SLOVENSKI STANDARD
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Nekurjene tlačne posode - 14. del: Dodatne zahteve za tlačno opremo in dele pod tlakom, narejene z dodajalno izdelavo

Unfired pressure vessels - Part 14: Additional requirements for pressure equipment and pressure components fabricated with additive manufacturing methods

Unbefeuerte Druckbehälter - Teil 14: Zusätzliche Anforderungen an additiv gefertigte Druckgeräte und deren Bauteile

Récipients sous pression non soumis à la flamme - Partie 14 : exigences complémentaires pour équipement et composants sous pression obtenus par fabrication additive

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Unfired pressure vessels - Part 14: Additional requirements for pressure equipment and pressure components fabricated with additive manufacturing methods

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (prEN 13445-14:2024) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, the secretariat of which is held by BSI.

This document is currently submitted to the CEN Enquiry.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZA, which is an integral part of this document.

Introduction

This document is applicable to unfired pressure vessels or parts of pressure vessels made with additive manufacturing (AM) processes.

This document is organized in a main part common to all additive manufacturing processes and normative Annexes A to D.

Those Annexes are dedicated to specific AM processes and contain requirements relevant to specific materials.

In this first edition of this document, only Annex A and Annex B are available. The other Annexes will be added to this document during amendment or revision as they are completed.

The structure of the specific Annexes is described in Table 1.

Table 1 — Structure of Annexes of this document

Annex		**Annex A**	**Annex B**	**Annex C**	**Annex D**
AM Process		**Powder bed fusion**	**DED using wire feedstock**	**DED using powder feedstock**	**Binder jetting**
General		A1	B1	C1	D1
Materials	Steel	A2	B2	C2	D2
	Aluminum alloys	A3	B3	C3	D3
	Nickel base alloys	A4	B4	C4	D4
	Titanium alloys	A5	B5	C5	D5
	Copper alloys	A6	B6	C6	D6
	Zirconium alloys	A7	B7	C7	D7

1 Scope

This document specifies general requirements for the application of additive manufacturing processes for pressure vessels and parts.

Separate Annexes of this document provide detailed requirements for specific additive manufacturing processes and materials.

This document is currently limited to metallic material applications. If a pressure part manufactured to this document is integrated into a pressure vessel, all parts of EN 13445 apply for this integration.

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.

EN 764-4:2014, *Pressure equipment — Part 4: Establishment of technical delivery conditions for metallic materials*

EN 764-5:2014, *Pressure equipment — Part 5: Inspection documentation of metallic materials and compliance with the material specification*

EN 10204:2004, *Metallic products — Types of inspection documents*

EN 13445-1:2021, *Unfired pressure vessels — Part 1: General*

EN 13445-2:2021+A1:2023, *Unfired pressure vessels — Part 2: Materials*

EN 13445-3:2021, *Unfired pressure vessels — Part 3: Design*

EN 13445-4:2021+A1:2023, *Unfired pressure vessels — Part 4: Fabrication*

EN 13445-5:2021+A1:2024, *Unfired pressure vessels — Part 5: Inspection and testing*

EN 13445-8:2021, *Unfired pressure vessels — Part 8: Additional requirements for pressure vessels of aluminium and aluminium alloys*

EN 13445-10:2021, *Unfired pressure vessels — Part 10: Additional requirements for pressure vessels of nickel and nickel alloys*

EN 14532-1:2004, *Welding consumables — Test methods and quality requirements — Part 1: Primary methods and conformity assessment of consumables for steel, nickel and nickel alloys*

EN 14532-2:2004, *Welding consumables — Test methods and quality requirements — Part 2: Supplementary methods and conformity assessment of consumables for steel, nickel and nickel alloys*

EN 14532-3:2004, *Welding consumables — Test methods and quality requirements — Part 3: Conformity assessment of wire electrodes, wires and rods for welding of aluminium alloys*

EN ISO 148-1:2016, *Metallic materials — Charpy pendulum impact test — Part 1: Test method (ISO 148-1:2016)*

EN ISO 636:2017, *Welding consumables — Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels — Classification (ISO 636:2017)*

EN ISO 3452-1:2021, *Non-destructive testing — Penetrant testing — Part 1: General principles (ISO 3452-1:2021)*

EN ISO 4136:2022, *Destructive tests on welds in metallic materials — Transverse tensile test (ISO 4136:2022)*

EN ISO 5173:2023, *Destructive tests on welds in metallic materials — Bend tests (ISO 5173:2023)*

EN ISO 5178:2019, *Destructive tests on welds in metallic materials — Longitudinal tensile test on weld metal in fusion welded joints (ISO 5178:2019)*

EN ISO 6892-1:2019, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2019)*

EN ISO 6892-2:2018, *Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature (ISO 6892-2:2018)*

EN ISO 9015-1:2011, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints (ISO 9015-1:2001)*

EN ISO 10042:2018, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections (ISO 10042:2018)*

EN ISO 14175:2008, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes (ISO 14175:2008)*

EN ISO 14341:2020, *Welding consumables — Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels — Classification (ISO 14341:2020)*

EN ISO 14343:2017, *Welding consumables — Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat resisting steels — Classification (ISO 14343:2017)*

EN ISO 14732:2013, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732:2013)*

EN ISO 15708-2:2019, *Non-destructive testing — Radiation methods for Computed tomography — Part 2: Principles, equipment and samples (ISO 15708-2:2017)*

EN ISO 15614-1:2017,[1] *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1 : arc and gas welding of steels and arc welding of nickel and nickel alloys*

EN ISO 15614-2:2005, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 2: Arc welding of aluminium and its alloys (ISO 15614-2:2005)*

EN ISO 15614-11:2002, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 11: Electron and laser beam welding (ISO 15614-11:2002)*

EN ISO 17635:2016, *Non-destructive testing of welds — General rules for metallic materials (ISO 17635:2016)*

[1] As impacted by EN ISO 15614-1:2017/A1:2019.

EN ISO 17636-1:2022, *Non-destructive testing of welds — Radiographic testing — Part 1: X- and gamma-ray techniques with film (ISO 17636-1:2022)*

EN ISO 17637:2016, *Non-destructive testing of welds — Visual testing of fusion-welded joints (ISO 17637:2016)*

EN ISO 17639:2022, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds (ISO 17639:2022)*

EN ISO 17640:2018, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment (ISO 17640:2018)*

EN ISO 18273:2015, *Welding consumables — Wire electrodes, wires and rods for welding of aluminium and aluminium alloys — Classification (ISO 18273:2015)*

EN ISO 21952:2012, *Welding consumables — Wire electrodes, wires, rods and deposits for gas shielded arc welding of creep-resisting steels — Classification (ISO 21952:2012)*

EN ISO/ASTM 52900:2021, *Additive manufacturing — General principles — Fundamentals and vocabulary (ISO/ASTM 52900:2021)*

EN ISO/ASTM 52904:2024, *Additive manufacturing of metals — Process characteristics and performance — Metal powder bed fusion process to meet critical applications (ISO/ASTM 52904:2024)*

EN ISO/ASTM 52907:2019, *Additive manufacturing — Feedstock materials — Methods to characterize metal powders (ISO/ASTM 52907:2019)*

EN ISO/ASTM 52911-1:2019, *Additive manufacturing — Design — Part 1 : Laser-based powder bed fusion of metals (ISO/ASTM 52911-1:2019)*

EN ISO/ASTM 52926-1:2023, *Additive Manufacturing of metals — Qualification principles — Part 1: General qualification of operators (ISO/ASTM 52926-1:2023)*

EN ISO/ASTM 52926-5:2023, *Additive manufacturing of metals — Qualification principles — Part 5: Qualification of operators for DED-Arc (ISO/ASTM 52926-5:2023)*

EN ISO/ASTM 52928:2024, *Additive manufacturing of metals— Feedstock materials — Powder life cycle management (ISO/ASTM 52928:2024)*

CEN ISO/ASTM/TS 52930:2021, *Additive Manufacturing — Qualification principles — Installation, operation and performance (IQ/OQ/PQ) of PBF-LB equipment (ISO/ASTM/TS 52930:2021)*

EN ISO/ASTM 52941:2020, *System performance and reliability — Acceptance tests for laser metal powder-bed fusion machines for metallic materials for aerospace application (ISO/ASTM 52941:2020)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13445-1:2021 and EN ISO/ASTM 52900:2021 and the following apply.

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

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

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

3.1
additive manufacturing
AM
process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies

Note 1 to entry: Historical terms: additive fabrication, additive processes, additive techniques, additive layer manufacturing, layer manufacturing, solid freeform fabrication and freeform fabrication.

[SOURCE: EN ISO/ASTM 52900:2021, 3.1.2]

3.2
annealed
heat treatment to increase the ductility of the material and reduce its hardness, making it more workable

Note 1 to entry: Annealed involves heating a material above its recrystallization temperature, maintaining a specified temperature for a defined time, and then cooling according to the selected method.

3.3
batch
<of feedstock> defined quantity of feedstock with uniform properties and composition

Note 1 to entry: One batch of any feedstock can be used in one or more production runs using different process parameters.

Note 2 to entry: For some types of feedstock, for example powders and resins, one batch can consist of virgin material, used material or a blend of virgin and used materials.

[SOURCE: EN ISO/ASTM 52900:2021, 3.6.1]

3.4
bead

single deposition run made on the build surface

3.5
build cycle
single process cycle in which one or more parts are built up in layers

[SOURCE: EN ISO/ASTM 52900:2021, 3.3.8, modified]

3.6
build platform
<of a machine> base which provides a surface upon which the building of the part(s) is started and supported throughout the build process

[SOURCE: EN ISO/ASTM 52900:2021, 3.3.5]

3.7
build surface
area where material is added, normally on the last deposited layer which becomes the foundation upon which the next layer is formed

Note 1 to entry: For the first layer, the build surface is often the build platform (A.2.3.5).

Note 2 to entry: In the case of directed energy deposition processes, the build surface can be an existing part onto which material is added.

Note 3 to entry: If the orientation of the material deposition or consolidation means, or both, is variable, it may be defined relative to the build surface.

[SOURCE: EN ISO/ASTM 52900:2021, 3.3.6]

3.8
component
part of pressure equipment which can be considered as an individual item for the calculation

[SOURCE: EN 13445-3:2021, 3.7]

3.9
design class
DC
class for design which determines the design class factor to use for the design according to the level of non-destructive testing (NDT)

3.10
design class factor
F_{dc}
reducing factor taking into account the NDT range, applied to the design stress to account for any manufacturing imperfections

3.11
directed energy deposition
DED
additive manufacturing process in which focused thermal energy is used to fuse materials by melting as they are being deposited

Note 1 to entry: "Focused thermal energy" means that an energy source (e.g. laser, electron beam, or plasma arc) is focused to melt the materials being deposited.

[SOURCE: EN ISO/ASTM 52900:2021, 3.2.2]

3.12
feedstock
bulk raw material supplied to the additive manufacturing building process

Note 1 to entry: For additive manufacturing building processes, the bulk raw material is typically supplied in various forms such as liquid, powder, suspensions, filaments, sheets, etc.

[SOURCE: EN ISO/ASTM 52900:2021, 3.6.5]

3.13
feedstock supplier
feedstock vendor
provider of feedstock

Note 1 to entry: In additive manufacturing, the feedstock supplier can often be a different entity than the feedstock manufacturer.

[SOURCE ISO/ASTM 52900:2021, 3.6.7]

3.14
layer
<matter> material laid out, or spread, to create a surface

Note 1 to entry: A layer may include single or multiple deposition runs.

[SOURCE: ISO/ASTM 52900:2021, 3.3.7 modified]

3.15
longitudinal bend test specimen
test specimen for a test that is longitudinally bisected by the portion of the weld included in it; tests in welding direction or within the layers, respectively

[SOURCE: ISO/TR 25901-1:2016, 2.2.3.8 modified]

3.16
multi-bead performance
wall thickness made from two or more beads

Note 1 to entry: Multi-bead performance can include weaving.

3.17
near net shape
condition where the components require little post-processing to meet dimensional tolerance

[SOURCE: EN ISO/ASTM 52900:2021, 3.11.7]

3.18
part
joined material forming a functional element that could constitute all or a section of a pressure equipment

Note 1 to entry: The functional requirements for a part are typically determined by the intended application.

[SOURCE: EN ISO/ASTM 52900:2021, 3.9.1, modified]

3.19
post-processing
process step, or series of process steps, taken after the completion of an additive manufacturing build cycle in order to achieve the desired properties in the final product

[SOURCE: EN ISO/ASTM 52900:2021, 3.6.10]

3.20
powder bed fusion
PBF
additive manufacturing process in which thermal energy selectively fuses regions of a powder bed

[SOURCE: EN ISO/ASTM 52900:2021, 3.2.5]

3.21
process parameters
operating parameters and system settings used during a build cycle

[SOURCE: EN ISO/ASTM 52900:2021, 3.3.10]

3.22
reference value
$\boldsymbol{R}_{\mathrm{r}}$
value used for design calculations or burst test procedure for pressure vessels and parts with varying mechanical properties depending on the position and orientation within the part

Note 1 to entry: This is the value taking into consideration all stress directions or for a simplified approach the lowest value of mechanical properties considering all positions/orientations.

3.23
single-bead performance
wall thickness made from one bead

Note 1 to entry: Single-bead performance can include weaving.

3.24
solution annealing
heat treatment in order to place the constituents into solid solution

Note 1 to entry: The material is held at the temperatures for a period necessary to bring the alloying elements into a solid solution.

4 General requirements

The material manufacturer is the party responsible for providing certification of the consolidated material. This is typically the party that performs the additive manufacturing process, although in exceptional cases where the feedstock supplier confirms that consolidated material properties comply with a European Standard or other published specification (see 5.1.2) then the feedstock supplier can be the material manufacturer (see Figure 1). The material manufacturer can also be the part manufacturer.

The material manufacturer shall produce a material certificate 3.1 or 3.2 as defined in EN 10204:2004 in accordance with EN 764-5:2014, based on a material specification issued in compliance with EN 764-4:2014 and the applicable Annex of this document. The material manufacturer shall affirm the mechanical properties used for the design.