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Unfired pressure vessels - Part 3: Design

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Unfired pressure vessels - Part 3: Design

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

Unbefeuerte Druckbehälter - Teil 3: Konstruktion

This draft amendment is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 54.

This draft amendment A1, if approved, will modify the European Standard EN 13445-3:2002. If this draft becomes an amendment, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for inclusion of this amendment into the relevant national standard without any alteration.

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

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Contents

Foreword

This document (EN 13445-3:2002/prA1:2004) 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 mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

5.1 General

In 5.1 change to:

The requirements in Part 3 shall apply when the materials and welds are not subject to localized corrosion in the presence of products which the vessel is to contain.

5.3.3 Failure modes considered in this Part

Add

f) creep rupture

g) creep deformation

h) creep fatigue

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

Change the beginning of the first paragraph to:

The requirements specified in clauses 7 to 16 and in clause 19 (DBF) provide satisfactory ...

In 5.4 change the heading 5.4.4 to:

5.4.4 Vessels of testing group 1, 2, and 3, working below the creep range, pressure loading predominantly of cyclic nature

In 5.4 add:

5.4.5 Vessels of testing group 1, working in the creep range, pressure loading predominantly of cyclic nature

The rules of Annex B shall be used.

5.7.1 General requirements

In 5.7.1 third bullet replace third bullet by:

— applicable testing groups. For vessels or parts designed by Design by Analysis – Direct Route testing group 1 only shall be used. For vessels or parts working in the creep range testing group 1 shall be used.

Replace the last sentence by:

Annex A gives requirements and recommendations for pressure bearing welds. Specific requirements are included when Design by Analysis – Direct Route is used. The same requirements apply for vessels working in the creep range.

In 6.1.1 add at the end of the first paragraph

The values to be used within the creep range are given in clause 19

19 Creep design

19.1 Purpose

This clause is for the design of vessels or vessel parts in the creep range. It may be applied for pressure and mechanical loading.

This clause is currently limited to sufficiently ductile materials, like the whole standard, but it is, for components operating in the creep range, also limited to sufficiently creep ductile materials, as defined in Part 2.

19.2 Specific definitions

period
duration of a load case with constant loading and constant temperature inside the creep range.

NOTE: All individual intervals of time with identical creep conditions (same temperature and same applied loading) occurring separately during the vessel life should be grouped to form a unique period.

single creep load case
case where only one period occurs in the whole lifetime of the vessel.

multiple creep load case
case where more than one period occur in the whole lifetime of the vessel.

monitoring
continuous recording and bookkeeping of pressure, temperature and deformation versus time (See Annex M)

19.3 Specific symbols and abbreviations

n is the total number of periods of f_{Fi}, t_{i}.

SF_{c} is the safety factor for mean creep rupture strength (see 19.5.1 and 19.5.2)

$S_{\mathrm{P1,0}/T/t}$ is the mean 1% creep strain limit at lifetime T and calculation temperature t

$S_{\mathrm{R}/T/t}$ is the mean creep rupture strength at lifetime T and calculation temperature t

NOTE: The creep rupture strengths given in harmonised materials standards are always mean values. If minimum values are given instead of mean values the conventional mean values can be calculated as 1,25 times the minimum values.

t is the calculation temperature in °C

T is the specified lifetime in hour of the pressure vessel (see 19.4)

T_i is the duration (h) of the ith period, during which the fictitious design stress f_{Fi} acts at the calculation temperature t_{i}.

$T_{\mathrm{D},f_{\mathrm{Fi}},t_{\mathrm{i}}}$ is the allowable time (h) to damage (caused by creep rupture or creep strain) for the material at fictitious design stress f_{Fi} and temperature t_{i}, taken from the creep design curve or formula (19-11) respectively.

$T_{\mathrm{P},f_{\mathrm{Fi}},t_{\mathrm{i}}}$ is the allowable time (h) to creep overstrain for the material at fictitious design stress f_{Fi} and temperature t_{i} calculated according to formula (19-20).

$T_{\mathrm{R},f_{\mathrm{Fi}},t_{\mathrm{i}}}$ is the allowable time (h) to creep rupture for the material at fictitious design stress f_{Fi} and temperature t_{i} calculated according to formula (19-12).

f_{Fi} is the fictitious nominal design stress for creep design of the ith period, as defined in 19.8.2.

$f_{\mathrm{non\text{-}creep}}$ is the nominal design stress outside the creep range according to clause 6

z_{creep} is the weld creep strength reduction factor, as defined in19.6.

19.4 Design in the creep range

This sub-clause applies for the design by formula in Part 3 clauses 1 to 16:

— When a single creep load case only occurs during the vessel life: the design procedure described in 19.8.1 shall be used. This procedure is based on use of the nominal design stress defined in 19.5. For determination of that nominal design stress, the lifetime T = 100.000 h shall be used if no lifetime T is specified.

— When multiple creep load cases occur during the vessel life: the design procedure based on cumulative damage described in 19.8.2 shall be used. Alternatively, a simplified and conservative design may also be made, using the procedure described in 19.8.1, replacing the various applied creep load cases by a unique one whose temperature shall be the highest among all individual creep load cases and whose duration shall be the total of that of all individual creep load cases.

In both procedures, the weld joint factor according to 19.6 and the creep weld strength reduction factor according to 19.7 shall be used.

19.5 Nominal Design stress in the creep range

19.5.1 Case where no lifetime monitoring is provided

$$f = \min\left\{ f_{\mathrm{non-creep}} ; \frac{S_{\mathrm{R}/T/t}}{SF_{\mathrm{c}}} ; S_{\mathrm{P1,0}/T/t} \right\} \qquad (19\text{-}1)$$

where:

$SF_{\mathrm{c}} = 1{,}5$

If no (short time) yield strength ($R_{\mathrm{p0,2}}$ or $R_{\mathrm{p1,0}}$) is available for $t > t_{\mathrm{H}}$ in the material standard the following extrapolation formula may be used.

$$R_{\mathrm{p}}(t) = \min\left\{ R_{\mathrm{p}}(t_{\mathrm{H}}) \cdot \sqrt{\frac{t - t_{\mathrm{L}}}{t_{\mathrm{H}} - t_{\mathrm{L}}} - \left(\frac{R_{\mathrm{p}}(t_{\mathrm{L}})}{R_{\mathrm{p}}(t_{\mathrm{H}})} \right)^2 \cdot \frac{t - t_{\mathrm{H}}}{t_{\mathrm{H}} - t_{\mathrm{L}}}} ; R_{\mathrm{p,4th-degree-polynom}} \right\} \qquad (19\text{-}2)$$

where:

t_{H} is the highest temperature for which yield strength is available

t_{L} is the temperature lower than t_{H} (recommended $t_{\mathrm{L}} = 0{,}5 \cdot t_{\mathrm{H}}$)

$R_{\mathrm{p,4th-degree-polynom}}$ is the short time yield strength R_{p} at temperature determined by a 4-th degree polynomial regression using all yield strength-temperature pairs given in the material standard.

19.5.1.1 Case where material creep characteristics are available for the specified lifetime but not for the calculation temperature

In the case where for the calculation temperature t no mean creep rupture strength or no mean 1% creep strain limit is available in the harmonised materials standard, the interpolation formulae (19-3), (19-4) or (19-5), (19-6) respectively may be used (or the value in the harmonised materials standard for the higher temperature may be used as a conservative value) to determine the appropriate creep characteristics:

19.5.1.1.1 Mean creep rupture strength

$$S_{\mathrm{R}/T/t} = \frac{S_{\mathrm{R}/T/t_1} \cdot (t_2 - t) + S_{\mathrm{R}/T/t_2} \cdot (t - t_1)}{(t_2 - t_1)} \quad \text{for } t_2 - t_1 \leq 20\,°\mathrm{C} \qquad (19\text{-}3)$$

$$S_{R/T/t} = S_{R/T/t_1} \cdot \left(\frac{S_{R/T/t_2}}{S_{R/T/t_1}} \right)^{Z_R} \quad \text{for } t_2\text{-}t_1 > 20°\text{C} \qquad (19\text{-}4)$$

where:

$$Z_R = \frac{\log t - \log t_1}{\log t_2 - \log t_1}$$

t_1 is the nearest temperature below t for which a mean creep rupture strength is available in the harmonised materials standard

t_2 is the nearest temperature above t for which a mean creep rupture strength is available in the harmonised materials standard

19.5.1.1.2 Mean 1% creep strain limit

$$S_{P1,0/T/t} = \frac{S_{P1,0/T/t_1} \cdot (t_2 - t) + S_{P1,0/T/t_2} \cdot (t - t_1)}{(t_2 - t_1)} \quad \text{for } t_2\text{-}t_1 \leq 20°\text{C} \qquad (19\text{-}5)$$

$$S_{P1,0/T/t} = S_{P1,0/T/t_1} \cdot \left(\frac{S_{P1,0/T/t_2}}{S_{P1,0/T/t_1}} \right)^{Z_P} \quad \text{for } t_2\text{-}t_1 > 20°\text{C} \qquad (19\text{-}6)$$

where:

$$Z_P = \frac{\log t - \log t_1}{\log t_2 - \log t_1}$$

t_1 is the nearest temperature below t for which a mean 1% creep strain limit is available in the harmonised materials standard

t_2 is the nearest temperature above t for which a mean 1% creep strain limit is available in the harmonised materials standard

NOTE: If the calculation temperature is higher than the highest temperature for which a mean creep rupture strength or a mean 1% creep strain limit is available, application of Part 3 is not permitted.

19.5.1.2 Case where material creep characteristics are available for the calculation temperature (including cases where these values are calculated by 19.5.1.1) but not for the specified lifetime T

In the case where for the specified lifetime T no mean creep rupture strength value or no mean 1% creep strain limit is available in the harmonised materials standard the interpolation formula (19-7) or (19-9) respectively may be used (or the value in the harmonised materials standard for a lifetime longer than the specified lifetime can be used as a conservative value) to determine the appropriate creep characteristics.

In the case where the specified lifetime T is longer than the highest lifetime for which a **mean creep rupture strength** is available in the harmonised materials standard, then the extrapolation method given in the informative Annex R shall be applied or other types of extrapolation should be agreed by involved parties.

In the case where the specified lifetime T is longer than the highest lifetime for which a **mean 1% creep strain limit** is available in the harmonised materials standard, then the value for the highest lifetime for which a mean 1% creep strain limit is available shall be used in formula (19-1).

19.5.1.2.1 Mean creep rupture strength

$$S_{R/T/t} = S_{R/T_A/t} \cdot \left(\frac{S_{R/T_B/t}}{S_{R/T_A/t}} \right)^{X_R} \qquad (19\text{-}7)$$

where:

$$X_R = \frac{\log T - \log T_A}{\log T_B - \log T_A} \qquad (19\text{-}8)$$

$S_{R/T_A/t}$ is the mean creep rupture strength for the nearest lifetime T_A below T for which a mean creep rupture strength is available

$S_{R/T_B/t}$ is the mean creep rupture strength for the nearest lifetime T_B above T for which a mean creep rupture strength is available

In case where the **specified lifetime** T **is shorter** than the lowest lifetime for which a mean creep rupture strength is available, then the following terms may be used in formulae (19-7) and (19-8) respectively as long as no better method is given in the informative Annex R or agreed by the involved parties:

$S_{R/T_A/t}$ and $S_{R/T_B/t}$ are the mean creep rupture strength for the both shortest lifetimes T_A and T_B for which a mean creep rupture strength is available

19.5.1.2.2 Mean 1% creep strain limit

$$S_{P1,0/T_A/t} = S_{P1,0/T_A/t} \cdot \left(\frac{S_{P1,0/T_B/t}}{S_{P1,0/T_A/t}} \right)^{X_P} \qquad (19\text{-}9)$$

where:

$$X_P = \frac{\log T - \log T_A}{\log T_B - \log T_A} \qquad (19\text{-}10)$$