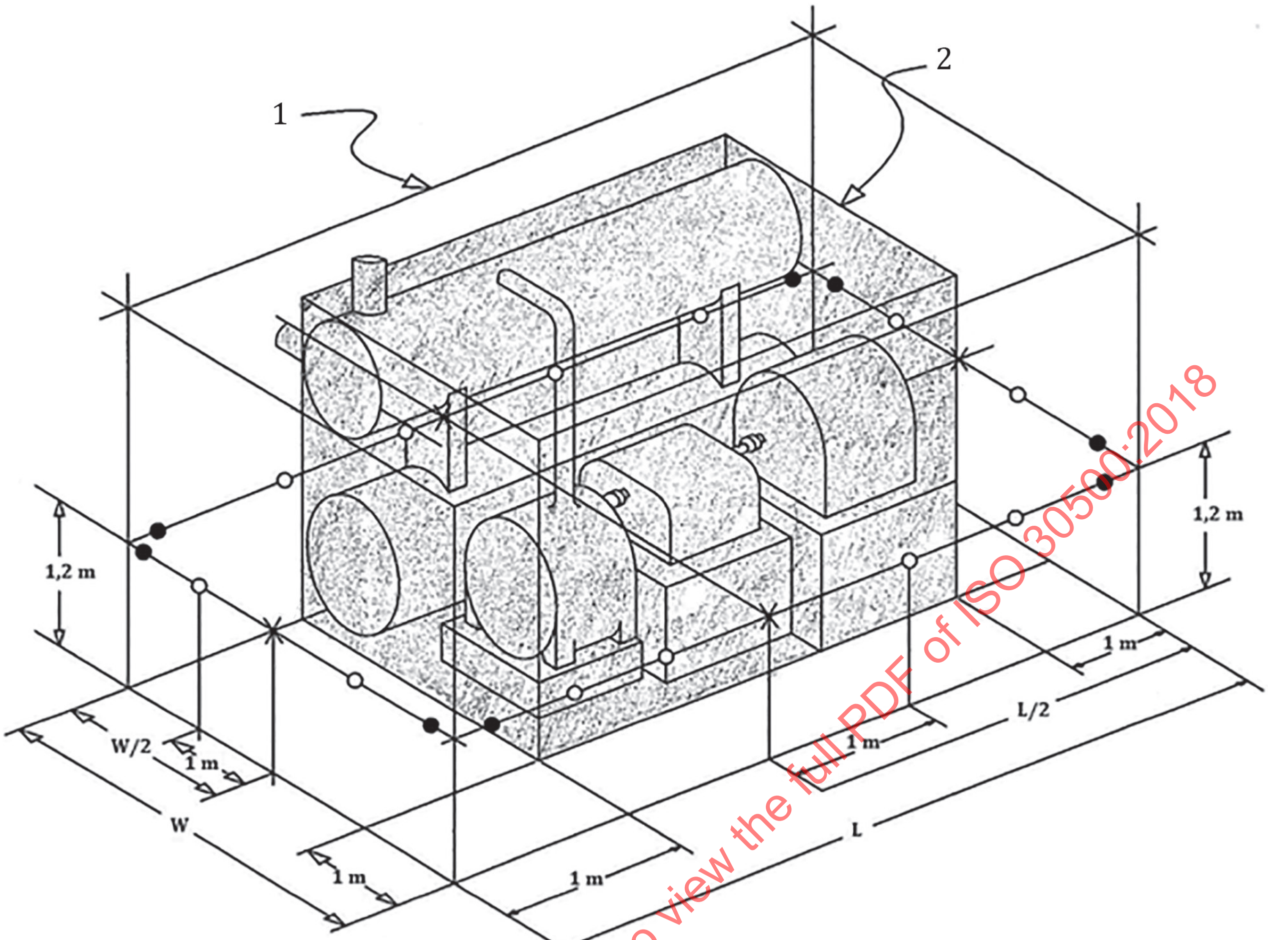
A.3.7.4.1.1 Within superstructure

For NSSS 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 centred above the squatting or seat 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.2). 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.2), 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*.



Key

1	measurement parallelepiped
2	reference parallelepiped
W	width
L	length
X	key measurement points
○	measurement points
●	points nearest to the corners to be discarded

Figure A.2 — Test unit measurement points
(Taken from Reference [53] – 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 NSSS, 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 NSSS 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;

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 (i.e. if $N - N_{K1} - N_{K2} \geq N/2$), then the representative A-weighted sound pressure level (L) shall be calculated using Formula (A.3):

$$L = 10\log 10\left[\sum_{i=1}^{n} 10^{Li/10}\right] - 10\log 10n \tag{A.3}$$

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;

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 assesses 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). Verify that while in transition mode, there is an indication (visual or audible) that the sanitation system is not available for use.

b) Following at least 4 h of stoppage, restart 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) Isolate the sanitation system from its electrical supply. Wait until all mechanical and electrical processes and operations have come to a halt. Reconnect the electrical supply. Observe and record the sanitation system reaction, confirming no automatic restart.

NOTE In some cases, treatment process could continue in an unpowered state (i.e. smouldering, biological process).

e) Subsequently, follow the relevant procedures to restart as defined by the manufacturer.

A.3.8.2 Operability following non-usage of sanitation system

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

a) Without shutting down the system, ensure that the sanitation system is not used for 60 h (i.e. no load enters the system, and no human interaction).

b) After the minimum of 60 h, resume the normal loading (see 7.2.8).

c) Verify that the system returns to normal operating state. Record any malfunction and additional efforts to resume operation that exceed normal operating procedures.

A.3.8.3 Operability following short-term shut down of sanitation system

The following test procedure assesses compliance with the short-term shut down requirements of 4.3.6.

a) Follow the manufacturer's instruction for short-term shut down.

b) Ensure that the sanitation system is shut down for the duration as specified by the manufacturer.

c) Follow manufacturer's procedures for restart following short-term shut down.

d) Verify that the system is able to immediately accept input and returns to normal operating state. Record any malfunction and additional efforts that differ from the manufacturer's "restart following short term shut down" procedures.

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 assess compliance with 5.3.1 and 5.3.2.

a) Separate and isolate the sanitation system from its 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 be in either a safe state or powered by a backup source of energy (see 5.3.1).

b) Energy remaining or stored in the system that poses a potential hazard shall be discharged (see 5.3.2.2). Follow manufacturer's instructions for energy discharge. Using an appropriate measuring device, verify and record whether all energy remaining or stored in the system is discharged.

c) If a backup source of energy is provided, check and record the capacity of the backup 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). If applicable, adapt steps a) to c) of A.3.8.4.1. If not applicable, justification on how the sanitation system intends to meet the requirements in 5.3.3 shall be provided.

A.3.8.5 Operability following long-term shut down

The following test procedure assesses compliance with 4.3.7.

a) Follow the manufacturer's procedures for long-term shut down. Record the duration from start of the procedure until the system is shut down and compare with what was indicated in the user manual or other manufacturer documentation.

b) Ensure that the sanitation system is shut down for at least 60 h before restarting.

c) Follow the manufacturer's procedures for restart following long-term shut down.

d) Verify that the system is able to immediately accept input and returns to normal operating state within the time specified by the manufacturer. Record any malfunction and additional efforts that differ from the manufacturer's "restart following long term shut down" procedures.

A.3.8.6 Overloading

The following test procedure assesses compliance with 4.3.4 and 4.3.8. Use of simulant faeces (see A.3.5.6.4.2) is acceptable.

a) Load the system with normal load (see 7.2.8) in terms of amount per use (see 4.3.2).

b) Allow the waiting time between uses defined by the manufacturer to pass (see 4.3.8), then repeat a) until treatment capacity in terms of uses per day is reached (see 4.3.2).

c) Upon reaching treatment capacity, continue to load the system until overload mechanism is triggered. System overload mechanism should trigger at load equal to design capacity multiplied by safety factor defined by manufacturer (see 4.3.4).

d) Verify that the system is ready for use after the manufacturer defined waiting time. Record any malfunction and whether the overload indicator mechanism (audible and/or visual indication/alarm) performs as intended.

A.3.8.7 Visibility of faeces

The following test procedure assesses compliance with 6.3.

a) Ensure adequate lighting and a viewing angle directly into the frontend squatting or seat 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 faeces from previous users is visible.

A.3.8.8 Discharge and cleaning

The following test procedure assesses compliance with 4.14.3.

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 assesses compliance with 6.2.1, applying recognized ergonomic and anthropometric data.

a) Compare the use of the sanitation system with the usability requirements [suitable complexity, 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;

   3) the activation forces are comfortable for the users.

A.3.8.10 Diarrhoea test day

A.3.8.10.1 General

For the diarrhoea test days, 50 % of the normal faeces loading (on a per user basis, as defined in 4.3.2) shall be 'diarrhoea input' instead of solid faeces. The normal loading pattern for urine input volume should be as follows.

— 35 % of daily capacity (kg/day, derived from 4.3.2) from 6 am to 9 am. Half of this load is to be as normal faecal load (solid faeces), the other half diluted as diarrhoea input.

— 25 % of daily capacity (kg/day, derived from 4.3.2) from 11 am to 2 pm. Half of this load is to be as normal faecal load (solid faeces), the other half diluted as diarrhoea input.

— 40 % of daily capacity (kg/day, derived from 4.3.2) from 5 pm to 8 pm. Half of this load is to be as normal faecal load (solid faeces), the other half diluted as diarrhoea input.

The procedure for preparing diarrhoea input prior to the test is as follows.

a) Combine fresh faeces with water at a ratio of 2 l of water per kg of fresh faeces. The target dry matter content of the diarrhoea input should be between 3 % and 10 %. Actual fresh faecal samples will vary in water content, and within the broad range specified. There is no intent or need to be very precise about the dry matter content of the simulated diarrhoea sample, and thus a twofold dilution by mass of fresh healthy faeces shall be used.

b) Stir gently in order to homogenize the mixture. The diarrhoea input should also be stirred just before use to avoid settling of solids. The dilution with water roughly triples the volume of the faeces. For this testing, the assumption is that each diarrhoea user produces 1,2 l of diarrhoea per day. As described in A.3.8.10.2, each diarrhoea event shall be conducted with 0,4 l of diarrhoea input, thus resulting in three diarrhoeal events to the toilet per user per day.

A.3.8.10.2 Diarrhoea test procedure

The procedure for conducting each diarrhoeal event is as follows.

a) Transfer 0,4 l of diarrhoeal input to the toilet bowl or squat pan using a circular motion to cover the sides of the bowl or pan.

b) Add 6 sheets of paper following the procedure of A.3.3.4.2 or A.3.3.5.2.

c) Wait 1 min before activating the evacuation mechanism.

A.3.8.11 Water seal test

The following procedure assesses compliance with 6.7.

If the frontend includes a water seal, measure the depth of the water in the seal (simple ruler may be used).

Record whether the water seal reaches a depth of at least 20 mm.

Annex B
(normative)

Risk assessment and list of significant hazards

B.1 Risk assessment requirements

B.1.1 General

When a risk assessment is conducted (see 5.1), the following provisions adapted from ISO 12100 and based on industrial best practice apply (see also E.3.3.2).

The manufacturer or their 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 NSSS. The NSSS shall be designed 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:

1) 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);

2) evaluate the identified hazards and determine the related health and safety requirements that apply to the design and realization of the NSSS;

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

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

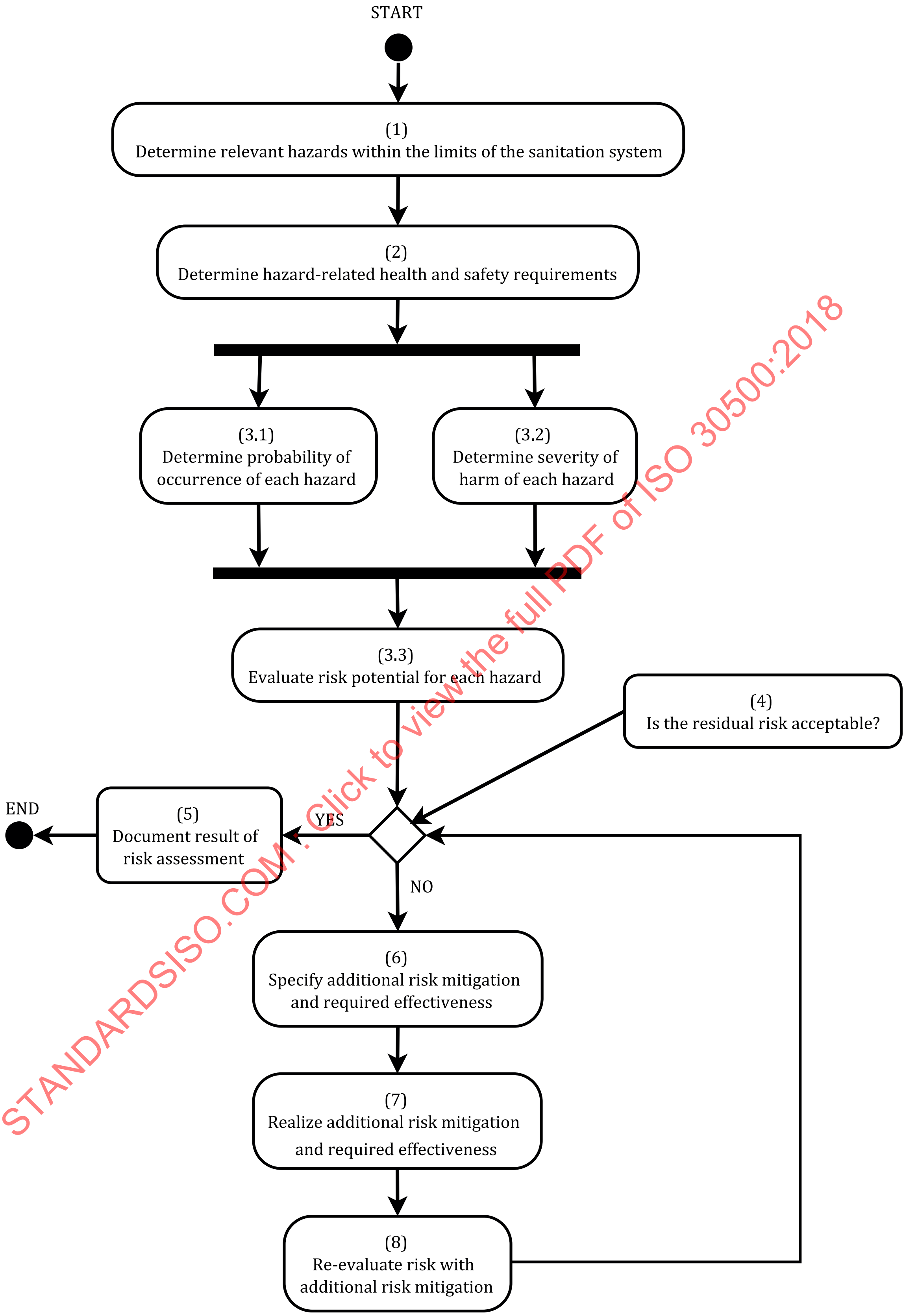
5) document the risk assessment result if the risk is deemed acceptable; or

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

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

8) 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 NSSS can be modified in response 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 NSSS, which include:

a) characteristics of the 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;

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 NSSS in all relevant phases of the NSSS life cycle, i.e.:

a) transport;

b) assembly and installation;

c) use and standby;

d) malfunction;

e) service and maintenance;

f) shut down and storage;

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 their authorized representative shall apply the following order of priority:

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) a description of the NSSS under consideration and its intended use on which the risk assessment is based;