# SLOVENSKI STANDARD
# SIST-TP CEN/TR 14585-3:2018

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**Valoviti kovinski cevni sestavi v tlačnih cevovodih - 3. del: Metode načrtovanja**

Corrugated metal hose assemblies for pressure applications - Part 3: Design methods

Gewellte Metallschlauchleitungen für Druckanwendungen - Teil 3: Auslegungsverfahren

Tuyauteries métalliques flexibles onduleuses pour applications sous pression - Partie 3: Méthode de conception



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TECHNICAL REPORT

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# CEN/TR 14585-3

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# Corrugated metal hose assemblies for pressure applications - Part 3: Design method

Tuyauteries métalliques flexibles onduleuses pour applications sous pression - Partie 3: Méthode de conception

Gewellte Metallschlauchleitungen für Druckanwendungen - Teil 3: Auslegungsverfahren

This Technical Report was approved by CEN on 25 September 2017. It has been drawn up by the Technical Committee CEN/TC 342.

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## European foreword

This document (CEN/TR 14585-3:2017) has been prepared by Technical Committee CEN/TC 342 “Metal hose, hose assemblies, bellows and expansion joints”, the secretariat of which is held by SNV.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

# Introduction

Technical Committee CEN/TC 342 “Metal hose, hose assemblies, bellows and expansion joints” is carrying out a revision of EN 14585-1:2006 and CEN/TR 14585-2:2006 to include calculation methods for the combined structure of hose and braid for:

— pressure resistance;

— fatigue life;

— allowable displacements.

The selection of materials for corrosive environments and the calculation of fluid pressure drops are also being included.

It is appreciated that these studies are ambitious and will involve much new analyses so that this revision will take some time.

Whilst continuing to work on this revision, CEN/TC 342 decided that the key aspects of the calculation method should be circulated as an informative Technical Report CEN/TR 14585-3, which is limited to the pressure resistance of the combined structure of hose and braid. This approach will enable manufacturers and Notified Bodies to use and gain experience of the calculation method and any feedback can be taken into account in the revision of EN 14585, harmonized to the Pressure Equipment Directive 2014/68/EU.

# 1 Scope

This Technical Report provides guidance on the design of corrugated metal hose assemblies for pressure applications, i.e. maximum allowable pressure PS greater than 0,5 bar. Allowable stresses are consistent with the requirements of the Pressure Equipment Directive 2014/68/EU.

# 2 Normative references

Not applicable.

# 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 7369 and the following apply.

**3.1**
**metal hose assembly**
assembly of a corrugated metal hose with its end fittings

Note 1 to entry: In the context of Pressure Equipment Directive [1], a metal hose assembly is a component of piping and not a PED assembly.

**3.2**
**maximum allowable pressure PS**
maximum pressure for which the metal hose assembly is designed



**3.3**
**maximum/minimum allowable temperature TS**
maximum and minimum temperature for which the metal hose assembly is designed



**3.4**
**nominal pressure PN**
dimensionless alphanumerical designation which is a convenient rounded number commonly used for reference purposes of piping components and stock parts; for this Technical Report PN represents the maximum allowable pressure at 20 °C as specified by the metal hose assembly manufacturer

**3.5**
**test pressure PT**
pressure at which the pressure metal hose assembly is pressure tested (normally at ambient temperature)

**3.6**
**main pressure bearing parts**
parts, such as corrugated metal hose, braid, pipe ends, the failure of which may result in a sudden discharge of pressure energy

**3.7**
**pressure bearing parts**
parts, such as swivel nuts, flanges, threaded fittings, that are not main pressure bearing parts defined in 3.6 and the failure of which may not lead to a sudden discharge of pressure energy

**3.8**
**attachments to pressure parts**
parts, such as ferrules, that are directly welded to parts defined in 3.6 or 3.7

**3.9**
**other parts**
parts, such as external protection, anti-kink device, braid protecting spiral, which are not parts according to 3.6 to 3.8

**3.10**
**equipment manufacturer**
natural or legal person responsible for the values of the parameters PS and TS

Note 1 to entry: This may be the manufacturer or planner of the piping for which the metal hose assembly is designed.

**3.11**
**hose manufacturer**
natural or legal person responsible for the design and the manufacturing of the corrugated metal hose and/or the metal hose assembly

**3.12**
**hydraulic forming (longitudinal welded)**
corrugating a tube by pressurizing the inside against external tooling which allows this corrugated tube to be axially shortened during the process

**3.13**
**roll forming (longitudinal welded)**
corrugating a tube by rolling from the outside to the inside and allowing or forcing this corrugated tube to be axially shortened during the process



**3.14**
**helical crest welded (resistance welded)**
profiling a strip, rolling it over helically and finally welding the overlaps



**3.15**
**strand**
group of parallel wires used for plain braid or wires woven together to form a braided strand

**3.16**
**braided braid**
braid that is manufactured from previously braided strands

## 4 Symbols and abbreviations

For the purposes of this document, the symbols listed in Table 1 apply.

**Table 1 — Symbols**

| Symbol | Description | Unit |
|---|---|---|
| $A$ | elongation at rupture according to EN ISO 6892–1 | % |
| $A_c$ | cross sectional metal area of one corrugation; see Formula (3a) and 3b) | mm² |
| $A_e$ | hose effective area; see Formula (5) | mm² |
| $a_w$ | Braid wire cross section; see Formula (29) | mm² |
| $b_c$ | width of corrugation crest; see Figures 2 a) and 2 b) | mm |

| Symbol | Description | Unit |
|---|---|---|
| $b_n$ | nominal width of material (strip) according to EN ISO 9445-1 | mm |
| $b_r$ | width of corrugation root; see Figures 2 a) and 2 b) | mm |
| $b_s$ | width of a strand; see Figure 4 | mm |
| $C_1$, $C_2$ | factors used to determine the calculation coefficients $C_p$, $C_f$, $C_d$; see Formulae (6) and (7) | — |
| $C_B$ | braid coverage; see Formula (38) | — |
| $C_p$, $C_f$, $C_d$ | calculation coefficients (see Annex A) | — |
| $c_{st}$ | stacking factor for crossing braid wires and strands; see Formula (26) | — |
| $D_i$ | inside diameter of the corrugated metal hose; see Figures 2 a) and 2 b) | mm |
| $D_m$ | mean diameter of the corrugated metal hose; see Formula (8) | mm |
| $D_o$ | outside diameter of the corrugated metal hose; see Formulae (9a) and (9b) | mm |
| $d_w$ | diameter of the braid wire; see Figure 4 | mm |
| $d_B$ | mean diameter of a braid layer; see Formula (30) | mm |
| $E$ | modulus of elasticity of hose material at room temperature | N/mm² (MPa) |
| $E_t$ | modulus of elasticity of hose material at design temperature | N/mm² (MPa) |
| $e$ | nominal thickness of hose material; see Figures 2 a) and 2 b) | mm |
| $e_p$ | nominal thickness of one ply | mm |
| $e^*$ | equivalent wall thickness, corrected for thinning during forming; see Formula (11) | mm |
| $e_p^*$ | equivalent thickness of one ply with thinning correction; see Formulae (10a) and (10b) | mm |
| $F_p$ | force due to pressure effect (pressure thrust); see Formula (12) | N |
| $f$ | allowable general membrane stress at design temperature; see Table 7 | N/mm² (MPa) |
| $f_T$ | allowable general membrane stress at test conditions; see Table 7 | N/mm² (MPa) |
| $G_\sigma$ | degree of load; see 5.5 and Formula (1) | — |
| $h_s$ | thickness of a strand; see Formula (27) | mm |
| $K_{ax(1)}$ | axial spring rate of one corrugation; see Formula (21) | N/mm |
| $K_f$ | forming factor; see Formulae (18) and (19) | — |
| $k_\Theta$ | reduction factor for circumferential stress due to braid; see Formula (32) | — |
| $k_{p,t}$ | derating factor for the pressure at operating temperature $t$ ; see 6.3 | — |
| $l_B$ | axial pitch of the braid; see Figure 4 and Formula (24) | mm |
| $l_c$ | active corrugated length of a metal hose | mm |
| $n_p$ | number of plies of a corrugated metal hose | — |
| $n_s$ | number of braid strands | — |

| Symbol | Description | Unit |
|---|---|---|
| $n_w$ | number of wires in one braid strand | — |
| $P_{1,0}$ | pressure resulting in an initial remaining (plastic) elongation of 1 %; see Formula (22) | N/mm² (MPa) |
| $P_{m,b}$ | primary meridional bending stress | N/mm² (MPa) |
| $P_{m,m}$ | primary meridional membrane stress | N/mm² (MPa) |
| $P_\Theta$ | primary circumferential stress | N/mm² (MPa) |
| PS a | maximum allowable pressure | N/mm² (MPa) |
| PT | test pressure | bar |
| $P_{t,\,max}$ | maximum allowable pressure at operating temperature $t$; see Formula (2) | bar |
| $q$ | corrugation length; see Figures 2 a) and 2 b) | mm |
| $R_1$ *to* $R_4$ | bend radii of hose assemblies; see Table 5 | mm |
| $R_{eH,\,t}$ | minimum specified value of upper yield strength at design temperature | N/mm² (MPa) |
| $R_{m,\,t}$ | minimum specified value of tensile strength at design temperature | N/mm² (MPa) |
| $R_{m,\,20}$ | minimum specified value of tensile strength at room temperature | N/mm² (MPa) |
| $R_{p\,0,2,\,t}$ | minimum specified value of 0,2 % proof strength at design temperature | N/mm² (MPa) |
| $R_{p\,1,0,\,t}$ | minimum specified value of 1 % proof strength at design temperature | N/mm² (MPa) |
| $r_m$ | mean radius of torus at crest and root of U-shaped corrugations; see Figures 2 a) and 2 b) and Formulae (4a) and (4b) | mm |
| $t$ | operating temperature | °C |
| $t_n$ | nominal thickness of the material (strip) | mm |
| $w$ | corrugation height, see Figures 2 a) and 2 b) and Formula (13) | mm |
| $\alpha$ | initial braid angle; see Figure 4 and Formula (25) | degree or radian |
| $\beta_0$ | initial side wall angle of the corrugation; see Figure 3 and Formula (14) | degree |
| $\Delta l_{el}$ | elastic hose elongation due to pressure; see Formula (20) | mm |
| $\Delta l_{pl}$ | plastic hose elongation due to pressure; see Formula (46) | mm |
| $\eta$ | load carrying efficiency of braid layer; see 7.3.2.4 | - |
| $\lambda$ | relative plastic elongation; see Formula (46) | - |
| $\nu$ | value of Poisson's ratio for stainless steel of 0,3 | - |
| $\sigma\,(P)$ | stress depending on $P$ | N/mm² (MPa) |
| $\sigma_w$ | longitudinal stress in the braid wire; see Formula (39) | N/mm² (MPa) |

| | |
|---|---|
| Subscripts: | o outside |
| 0 initial | p ply |
| B braid | pl plastic |
| H hose | r root |

| Symbol | Description | Unit |
|---|---|---|
| *t* test condition | t temperature | |
| b bending or burst condition | w wire | |
| c corrugation or crest | Δ difference | |
| el elastic | λ relative elongation | |
| i inside or running index | Θ circumferential | |
| m membrane, meridional or mean | Σ sum | |
| n number of or upper summation index | | |
| a All pressures for calculation purpose are in N/mm² (MPa). | | |

# 5 Materials

## 5.1 General requirements

Materials for the manufacture of hose assemblies including filler metal should be selected on the basis of their suitability for fabrication, e.g. forming, joining, and for the conditions under which they will be used.

When combining different materials, special care should be taken regarding compatibility with each other.



## 5.2 Suitable materials

Materials suitable for hoses assemblies are given as follows:



a) materials suitable for corrugated metal hoses and their temperature limits are given in Table 2;

b) materials suitable for braid, fittings, and additional parts are given in Table 3.

**Table 2 — Materials for corrugated metal hoses and their temperature limits**

| Material | | | Temperature °C | | Document |
|---|---|---|---|---|---|
| Type | Number | Steel name | Minimum | Maximum | |
| stainless austenitic steels | 1.4306 | X2CrNi19–11 | – 273 a | 550 | EN 10028–7 |
| | 1.4401 | X5CrNiMo17–12–2 | – 196 a | 550 | |
| | 1.4404 | X2CrNiMo17–12–2 | – 273 a | 550 | |
| | 1.4435 | X2CrNiMo18–14–3 | – 273 a | 550 | |
| | 1.4539 | X1NiCrMoCu25–20–5 | – 196 a | 550 | |
| | 1.4541 | X6CrNiTi18–10 | – 273 a | 550 | |
| | 1.4547 | X1CrNiMoCuN20–18–7 | – 196 a | 500 | |
| | 1.4571 | X6CrNiMoTi17–12–2 | – 273 a | 550 | |
| heat resistant austenitic steels | 1.4876 | X10NiCrAlTi32–21<br>X10NiCrAlTi32–21 (H) | – 196 | 600<br>900 b | EN 14917, B (2.1)<br>EN 14917, B (2.2) |

| Material | | | Temperature °C | | Document |
|---|---|---|---|---|---|
| Type | Number | Steel name | Minimum | Maximum | |
| Nickel alloys | 2.4360 | NICu30Fe | – 196 | 425 | EN 14917, B (3) |
| | 2.4610 | NiMo16Cr16Ti | – 196 | 400 | EAM-0526–28 |
| | 2.4816 | NiCr15Fe | – 10<br>(– 273) | 450<br>(900) [b] | EAM-0526–43–1, EAM-0526–43–2<br>EN 14917:2009+A1: 2012, Annex J |
| | 2.4819 | NiMo16Cr15W | – 196 | 400 | EAM-0526–18 |
| | 2.4856 | NiCr22Mo9Nb | – 196<br>(– 273) | 450<br>(900) [b] | EAM-0526–40<br>EN 14917:2009+A1: 2012, Annex J |
| | 2.4858 | NiCr21Mo | – 10 | 540 | EN 14917, B (4) |
| Copper | CW024A | Cu-DHP (R200) | - 180 | 250 | EN 1652 [c] |
| Copper alloy | CW452K | CuSn6 (R350) | - 250 | 500 | |
| | CW503L | CuZn20 (R270) | - 200 | 300 | |
| | CW508L | CuZn37 (R300) | - 200 | 500 | |

[a] Minimum temperature in accordance with EN 13445–2 / Annex B or EN 13480–2 / Annex B.

[b] Special care should be exercised due to the risk of embrittlement when using the materials at elevated temperatures above 550 °C.

[c] Copper and copper alloys for general purpose (not harmonized to PED); Particular Material Appraisals (PMA) are necessary for applications within the scope of the PED.



**Table 3 — Materials for braid, fittings, ferrules, and additional parts**

| Component | Material No | | Document |
|---|---|---|---|
| **Pressure parts** | | | |
| Braid | 1.4301, 1.4306, 1.4401, 1.4404, 1.4541, 1.4571 | | EN 10088–3 |
| | 1.4876, 2.4360, 2.4816, 2.4819, 2.4856, 2.4858 | | Table 2 |
| | Cu-based material: CW450K, CW452K, CW508L | | EN 12166 [a] |
| Fixed flange, Weld collar, Floating flange [b] | Carbon steel | forged | EN 10222–2 and –3 |
| | | flat products | EN 10028–2 |
| | 1.4301, 1.4306, 1.4401, 1.4404, 1.4541, 1.4571 | | EN 10222–5, EN 10028–7 |
| | 1.4876, 2.4360, 2.4816, 2.4819, 2.4856, 2.4858 | | Table 2 |
| | Cu-based material: | CW024A | EN 1653+A1 |