# SLOVENSKI STANDARD
# SIST EN 13121-3:2008

**01-oktober-2008**

**Nadzemni rezervoarji iz armiranega poliestra - 3. del: Konstruiranje in izdelava**

GRP tanks and vessels for use above ground - Part 3: Design and work-manship

Oberirdische GFK-Tanks und -Behälter - Teil 3: Auslegung und Herstellung

Réservoirs et récipients en PRV pour applications hors sol - Partie 3 : Conception et exécution



**Ta slovenski standard je istoveten z:** **EN 13121-3:2008**



**ICS:**

| | | |
|---|---|---|
| 23.020.10 | Nepremiļne posode in rezervoarji | Stationary containers and tanks |

**SIST EN 13121-3:2008** **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

**EN 13121-3**

June 2008

ICS 23.020.10

English Version

# GRP tanks and vessels for use above ground - Part 3: Design and workmanship

Réservoirs et récipients en PRV pour applications hors sol - Partie 3: Conception et fabrication

Oberirdische GFK-Tanks und -Behälter - Teil 3: Auslegung und Herstellung

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Ref. No. EN 13121-3:2008: E

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# Foreword

This document (EN 13121-3:2008) has been prepared by Technical Committee CEN/TC 210 “GRP tanks and vessels”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2008, and conflicting national standards shall be withdrawn at the latest by December 2009.

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For relationship with EC Directive(s), see informative Annex ZA, which is an integral part of this document.

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

# Introduction

EN 13121 consists of the following parts under the general title "*GRP tanks and vessels for use above ground*":

— Part 1: Raw materials — Specification conditions and acceptance conditions

— Part 2: Composite materials — Chemical resistance

— Part 3: Design and workmanship (this standard)

— Part 4: Delivery, installation and maintenance

These four parts together define the responsibilities of the tank or vessel manufacturer and the materials to be used in their manufacture.

Part 1 of this standard specifies the requirements and acceptance conditions for the raw materials - resins, curing agents, Thermoplastics linings, reinforcing materials and additives. These requirements are necessary in order to establish the chemical resistance properties determined in Part 2 and the mechanical, thermal and design properties determined in Part 3. Together with the workmanship principles determined in Part 3, requirements and acceptance conditions for raw materials ensure that the tank or vessel will be able to meet its design requirements. Part 4 of this standard specifies recommendations for delivery, handling, installation and maintenance of GRP tanks and vessels.

The design and manufacture of GRP tanks and vessels involve a number of different materials such as resins, thermoplastics and reinforcing fibres and a number of different manufacturing methods. It is implicit that tanks and vessels conforming to this standard should be made only by manufacturers who are competent and suitably equipped to fulfil all requirements, using materials manufactured by competent and experienced material manufacturers.



Metallic vessels, and those manufactured from other isotropic, homogeneous materials, are conveniently designed by calculating permissible loads based on measured tensile and ductility properties. GRP, on the other hand, is a laminar material, manufactured through the successive application of individual layers of reinforcement. As a result there are many possible combinations of reinforcement type that will meet the structural requirement of any one-design case. This allows the designer to select the laminate construction best suited to the available manufacturing facilities and hence be most cost effective.

In considering a layered GRP structure it is assumed that it is the glass reinforcement that provides the stiffness and strength required to resist mechanical loadings. Also, since the quantity of glass reinforcement is most readily assessed by weight, the weight of glass per unit area (m) is used instead of thickness in determining mechanical properties, thus the concepts of load and modulus are replaced by unit strength (U) and unit modulus (X), these being defined in Table 1.

NOTE To convert a unit load, or a unit modulus to a load and a modulus respectively, $U$ and $X$ may be simply divided by $t$, where $t$ is the thickness per weight of glass per unit area of the lamina, or laminate under consideration.

# 1 Scope

This European Standard gives requirements for the design, fabrication, inspection, testing and verification of GRP tanks and vessels with or without Thermoplastics lining for storage or processing of fluids, factory made or site built, non pressurised or pressurised up to 10 bar, for use above ground.

The terms vessels and tanks as used in this European Standard include branches up to the point of connection to pipe work or other equipment by bolting and supports, brackets or other attachments bonded directly to the shell. In addition to the definitive requirements, this European Standard also requires the items in Clause 5 to be fully documented.

This European Standard covers vessels and tanks subject to temperatures between – 40 °C and + 120 °C.

NOTE It is possible that future advances in resin technology would allow tanks and vessels to be considered for operating temperatures above + 120 °C. Should such a situation arise and a manufacturer wishes to take advantage of such developments, then all other requirements of the standard shall be maintained and such tanks and vessels shall only be designed in accordance with the advanced design method given in 7.8.3.

Excluded from this European Standard are:

— tanks and vessels for the transport of fluids;

— underground storage tanks;

— spherical vessels;

— vessels and tanks of irregular shape;

— tanks and vessels with double containment;

— tanks and vessels which are subject to the risk of explosion, or failure of which may cause an emission of radioactivity;

— specification for fibre reinforced cisterns of one piece and sectional construction for the storage, above ground, of cold water (see EN 13280:2001).



# 2 Normative references

The following referenced documents are indispensable for the application 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 59, *Glass reinforced plastics — Measurement of hardness by means of a Barcol impressor*

EN 1993-1-1, *Eurocode 3: Design of steel structures — Part 1-1: General rules and rules for buildings*

EN 1993-1-2, *Eurocode 3: Design of steel structures — Part 1-2: General rules — Structural fire design*

EN 1993-1-3, *Eurocode 3 — Design of steel structures — Part 1-3: General rules — Supplementary rules for cold-formed members and sheeting*

EN 13121-1:2003, *GRP tanks and vessels for use above ground — Part 1: Raw materials — Specifications conditions and acceptance conditions*

EN 13121-2:2003, *GRP tanks and vessels for use above ground — Part 2: Composite materials — Chemical resistance*

EN 13121-4:2005, *GRP tanks and vessels for use above ground — Part 4: Delivery, installation and maintenance*

EN 13923, *Filament-wound FRP pressure vessels — Materials, design, manufacturing and testing*

EN ISO 75-2, *Plastics - Determination of temperature of deflection under load - Part 2: Plastics, ebonite and long-fibre-reinforced composites (ISO 75-2:2004)*

EN ISO 291, *Plastics - Standard atmospheres for conditioning and testing (ISO 291:2005)*

EN ISO 527-4, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites (ISO 527-4:1997)*

EN ISO 527-5, *Plastics — Determination of tensile properties — Part 5: Test conditions for unidirectional fibre-reinforced plastic composites (ISO 527-5:1997)*

EN ISO 899-1, *Plastics — Determination of creep behaviour — Part 1: Tensile creep (ISO 899-1:2003)*

EN ISO 899-2, *Plastics — Determination of creep behaviour — Part 2: Flexural creep by three-point loading (ISO 899-2:2003)*

EN ISO 1172, *Textile-glass-reinforced plastics — Prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content — Calcination methods (ISO 1172:1996)*

EN ISO 2592, *Determination of flash and fire points - Cleveland open cup method (ISO 2592:2000)*



EN ISO 3915, *Plastics — Measurement of resistivity of conductive plastics (ISO 3915:1981)*



EN ISO 7500-1, *Metallic materials —Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system (ISO 7500-1:2004)*



EN ISO 9513, *Metallic materials — Calibration of extensometers used in uniaxial testing (ISO 9513:1999)*

EN ISO 14125:1998, *Fibre-reinforced plastic composites — Determination of flexural properties (ISO 14125: 1998)*

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

ISO 4901, *Reinforced plastics based on unsaturated polyester resins — Determination of residual styrene monomer content*

## 3 Terms and definitions

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

**3.1**
**manufacturer**
the organisation that designs, manufactures and tests the vessel or tank in accordance with this European Standard

**3.2**
**purchaser**
the organisation or individual that buys the finished vessel or tank and specifies the process requirements

**3.3**
**authorised inspecting authority**
the body or organisation that may be required to check that the design, materials and construction comply with this European Standard when $PS \leq 0{,}5$bar

**3.4**
**vessel**
a closed container subject to applied pressure or vacuum, with or without hydrostatic head, including branches up to the first flanged connection

**3.5**
**tank**
a container for the storage of fluids subject only to the fluid hydrostatic head and freely vented to atmosphere, including branches up to the first flanged connection



**3.6**
**laminate**
resin reinforced with glass fibre



**3.7**
**gel coat**
a thin layer of resin on the surface of a laminate that may or not be reinforced with a glass or a synthetic fibre tissue

**3.8**
**cure**
the chemical reaction resulting in the polymerised laminate

**3.9**
**post cure**
the application of heat to take the polymerisation to a final stage

**3.10**
**maximum allowable pressure (*PS*)**
the maximum pressure for which the equipment is designed, as decided by the manufacturer

**3.11**
**differential pressure**
the difference of pressure on both sides of a component

**3.12**
**design pressure ($\rho_D$)**
the design pressure used in the calculations for a component

**3.13**
**maximum/minimum allowable temperature (*TS*)**
the maximum or minimum temperature for which the equipment is designed, decided by the manufacturer

**3.14**
**test temperature**
the temperature at which the pressure test of the equipment is carried out

**3.15**
**test pressure (*TP*)**
the pressure to which the tank or vessel is tested

## 4 Symbols and abbreviations

For the purposes of this standard, the symbols and abbreviations common to all clauses and annexes are given in Table 1.

Further symbols are defined in the relevant clauses as required.

**Table 1 — Standard symbols and abbreviations**

| Symbol | Unit | Definition |
|---|---|---|
| $A$ | mm | Distance |
| $a$ | mm | Dimension |
| $b$ | mm | Dimension |
| $d$ | mm | Diameter |
| $D$ | mm | Internal diameter of tank, vessel |
| $\Delta$ | - | Difference or additional |
| $E$ | N/mm² | Modulus of elasticity = $\frac{X}{t}$ |
| $\varepsilon$ | % | Strain |
| $F$ | - | Buckling design factor |
| $\phi$ | ° | Half the angle at the apex of the cone |
| $\Theta$ | ° | Support saddle angle |
| $g$ | m/s² | Gravity |
| $h$ | mm | Height of dished end |
| $H$ | mm | Height of cone |
| $I$ | $mm^4$ | Second moment of area |
| $k$ | - | Correction factor |
| $K$ | - | Overall design factor |
| $l$ | mm | Length |
| $L$ | mm | Overall length |

**Table 1** (*continued*)

| Symbol | Unit | Definition |
|---|---|---|
| $m$ | kg/m² | Mass per unit area |
| $M$ | Nmm | Bending moment |
| $u$ | N/mm | Unit load = load/width |
| $\nu$ | – | Poissons ratio |
| $P$ | N | Direct load |
| $p$ | $N/mm^2$ | Pressure |
| $Q$ | N | Shear load |
| $r$ | mm | Knuckle radius |
| $R$ | mm | Radius |
| $\rho$ | kg/m³ | Density of liquid |
| $\sigma$ | N/mm² | Load = $\frac{U}{t}$ and $\frac{q}{t}$ |
| $t$ | mm | Thickness |
| $\tau$ | N/mm² | Shear load |
| $T$ | °C | Temperature |
| $TS$ | °C | Design temperature |
| all. $U_{lam}$ | N/mm | allowable unit load for the laminate |
| $U$ | N/mm per kg/m² glass | Ultimate tensile unit strength of the laminate (UTUS) |
| $V$ | m³ | Volume |
| $W$ | kg | Weight |
| $\chi$ | – | Coordinate in axial direction |
| $X$ | N/mm | Unit modulus = Load/width x strain |
| $X_i$ | N/mm per kg/m² glass | Unit tensile-modulus of the lamina per kg/m² glass |
| $q$ | N/mm | Applied unit load |

**Table 1** (*continued*)

| **Abbreviations** | | |
|---|---|---|
| CSM | - | Chopped strand mat |
| ECTFE | - | Ethylene-chlorotrifluoroethylene copolymer |
| all. | - | Allowable |
| FEP | - | Fluorinated ethylene-propylene copolymer |
| FU | - | Furane |
| FW | - | Filament winding |
| HDT | °C | Heat deflection temperature |
| IRHD | ° | International rubber hardness |
| ln | | Natural logarithm |
| PF | - | Phenolic |
| PFA | - | Perfluoro-alkoxy copolymer |
| PP-B | - | Polypropylene, block polymer |
| PP-H | - | Polypropylene, homopolymer |
| PP-R | - | Polypropylene, random polymer |
| PVC-U | - | Polyvinyl chloride, unplasticised |
| PVDF | - | Polyvinylidene fluoride |
| UP | - | Unsaturated polyester |
| VE | - | Vinyl ester |
| WR | - | Woven rovings |
| CRL | - | Chemical Resistant Layer, see EN 13121-2 |
| VL | - | Veil Layer, see EN 13121-2 |
| TPL | - | Thermoplastics Liner, see EN 13121-2 |
| Supp. | - | Support |
| lam | - | Laminate |
| S.G | - | Specific Gravity (Relative Density) |
| O.D | - | Outside Diameter |
| I.D | - | Inside Diameter |