INTERNATIONAL WORKSHOP AGREEMENT

IWA 28

First edition
2018-04

Faecal sludge treatment units — Energy independent, prefabricated, community-scale resource-recovery units — Safety and performance

Unités de traitement de matières de vidange — Unités de récupération préfabriquées et autonomes en énergie pour des ressources à l'échelle locale — Sécurité et performances

Reference number
IWA 28:2018(E)

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Published in Switzerland

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Foreword

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

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

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

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

For an explanation on the 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 the following URL: www.iso.org/iso/foreword.html.

International Workshop Agreement IWA 28 was developed and approved over a series of three workshops hosted by the American National Standards Institute (ANSI) in Durban, South Africa, in June 2017, in Singapore in September 2017 and in Dakar, Senegal, in January 2018.

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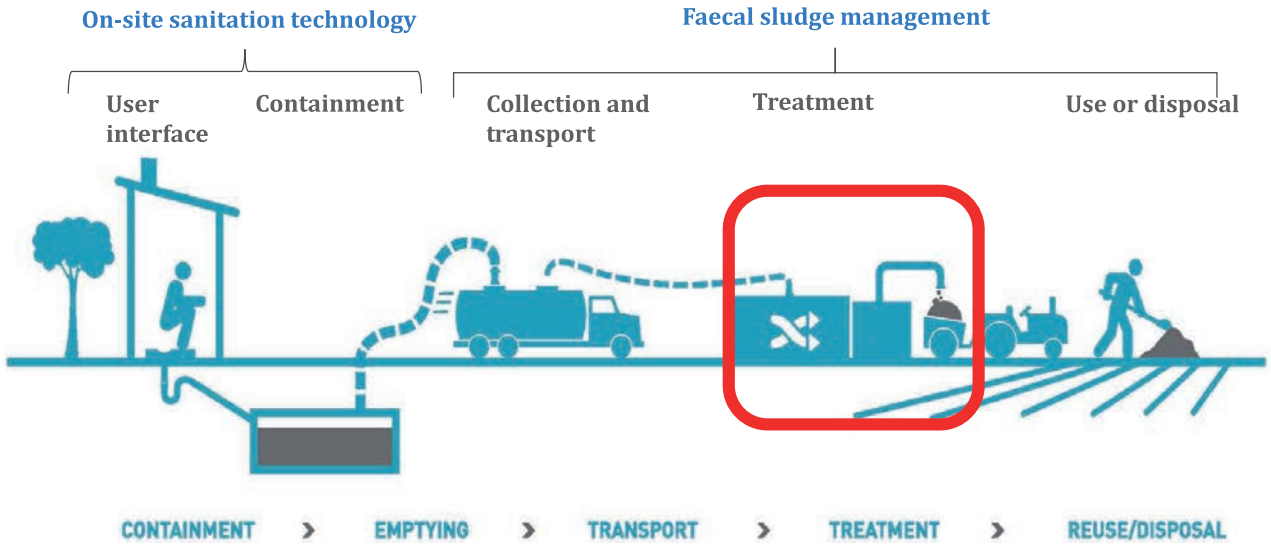
Introduction

Hygienic sanitation facilities are crucial for public health, yet 61 % of the global population do not use safely managed sanitation services, i.e. excreta safely disposed of in situ or treated off-site (see Reference [186]).

Improved environmental sanitation has a multitude of socio-economic benefits. Functional sanitation systems improve health and welfare and are fundamental to human development. Integrated business models throughout the sanitation value chain can ensure the economic viability of processes that turn waste into valuable resources, such as biofuels or agriculture products. Sanitation systems can also conserve water, thus leading to even broader livelihood improvements. According to the World Health Organization, the estimated economic benefit of the return on a US$1 investment in sanitation is in the range of US$5 to US$28 (see Reference [185]).



NOTE The focus of this document is treatment (as depicted in the red box).

Figure 1 — Sanitation value chain

The focus of this technical document on non-sewered faecal sludge treatment units is represented by the red box along the sanitation value chain in Figure 1, indicating the treatment components of faecal sludge management. The purpose of this document is to specify performance and safety requirements of community-scaled resource-oriented faecal sludge treatment units serving approximately 1 000 to 100 000 people, ensuring technical robustness and safety in terms of human health and the environment. This document aims to facilitate the commercialization and transfer of these treatment units into the market.

This document complements ISO 30500[1)] on-site user-interface non-sewered sanitation systems (depicted at left in Figure 1).

This document aims to specify technical requirements and recommendations for community-scale resource-oriented faecal sludge treatment units in terms of performance, reliability, availability, maintainability and safety. This document further aims to promote trust among the different stakeholders involved in faecal sludge management, such as investors, technology developers, regulatory bodies, local service providers and users, increasing their willingness to implement innovative new technologies. Manufacturers and technology developers can use this document to gain consumer confidence in the reliability and safety of treatment units. Stakeholders can use this document as a benchmark to compare performance capabilities of different treatment unit options and identify which option is most suitable for their needs.

1) Under preparation. Stage at the time of publication: ISO/DIS 30500:2018.

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This document specifies minimum requirements of all types of outputs from the treatment unit to ensure safety for human health and the environment. It does not specify or mandate the quality of resources recovered as these are highly dependent on the local (e.g. economic, social) context.

This document is intended to ensure the general performance, safety and sustainability of such units. This document also includes requirements for operability and maintainability to ensure safety and performance of the treatment unit. Figure 2 illustrates the scope of this document with respect to treatment unit inputs and outputs.

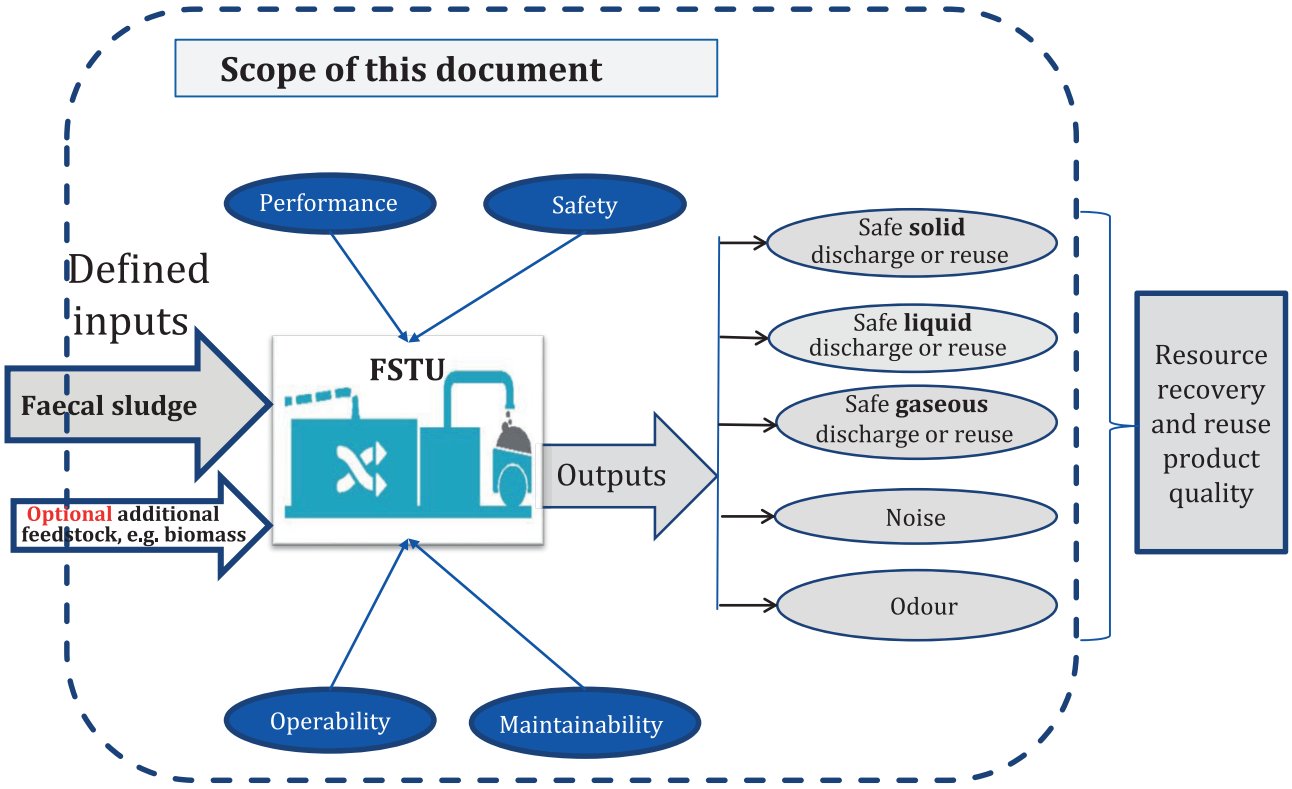

Figure 2 — Scope of this document

The dashed line in Figure 2 shows the boundary of the scope of this document. Inputs are primarily faecal sludge derived from human excreta (likely contaminated with domestic waste) and can include additional inputs at the discretion of the manufacturer. This document does not specify which forms of excreta and additional inputs are treated within the unit (e.g. urine, faeces, greywater); these inputs are defined by the manufacturer.

Inputs are illustrated as partially within and partially outside the document's scope to illustrate that the manufacturer defines the input characteristics which meet the requirements set forth in this document. The performance, safety, operability and maintainability of the treatment unit are addressed in this document, as are human health and safety aspects of the treatment unit's solid, liquid and gaseous outputs. Noise and odour outputs of the treatment unit are also addressed within this document. However, the quality and value of any resource recovery and reuse products derived from treatment unit outputs are outside the scope of this document. Apart from the requirement for energy independence during steady-state operation, this document does not set performance targets with respect to the amount or type of energy or resources that needs to be recovered and/or locally used.

This document excludes transportation and any intermediary processes required to supply the treatment unit with the defined inputs.

Provisions of this document apply to the treatment unit according to its unit boundaries, i.e. within the process chain beginning with its specified inputs and ending with its outputs.

Annex C on sustainability highlights some of these considerations.

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Faecal sludge treatment units — Energy independent, prefabricated, community-scale resource-recovery units — Safety and performance

1 Scope

This document specifies requirements and test methods to ensure safety, performance and sustainability of community-scale resource-oriented faecal sludge treatment units that serve approximately 1 000 to 100 000 people. This document applies to treatment units that:

a) primarily treat faecal sludge;

b) are able to operate in non-sewered and off-grid environments;

c) are prefabricated.

This document does not apply to sanitation treatment units requiring sewer infrastructure, or to those requiring electric grid access during steady state operation.

Treatment units to which this document applies exhibit resource recovery capability (e.g. recovering energy, reusable water, soil amendment) and are capable of being energy neutral or energy net positive.

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 7250 (all parts), *Basic human body measurements for technological design*

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

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

ISO 55000, *Asset management — Overview, principles and terminology*

IEC 60050, *International electrotechnical vocabulary*

IEC 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60942, *Electroacoustics — Sound calibrators*

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

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

IEC 82079-1, *Preparation of instructions for use — Structuring, content and presentation — Part 1: General principles and detailed requirements*

API 650, *Welded steel tanks for oil storage*

ASTM D7348-13, *Standard test methods for loss on ignition (LOI) of solid combustion residues*

AWWA D-100, *Welded carbon steel tanks for water storage*

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DIN 4109-1, *Sound insulation in buildings*

EN 13137, *Characterization of waste — Determination of total organic carbon (TOC) in waste, sludges and sediments*

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

EN 15259, *Air quality — Measurement of stationary source emissions — Requirements for measurement sections and sites and for the measurement objective, plan and report*

EN 15936, *Sludge, treated biowaste, soil and waste — Determination of total organic carbon (TOC) by dry combustion*

FDBR-RL7, *Acceptance testing of waste incineration plants with grate firing systems*

NFPA 30:2018, *Flammable and Combustible Liquids Code*

UL 58, *Standard for steel underground tanks for flammable and combustible liquids*

UL 142, *Standard for steel aboveground tanks for flammable and combustible liquids*

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

3 Terms, definitions and abbreviated terms

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 General

3.1.1
human excreta
waste products of human metabolism, in solid or liquid form, generally urine and/or faeces

[SOURCE: ISO 24521:2016, 3.3]

3.1.2
faecal sludge
untreated sludge generated from the storage of *human excreta* (3.1.1) that can be mixed with flush water, solid *domestic waste* (3.2.1) and other liquids

3.1.3
input
substances fed to the treatment unit for the purpose of treating those substances

Note 1 to entry: Input to treatment units covered by this document is required to be derived primarily from *faecal sludge* (3.1.2), which can be contaminated by liquid and solid *domestic waste* (3.2.1) and can include different forms of *biomass* (3.2.2).

3.1.4
prefabricated
factory produced, either as a fully assembled unit or as a set of components that assemble to form the unit

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3.1.5
design requirement
requirement that specifies or constrains the design of a system or system componentcf. functional requirement, implementation requirement, interface requirement, performance requirement, physical requirement

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.1146]

3.1.6
risk assessment
overall process comprising a risk analysis and a risk evaluation

[SOURCE: ISO 14971:2007, 2.18]

3.1.7
safety assessment
review of the aspects of design and operation of the treatment unit, which are relevant to the protection of persons or the safety of the treatment unit, including the analysis of the safety and protection provision established in the design and operation of the treatment unit and the analysis of risks associated with normal conditions and accident situations

3.1.8
design process
process of converting the requirements of the functional specification into the technical specification

[SOURCE: ISO 13880:1999, 3.3]

3.1.9
functioning as intended
conforming to all expectations in terms of performance, capacity and safety as specified by the manufacturer

EXAMPLE The treatment process is functioning as intended when the process is stable and the output criteria are met.

3.1.10
reasonably foreseeable misuse
use of a machine in a way not intended by the designer, but which can result from readily predictable human behaviour

[SOURCE: ISO 12100:2010, 3.30]

3.2 Input, energy balance and resource recovery

3.2.1
domestic waste
waste that arises from domestic use of a private dwelling

3.2.2
biomass
material of biological origin excluding material embedded in geological and/or fossilized formations

[SOURCE: ISO 16620-1:2015, 3.1.2]

3.2.3
steady state
condition in which all relevant operational parameters are not significantly changing with time

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3.2.4
energy balance
accounting of *input* (3.1.3) and/or generation of energy supply versus energy outputs based on energy consumption by energy use

[SOURCE: ISO 50002:2014, 3.6, modified — Notes to entry have been deleted.]

3.2.5
energy independent
able to perform the intended functions of the treatment unit relying exclusively on energy from its defined *input* (3.1.3) during *steady state* (3.2.3) operation

3.2.6
energy positive
generating excess energy from the treatment unit's defined *input* (3.1.3) (e.g. as biocrude or biogas) that can be used in applications beyond the treatment unit

3.2.7
thermal treatment
treatment process using heat to convert energy from the treatment unit *input* (3.1.3) into a useful form

3.2.8
calorific value
quantity of heat produced by the combustion, the constituents of the combustible mixture being taken at reference conditions and the products of combustion being brought back to the same conditions

[SOURCE: ISO 22967:2010, 3.2.2, modified — The words "at a constant pressure equal to 0,101 325 MPa, of unit volume or mass of gas" have been deleted from the definition and the Note to entry has been deleted.]

3.2.9
biochemical oxygen demand
BOD
mass concentration of dissolved oxygen consumed under specified conditions by the aerobic biological oxidation of a chemical compound or organic matter in water

[SOURCE: ISO 9408:1999, 2.5, modified — Note to entry has been deleted.]

3.2.10
chemical oxygen demand
COD
mass concentration of oxygen equivalent to the amount of a specified oxidant consumed by a chemical compound or organic matter when a water sample is treated with that oxidant under defined conditions

[SOURCE: ISO 9408:1999, 2.6, modified — Note to entry has been deleted.]

3.2.11
volatile organic compound
VOC
organic liquid and/or solid that evaporates spontaneously at the prevailing temperature and pressure of the atmosphere with which it is in contact

[SOURCE: ISO 17895:2005, 3.1, modified — The word "any" has been deleted at the start of the definition and the Notes to entry have been deleted.]

3.3 Performance

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3.3.1
utilization time
period in which the treatment unit is in operation

Note 1 to entry: It is calculated as the sum of the *mean time between failure* (3.3.6), *technical downtime* (3.3.5) and all other *downtimes* (3.3.5) including *preventive maintenance* (3.3.3)

3.3.2
technical availability
portion of the treatment unit's uptime within the *utilization time* (3.3.1) compared to the sum of its uptime and *technical downtime* (3.3.5):

Note 1 to entry: It is calculated as the *mean time between failure* (3.3.6) divided by the sum of the mean time between failure and the *mean time to repair* (3.3.7).

Note 2 to entry: See also Figure 3.

3.3.3
preventive maintenance
activities that effectively preclude failure or damage through scheduled maintenance occurring at defined time periods or triggered through defined indicators such as wear and tear of components

3.3.4
downtime
period of time during which an item is not in a condition to perform its required function

Note 1 to entry: See also *functioning as intended* (3.1.9).

[SOURCE: ISO 8107:1993, 3.2]

3.3.5
technical downtime
unscheduled *downtime* (3.3.4) during which the treatment unit's processes are not *functioning as intended* (3.1.9), which can be due to shortcomings in the design, material defects, process interruptions due to design deficits, or shortcomings in the product literature provided by the manufacturer.

Note 1 to entry: The technical downtime is expressed through the *mean time to repair* (3.3.7).

3.3.6
mean time between failure
MTBF
average operating time between two consecutive failures of a technical system that each initiate a period of *downtime* (3.3.4)

3.3.7
mean time to repair
MTTR
average maintenance repair time for failures resulting in *technical downtime* (3.3.5)

Note 1 to entry: Mean time to repair generally does not reflect lead time for parts or administrative or logistical *downtime* (3.3.4).

3.3.8
failure on demand
failure of the treatment unit to respond as intended to operator signals

EXAMPLE 1 Failure to resume stable operations after starting or re-starting the treatment process.

EXAMPLE 2 Failure to enter a safe state following shutoff.

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3.3.9
interlock
mechanical, electrical or other type of device, the purpose of which is to prevent the operation of machine elements under specified conditions by an inhibit command from the interlocking device that

a) directly interrupts the energy supply or directly disconnects parts from the equipment, or

b) is introduced into the control system so that interruption of the energy or disconnection of parts from the equipment is triggered by the control system

[SOURCE: ISO 21789:2009, 3.6]

3.3.10
redundancy
existence of more than one means for performing a required function

[SOURCE: ISO 20815:2008, 3.1.40]

3.3.11
atmospheric tank
tank of which the inner vessel is designed to operate at atmospheric pressure

[SOURCE: ISO 5708:1983, 4.3]

3.4 Operability

3.4.1
process stability
process condition exhibiting consistent means and variances throughout the *utilization time* (3.3.1)

3.4.2
water tightness
ability of the closed non-sewered sanitation system to resist water penetration and prevent leakage

[SOURCE: ISO 30500:—[2)], 3.1.3.9]

3.4.3
technical tightness
inherent characteristics of a non-sewered sanitation system that prevent fluids, gases, or dusts from passing from the external through to the internal environment, or from the internal to the external environment, or both; the sanitation system or components thereof are considered technically tight if the leakage rate does not exceed 0,000 01 mbar l/s

[SOURCE: IWA 24:2016, 3.1.3.10]

3.5 Outputs

3.5.1
effluent
liquid discharged from any item of equipment after fulfilment of its function or after having itself been treated (e.g. for clarification)

[SOURCE: ISO 1213-1:1993, 6.1.09]

3.5.2
odour
property of a substance that activates the human sense of smell

2) Under preparation. Stage at the time of publication: ISO/DIS 30500:2018.

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3.5.3
pathogen
organism capable of producing disease in a susceptible plant or animal, including humans

[SOURCE: ISO 6107-5:2004, 39, modified — The word “man” has been replaced with “humans”.]

3.5.4
protozoa
phylum of unicellular eukaryotic animals varying from simple uninucleate organisms to cell colonies or highly organized structures and with a considerable diversity of forms and nutrition

[SOURCE: ISO 6107-5:2004, 47]

3.6 Abbreviated terms

APHA	American Public Health Association
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASSE	American Society of Safety Engineers
ASTM	American Society for Testing and Materials
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BOD	biochemical oxygen demand
CAPEX	capital expenditure
CFU	colony-forming units
COD	chemical oxygen demand
EPA	US Environmental Protection Agency
HAZOP	hazard and operability study
HSE	UK Health and Safety Executive
IFA	Institute for Occupational Safety and Health of the German Social Accident Insurance
LEL	lower explosive limit
LOI	loss on ignition
NFPA	National Fire Protection Association
NIOSH	US National Institute for Occupational Safety and Health
OPEX	operational expenditures
OSHA	US Occupation Safety and Health Administration
OU_e	odour unit (European)
PAH	polycyclic aromatic hydrocarbon
PFD	probability of failure on demand
PFU	plaque-forming units
$PM_{2.5}$	particulate matter with a diameter less than 2,5 micrometres
R_a	colour rendering value
TOC	total organic carbon
TSS	total suspended solids
UEL	upper explosive limit
UL	Underwriters Limited
UN	United Nations

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VDI	Association of German Engineers
VOC	volatile organic compound
WHO	World Health Organization

4 General requirements

4.1 Industrial design and manufacture

Treatment units shall be designed and made in accordance with industrial standards. For the purposes of this document, industrial design and manufacture comprises the following requirements.

a) Design and manufacture of the treatment unit shall be specified and realized in accordance with the International System of units (SI) set forth in ISO 80000, IEC 80000 or an equivalent international or national standard.

b) Design and manufacture shall be systematically planned, realized and tested along a defined product safety lifecycle that ensures testability, quality and regulatory conformity of the treatment unit.

c) Design and manufacture of the treatment unit shall be based on a clearly specified design base and uniform manufacturing process. The design base shall cover electrical, mechanical and process engineering, including the base for the declared capacity, availability and performance of the treatment unit. International and/or national standards should be used to guide compliance with these design requirements.

d) Design and manufacture of the treatment unit shall be documented in a systematic technical file.

4.2 Hazard and operability study and risk assessment

The manufacturer of a treatment unit shall carry out a hazard and operability study (HAZOP) following EN 61882 or an equivalent standard, and either

a) a risk assessment following ISO 12100 or IEC 31010, or

b) an equivalent standard or an equally effective assessment capable of demonstrating proven safety of treatment units.

NOTE Operational issues over which the operator (rather than the manufacturer) has control, such as material handling and loading, are outside the scope of this document and therefore excluded from this assessment.

The safety assessment shall:

a) determine the health and safety requirements that apply to the treatment unit;

b) determine risk-mitigating measures to be taken;

c) demonstrate the safety of the product by documenting the results of a 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 treatment unit, considering its expected use and reasonably foreseeable misuse.

4.3 Ambient operation conditions

The treatment unit shall operate within the ambient temperature range, air humidity and pressures specified by the manufacturer (see 12.1).

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