SLOVENSKI STANDARD
SIST EN 12952-4:2011

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Vodocevni kotli in pomožne napeljave - 4. del: Izračun pričakovane življenjske dobe obratovanja

Water-tube boilers and auxiliary installations - Part 4: In-service boiler life expectancy calculations

Wasserrohrkessel und Anlagenkomponenten - Teil 4: Betriebsbegleitende Berechnung der Lebensdauererwartung

Chaudières à tubes d'eau et installations auxiliaires - Partie 4 : Calculs de la durée de vie prévisible des chaudières en service

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27.060.30	Grelniki vode in prenosniki toplote	Boilers and heat exchangers

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EUROPEAN STANDARD

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Water-tube boilers and auxiliary installations - Part 4: In-service boiler life expectancy calculations

Chaudières à tubes d'eau et installations auxiliaires - Partie 4: Calculs de la durée de vie prévisible des chaudières en service

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Foreword

This document (EN 12952-4:2011) has been prepared by Technical Committee CEN/TC 269 “Shell and water-tube boilers”, 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of an identical text or by endorsement, at the latest by January 2012, and conflicting national standards shall be withdrawn at the latest by January 2012.

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

This document supersedes EN 12952-4:2000.

Annex C provides details of significant technical changes between this European Standard and the previous edition.

The European Standard EN 12952, concerning *water-tube boilers and auxiliary installations,* consists of the following parts:

— *Part 1: General;*

— *Part 2: Materials for pressure parts of boilers and accessories;*

— *Part 3: Design and calculation for pressure parts;*

— *Part 4: In-service boiler life expectancy calculations;*

— *Part 5: Workmanship and construction of pressure parts of the boiler;*

— *Part 6: Inspection during construction; documentation and marking of pressure parts of the boiler;*

— *Part 7: Requirements for equipment for the boiler;*

— *Part 8: Requirements for firing systems for liquid and gaseous fuels for the boiler;*

— *Part 9: Requirements for firing systems for pulverized solid fuels for the boiler;*

— *Part 10: Requirements for safeguards against excessive pressure;*

— *Part 11: Requirements for limiting devices of the boiler and accessories;*

— *Part 12: Requirements for boiler feedwater and boiler water quality;*

— *Part 13: Requirements for flue gas cleaning systems;*

— *Part 14: Requirements for flue gas DENOX-systems using liquified pressurized ammonia and ammonia water solution;*

— *Part 15: Acceptance tests;*

— *Part 16: Requirements for grate and fluidized-bed firing systems for solid fuels for the boiler;*

— *CR 12952 Part 17: Guideline for the involvement of an inspection body independent of the manufacturer.*

NOTE 1 A Part 18 on operating instructions is currently in preparation.

Although these parts may be obtained separately, it should be recognized that the parts are inter-dependent. As such, the design and manufacture of water-tube boilers requires the application of more than one part in order for the requirements of this European Standard to be satisfactorily fulfilled.

NOTE 2 Part 4 and Part 15 are not applicable during the design, construction and installation stages.

NOTE 3 A "Boiler Helpdesk" has been established in CEN/TC 269 which may be contacted for any questions regarding the application of European Standards series EN 12952 and EN 12953, see the following website: http://www.boiler-helpdesk.din.de

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, Croatia, 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.

1 Scope

This European Standard is applicable to water-tube boilers as defined in EN 12952-1:2001.

This European Standard specifies procedures for calculating the creep and/or the fatigue damage of boiler components during operation. These calculations are not required to be carried out by the manufacturer as part of his responsibilities within this European Standard.

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 12952-1:2001, *Water-tube boilers and auxiliary installations — Part 1: General*

EN 12952-3:2011, *Water-tube boilers and auxiliary installations — Part 3: Design and calculation for pressure parts*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12952-1:2001 apply.

4 Symbols and abbreviations

For the purposes of this document, the symbols and abbreviations given in EN 12952-1:2001, Table 4-1 apply.

5 General

The calculations may be carried out, using transposed design equations. The measured (actual) wall thickness of the components shall be used in the calculations, i.e. taking into account any wall thickness reduction that may have occurred due to corrosion or erosion during the service life up to the time of the analysis, see EN 12952-3:2011, 5.7.

Operating temperature, pressure and especially the magnitude of load changes often differ from the estimations used for the design. Thus, these calculations may help to prevent unexpected early failure of components. The results may be used as a guideline for the decision to inspect a component for fatigue cracks or to inspect for creep pores by the replica method or any other suitable method.

NOTE In some cases, the influence of both creep and fatigue damage will be significant. It is normally conservative to combine the creep and fatigue damage mechanisms by adding the calculated usage factors. If necessary, more detailed methods of assessment may be used (see [1] PD 7910 Published by British Standardization Institute, London, UK). Thus, the components are not necessarily to be replaced, if the calculated usage factor exceeds the value of 1.

The highest loaded components shall be chosen for monitoring purposes.

6 Calculations

Annex A describes the creep damage calculation. Annex B describes the fatigue damage calculation.

Annex A
(informative)

Calculation of in-service creep damage

A.1 General

This annex describes a procedure for calculating the creep damage of a boiler and its major components during operation. It is based on measured values of pressure and temperature, from which the actual primary stress and the expected lifetime at these conditions may be determined.

Design lifetime is not necessarily identical with the operating lifetime. It is therefore necessary to make projections at various stages throughout the operating lifetime of the boiler to determine its expected lifetime.

A.2 Symbols and abbreviations

In addition to the symbols given in EN 12952-1:2001, Table 4-1, the symbols given in Table A.1 apply.

Table A.1 — Symbols

Symbol	Description	Unit
f_{op}	Membrane stress at operating conditions	N/mm^2
T_{op}	Operated time at operating conditions	h
T_{al}	Time to reach the theoretical rupture by creep	h
D_c	Creep damage	–

A.3 Calculation of in-service lifetime and creep damage

A.3.1 General

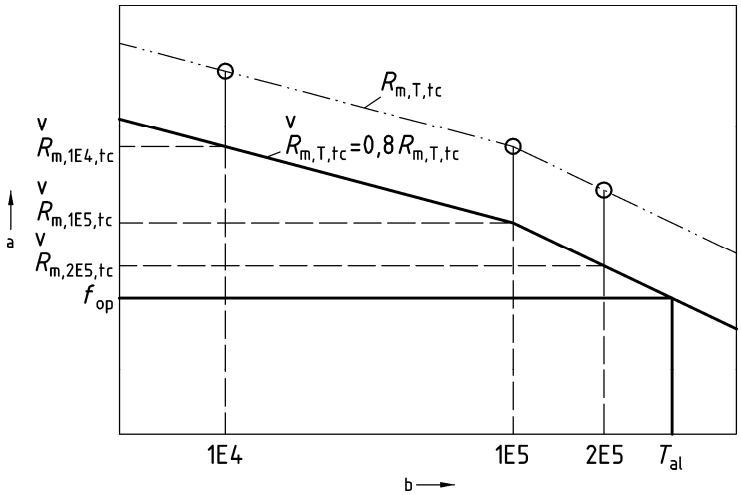
The calculation of the usage factor due to creep is a method that retrospectively takes into consideration the previous modes of operation. It is carried out for highly loaded components on the basis of the measured operating temperatures and gauge pressures.

In order to limit the number of the required calculations and to more clearly present the results, the pressure and temperature range over which the component has been operated, shall be broken down into increments.

The membrane stress f_{op} at the highest loaded point in the component shall be obtained by transposing the design formula using the mean pressure of each pressure increment. If the operating pressure is not measured continuously during operation the separation into increments is not valid and under such circumstances the operating pressure for 100 % load may be used, thus resulting in more conservative predictions. If available, the measured minimum wall thickness may be used. If this was not measured, the guaranteed minimum wall thickness of the material as delivered shall be used.

The theoretical lifetime T_{al} shall be calculated for each rating temperature/pressure. According to Figure A.1, T_{al} is obtained at the intersection of the stress line f_{op} and the lower limit curve of the scatter band of the creep rupture strength (= 0,8 $R_{m\,T\,tc}$) at the mean temperature of each temperature increment.

The respective portion of the creep damage $\Delta D_{ci\,k}$ for each incremental temperature/pressure is obtained by the ratio of the operating time T_{op} for this increment divided by the theoretical lifetime T_{al} for the same increment.



Key

a) lg (R_m)

b) lg (T), h

Figure A.1 — Diagram for the determination of T_{al}

The operating times in the temperature/pressure increment shall be summarized, taking into account the temperature allowances for measuring uncertainties and for temperature asymmetries in due consideration at this classification.

The usage portion for each increment is given by

$$\Delta D_{ci\,k} = \frac{T_{op}}{T_{al}} \tag{A.1}$$

The creep damage D_c during the evaluated period shall be obtained from the linear damage rule by summing up the values $\Delta D_{ci\,k}$ for all temperature increments and, if any, pressure as follows:

$$D_c = \sum_i \sum_k \Delta D_{ci\,k} \tag{A.2}$$

A.3.2 Online computerized data storage

In the case of on-line data storage by means of a data processing system a separation into increments may be waived. For calculation of the theoretical lifetime T_{al} the on-line measured values of pressure and temperature including the above mentioned allowances shall be used instead of the mean values of the increments. The increase of creep damage is obtained in this case from the measured time divided by the theoretical lifetime (see Tables A.2 and A.3).

The computer programme used shall permit the results to be verified by at least a random test.

Table A.2 — Summation of data for the calculation of in-service creep damage

User and boiler plant:	XY		
Power station:	XY		
Boiler:	3		
Works-No.:	12345		
Year built:	2003		
Maximum allowable pressure	HP: 84 bar	Reheater: – bar	
Superheated steam temperature:	HP: 525 °C	Reheater: – °C	
Steam output:	128 t/h		

1	2	3	4	5	6	7	8	9	10	11	12	13
No.	**Component** **Material; Steel group**	a	b	d mm	c	e_s mm	e_{rs} mm	p_c bar	t_o °C	t_c °C	f_{ap} N/mm^2	T_{al} 10^3 h
1	HP-line 13CrMo44; 5.1	m	A B	292,0	o	24,0	21,0	75,5	525	530	48,7	208
2	Superheater 2 – header 13CrMo44; 5.1	n	A B	419,0	o	39,0	39,0	75,5	510	525	56,3	186
3	Superheater 2 – outlet line 13CrMo44; 5.1	n	A B	241,0	o	17,5	17,5	75,5	510	525	48,2	304
4	Superheater 2 – outlet header 16CrMo44; 5.1	n	A B	250,0	i	20,0	28,0	75,5	510	525	47,1	329
7	Fitting at control 20Mo3; 1.2	m	A B	225,0	i	28,0	20,0	80,4	460	465	86,6	> 500
11	Superheater 1 – outlet line 16Mo3; 1.1	n	A B	241,0	o	14,0	14,0	80,4	460	475	65,2	> 500
12	Superheater 1 – outlet header 20Mo3; 1.2	n	A B	250,0	i	22,0	22,0	80,4	460	475	67,0	> 500

[a] Column 3: Temperature allowances according to EN 12952-3:2011, Table 6.1-1
- m unheated = mixed or controlled (+ 5 °C)
- n unheated (+ 15 °C)

[b] Column 4:
- A Nominal or design values
- B Operational or actual values

[c] Column 6:
- i Inside diameter
- o Outside diameter

Table A.3 — Summation of data for the calculation of in-service creep damage

User and boiler plant:	XY
Power station:	XY
Boiler:	6
Works-No.:	12345
Component:	Connecting pipes between primary super heater and secondary super heater ∅ 90 × 8
Commissioning:	2003
Material:	Steel group 5.1 (13CrMo44)
Calculation pressure pc:	100 bar
Mean wall temperature tc:	530 °C
Stress at pc:	57,5 N/mm^2
Evaluated period:	from to

1	2			3	4	5	6	7
Evaluation range	**At outlet of component**			**Calculation pressure**	**Calculation temperature**	**Related to mean wall temperature**	**Elapsed operating time**	**Creep damage for evaluated period**
	t_o			p_c	t_c	T_{al}	T_{op}	ΔD_c
	From	to	mean					
	°C			bar	°C	10^3 h	h	%
1		< 500	< 500	100	515	430	1 250	0,29
2	500	510	505	100	520	260	820	0,31
3	510	515	512,5	100	527,5	162	6 800	4,20
4	515	520	517,5	100	532,5	106	5 760	5,45
5	520	525	522,5	100	537,5	80	610	0,76
						Sum for evaluated period	15 240	11,01
						Sum prior to evaluated period	20 000	14,00
						Total	35 240	25,01