SLOVENSKI STANDARD
SIST EN 13445-3:2014/A5:2018

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Neogrevane (nekurjene) tlačne posode - 3. del: Konstruiranje - Dopolnilo A5

Unfired pressure vessels - Part 3: Design

Unbefeuerte Druckbehälter - Teil 3: Konstruktion

Récipients sous pression non soumis à la flamme - Partie 3 : Conception

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Unfired pressure vessels - Part 3: Design

Récipients sous pression non soumis à la flamme - Partie 3 : Conception

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This amendment A5 modifies the European Standard EN 13445-3:2014; it was approved by CEN on 4 June 2018.

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

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European foreword

This document (EN 13445-3:2014/A5:2018) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by May 2019, and conflicting national standards shall be withdrawn at the latest by May 2019.

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

1 Modification to 5.4.2, Vessels of all testing groups, pressure loading predominantly of non-cyclic nature

Replace the whole subclause with the following one:

“

5.4.2 Vessels of all testing groups, pressure loading predominantly of non-cyclic nature

The DBF requirements specified in Clauses 7 to 16, Annexes G and J, and in Clause 19 (for testing sub-groups 1c and 3c only) and the DBA requirements of Annex B and Annex C provide satisfactory designs for pressure loading of non-cyclic nature, i.e. when the number of full pressure cycles or equivalent full pressure cycles is less than or equal to 500.

$$n_{\mathrm{eq}} \leq 500 \tag{5.4-1}$$

The equivalent number of full pressure cycles n_{eq} is given by:

$$n_{\mathrm{eq}} = \sum n_{\mathrm{i}} \cdot \left(\frac{\Delta P_{\mathrm{i}}}{P_{\mathrm{max}}} \right)^{3} \tag{5.4-2}$$

In the above equation, P_{max} is the maximum permissible pressure P_{max} calculated for the whole vessel (see 3.16) in the normal operating load case (see 5.3.2.1).

For simplification, P_{max} may be replaced by the calculation pressure P_{c}.

NOTE The value of 500 equivalent full pressure cycles is only a rough indication. It can be assumed that for components with irregularities of profile, strongly varying local stress distributions, subjected to additional non-pressure loads, fatigue damage can occur before 500 cycles.

Cyclic thermal loads can be neglected if:

— for start-up and shutdown cycles, the number shall not exceed 2 000 and the rate of temperature change at the surface shall be less than 60 °C per hour for ferritic steel sections. The designer can specify a higher rate of surface temperature change based on favourable/good industry experience and practice;

— if the requirements of Annex U are satisfied for operating conditions.

If these conditions on pressure and thermal loads are met, then no fatigue analysis is necessary and the standard requirements of non-destructive testing given in EN 13445-5 shall be applied.

If these conditions cannot be met, then a fatigue assessment is necessary according to either Clause 17 or Clause 18.”.

2 Modifications to Clause 6, Maximum allowed values of the nominal design stress for pressure parts

In 6.1.3 delete the following:

“For testing group 4 vessels, the maximum value of the nominal design stress for the normal operating load cases shall be multiplied by 0,9.”.

In Table 6-1, delete the following Footnote [a]:

"[a] For testing group 4 the nominal design stress shall be multiplied by 0,9.”;

and re-name the following footnotes accordingly.

3 Modifications to 17.1, Purpose

Replace the whole subclause with the following one:

"

17.1.1 This clause specifies:

— an alternative to the 500 cycles rule stated in 5.4.2 for vessels predominantly subjected to pressure fluctuations,

— a substitute to the 500 cycles rule stated in 5.4.2 for vessels subjected additionally to thermal gradient fluctuations, and

— rules for the simplified assessment of fatigue damage due to both pressure and thermal gradients fluctuations.

NOTE The rules in this clause are based on simplified and conservative assumptions. More precise, less conservative results will usually be obtained by application of Clause 18.".

In 17.1.2, replace the first sentence with the following one:

"

17.1.2 Other cyclic loads, e.g. due to variation of external loads, are normally to be assessed according to Clause 18. However, it is permitted to take non-pressure cyclic loads into account in this clause by:".

In 17.1.2, replace the NOTE with the following one:

"

NOTE This clause gives information for estimating the stress ranges due to pressure and thermal loads only. When other loads are taken into account, the determination of the corresponding stress ranges is under the responsibility of the Manufacturer.".

4 Modifications to 17.2, Specific definitions

Replace Definition 17.2.7 by the following:

"

17.2.7

equivalent number of full pressure cycles

number n_{eq} of full pressure cycles that cause the same damage as all the applied cycles of various sources and ranges

Note 1 to entry: For pressure loading only, n_{eq} is given by Formula (17.5–1).

Note 2 to entry: For pressure + thermal loading, n_{eq} is given by Formula (17.5–4).".

Replace Definition 17.2.9 by the following:

“

17.2.9

range

value from maximum to minimum (stress or load) in the cycle (twice the amplitude)”.

Replace Definition 17.2.10 by the following:

“

17.2.10

pseudo-elastic stress

stress calculated assuming purely linear elastic material behaviour”.

Replace Definition 17.2.13 by the following:

“

17.2.13

pressure stress factor

factor for determination of the maximum structural stress that may occur under pressure loading in a vessel detail, due to the geometrical configuration of component(s)”.

Add the following new definitions after Definition 17.2.13:

“

17.2.14

thermal stress factor

factor for determination of the maximum structural stress that may occur under some thermal gradient type in a vessel detail, due to the geometrical configuration of component(s)

17.2.15

adjacent point

point to be considered for determination of the metal temperature difference on which thermal stresses are estimated.

Note 1 to entry: They are defined as any two points:

— on the inside and outside surfaces, for a gradient through the thickness;

— along the surface within a distance $1{,}75\sqrt{D \cdot e}$ for a gradient along the longitudinal and/or circumferential directions of a shell;

— along the surface within a distance $3{,}5R$, for a gradient along the longitudinal and/or circumferential directions of a flat end, where R is the radius of the point at the highest temperature in the flat end.

17.2.16

metal temperature difference between adjacent points

temperature difference between adjacent points, determined by reference to the metal temperature at these points (not the fluid temperature at these points)

17.2.17

theoretical stress concentration factor

ratio of notch stress, calculated on purely elastic basis, to structural stress at same point".

Change accordingly the numbering for Definitions 17.2.14 to 17.2.17.

Replace Definitions 17.2.16 (to be renumbered as 17.2.20) with the following one:

"

17.2.20

critical area

area where the total cumulative fatigue damage (usage factor) exceeds the value D_{max} = 0,5".

5 Modification to 17.3, Specific symbols and abbreviations

Replace the whole table with the following one:

"

Symbol	Description	Unit
C	fatigue class C (see Table 17–4)	MPa
C_{min}	lowest fatigue class C (see 17.5.4.1)	MPa
N_{eq}	allowable number of full pressure cycles	
D	total fatigue damage index, see Formula (17.7–1)	
D_{max}	maximum allowable value of total fatigue damage index in non-critical areas	
C_e	correction factor to account for influence of wall thickness on fatigue resistance	
C_T	correction factor to account for influence of temperature on fatigue resistance	
E	Young's modulus of the material	MPa
K_f	effective stress concentration factor	
K_t	theoretical stress concentration factor	
k	number of pressure ranges which together form the loading specification	
N	allowable number of cycles obtained from the relevant fatigue design curve (suffix i refers to number for i^{th} stress range, $i = 1,...k$)	
n	number of applied stress cycles (suffix i refers to number for i th stress range, $i = 1,...q$)	

Symbol	Description	Unit
n_{eq}	equivalent number of full pressure cycles	
n_P	number of applied pressure cycles (suffix *i* refers to number for *i* th pressure range, $i = 1,...q_i$)	
n_T	number of applied cycles of temperature difference (suffix *j* refers to number for *j* th range of temperature difference, $k = 1,...q_k$)	
n_{PT}	number of applied cycles of combined pressure + temperature difference (suffix *k* refers to number for *k* th range of pressure + temperature difference, $k = 1,...q_k$)	
R	radius of the point at the highest temperature in the flat end	mm
r	transition radius at junction of walls	mm
T_{diff}	metal temperature difference between adjacent points (see 17.2.15)	°C
T_{min}	minimum operating temperature during a cycle	°C
T_{max}	maximum operating temperature during a cycle	°C
T^*	assumed mean cycle temperature	°C
u	ovality (of circular cross section of a vessel)	
α	thermal expansion coefficient of the material	(°C)-1
δ	parameter for measure of misalignment, peaking or flat	mm
ΔP	pressure range calculated from the algebraic difference of the maximum and minimum pressures which apply in the cycle under consideration. Vacuum and other external pressures stress shall be considered negative NOTE In that case, some cycles may have a range ΔP greater than the maximum calculation pressure P_{max} of the vessel or part thereof.	MPa
ΔT	range of metal temperature difference between adjacent points (adjacent points are defined at 17.2.15)	°C
$\Delta\sigma$	pseudo-elastic stress range	N/mm²
$\Delta\sigma^*$	fictitious stress range for insertion into the fatigue design curves	N/mm²
$\Delta\sigma_R$	reference stress range of fatigue design curves	N/mm²
$\Delta\sigma_D$	endurance limit at constant stress range	N/mm²
$\Delta\sigma_{Cut}$	cut-off limit	N/mm²
κ	thermal stress factor for a vessel detail, given in Table 17–2	
η	pressure stress factor for a vessel detail, given in Table 17–1	
η_{max}	maximum pressure stress factor found throughout the vessel	
NOTE	The pressure P_{max} used in Clause 17 is defined in 3.16, NOTE 3.	

”.

6 Modifications to 17.4, Conditions of applicability

Replace the Subclause 17.4.1 with the following one:

“

17.4.1 This clause applies to pressure-bearing components and junctions of pressure vessels designed in accordance with Clauses 7 to 16 without Clause 15, Clauses 20 and 21 and Annex G (i.e. those clauses and annexes where design by formula applies), with the exception of:

— bellows;

— heat exchanger tubesheets.

NOTE 1 Fatigue assessment of heat exchanger tubesheets can be performed using Annex J of this Standard.

Application of this clause to jacketed vessels is permitted if subjected to pressure cycles only. For jacketed vessels subjected to both pressure and thermal cycles, application is limited to the non-jacketed parts.

NOTE 2 It is not necessary to check flanges and their bolts if the adjacent shells are designed according to this Clause.

It is assumed that the vessels have been designed, manufactured and tested in accordance with all other requirements of this standard.”.

Replace Entry 17.4.4 with the following one:

“

17.4.4 This clause applies only to components operating below the creep range. Thus, the fatigue design curves are applicable up to 375 °C for ferritic steels and 425 °C for austenitic steels.”.

Replace Entry 17.4.5 with the following one:

“

17.4.5 As regards weld defects:

For application of this clause, the following conditions (as required by EN 13445-5:2014, Annex G) shall be met in addition to the general acceptance criteria for weld imperfections given in EN 13445-5:2014:

— no undercut,

— no root concavity,

— no lack of penetration for full penetration welds, except as permitted by Table 17-4,

— 100 % inspection, visually and by NDT, with acceptance criteria as specified in EN 13445-5:2014, Annex G, of all critical areas.”.

Replace Entry 17.4.8 with the following one:

“

17.4.8 Vessels which fulfil the requirements of 17.5.3 or 17.5.4 or 17.5.5 are of non-cyclic nature and the standard requirements of non-destructive testing given in EN 13445-5 shall be applied.”.

Add the following new numbered entries:

“

17.4.9 For application of 17.6, instructions for appropriate maintenance shall be included in the operating instructions.

NOTE Recommendations on appropriate maintenance are given in Annex M.

17.4.10 Guidance for metal temperature estimates:

For cases where significant thermal loading occurs, attention is drawn to the importance of approximating as closely as possible the temperature distributions that appear in the vessel walls during service, in order to reduce as much as possible the conservatism of the thermal stress estimate and resulting fatigue assessment.

In this respect, the quite common approach which consists in taking the fluid temperature variations as representative of the temperature variations of the vessel wall surface is not recommended because it generally leads to strong over-estimates of the real thermal gradients. As far as possible these gradients should be determined from thermal calculations (even simple ones based on analytic models) in which the thermal exchange which takes place at the fluid-metal interface is taken into account.

To enable such calculations, enough information on the thermodynamic conditions attached to the process should be obtained from the Purchaser (e.g.: fluid heating or cooling rate, thermal exchange coefficient at fluid-metal interface, etc.).”.

7 Modification to 17.5, General

Replace the whole subclause with the following one (Figures 17.5-1, 17.5-2 and 17.5-3 are thereby deleted):

“

17.5 General

17.5.1 Pressure and temperature ranges to be considered for the fatigue assessment:

The various ranges $(\Delta P)_i$ to be considered for the fatigue assessment shall be obtained by applying a cycle counting method described in Annex NB and considering fluctuations of the pressure P instead of fluctuations of stress.

The various $(\Delta T_{diff})_i$ to be considered for the fatigue assessment shall be obtained by applying the same cycle counting methods but considering fluctuations of the metal temperature difference T_{diff} instead of fluctuations of stress.

To distinguish whether the pressure and the thermal cycles act simultaneously or not simultaneously the load history (variation with time) of the both loads shall be considered. When the duration time of the cycle (time from minimum value via maximum value to minimum value) from one load type (e.g. pressure) is overlapped with the duration time of the other load type (e.g. temperature differences) then these cycles act simultaneously. On the contrary, if during the complete cycle time of one load type the other load type does not change then the cycles act not simultaneously.

The ΔP ranges are normally valid for assessment of all vessel parts subjected to the same pressure fluctuations. In case where pressure fluctuations result (at least partly) from hydrostatic pressure or from pressure differences between adjacent vessel chambers, the pressure ranges may be different from part to part.