

Water-tube boilers and auxiliary installations —

Part 4: In-service boiler life expectancy calculations

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PVE/2, Water-tube boilers, which has the responsibility to:

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- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 18, an inside back cover and a back cover.

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

Wasserrohrkessel und Anlagenkomponenten –
Teil 4: Betriebsbegleitende Berechnung der
Lebensdauererwartung

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 269, Shell and water tube boiler, 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of an identical text or by endorsement, at the latest by August 2000, and conflicting national standards shall be withdrawn at the latest by August 2000.

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

The standard 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, and safety circuits 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
- Part 15: Acceptance tests
- Part 16: Requirements for grate and fluidized bed firing systems for solid fuels for the boiler

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

The annexes A and B of this European Standard are informative.

1 Scope

This part of the European Standard applies to water-tube boilers as defined in prEN 12952-1:1997.

This part describes 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 standard.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

prEN 12952-1:1997

Water-tube boilers and auxiliary installations – Part 1: General

prEN 12952-3:1997

Water-tube boilers and auxiliary installations – Part 3: Design and calculation for pressure parts

3 Definitions

For the purposes of this standard the definitions given in prEN 12952-1:1997 apply.

4 Symbols and abbreviations

For the purposes of this standard, the symbols and abbreviations indicated in table 4-1 of prEN 12952-1:1997 shall 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 5.7 of prEN 12952-3:1997.

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 6539 Published by British Standards Institution, 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 boiler and 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 table 4-1 of prEN 12952-1:1997 the symbols given in table A.2-1 apply.

Table A.2-1: 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.3-1 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 ($= 0,8 R_{mTtc}$) at the mean temperature of each temperature increment.

The respective portion of the creep damage ΔD_{cik} 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.