vgbe-Standard

Rating charts for rating the microstructural composition and creep rupture damage of creep-resistant steel for high pressure pipelines and boiler components and their weld connections

VGBE-S-517-00-2024-11-EN
4th Edition
(formerly VGB-S-517-00-2014-11-DE-EN)

www.vgbe.energy

vgbe-Standard

Rating charts for rating the microstructural composition and creep rupture damage of creep-resistant steel for high pressure pipelines and boiler components and their weld connections

VGBE-S-517-00-2024-11-EN
4th Edition
(formerly VGB-S-517-00-2014-11-DE-EN)

Publisher:
vgbe energy e.V.

Publishing house:
vgbe energy service GmbH
Verlag technisch-wissenschaftlicher Schriften
Deilbachtal 173 | 45257 Essen, Germany

Phone: +49 201 8128-200
E-mail: sales-media@vgb.org

ISBN 978-3-96284-384-7 (print, English)
ISBN 978-3-96284-385-4 (e-book, English)
ISBN 978-3-96284-382-3 (print, German)
ISBN 978-3-96284-383-0 (e-book, German)

All rights reserved, vgbe energy.

www.vgbe.energy | www.vgbe.services

Preface to the fourth edition

In this fourth edition, the optional assessment of creep damage based on porosity determination for martensitic 9 % to 12 % Cr steels has been included as an extension to the third edition.

The assessment classes for base materials have been adapted to the new state of knowledge in damage assessment and the illustration appendix has been supplemented and updated with the latest high-quality illustrations.

Helpful additions for the user, such as a correlation table of the relative creep rupture life consumption as a function of porosity with reference values and etching agents typically to be used, have been added.

Furthermore, examples of the interaction and differentiation of creep rupture and relaxation cracking have been included.

We would like to take this opportunity to thank all those involved in the revision of this edition.

Essen, November 2024

vgbe energy e.V.*

* vgbe energy e.V. has been the new name of VGB PowerTech since April 2022.

Notes on the translation

In English-language texts, the “dot” is generally used as the decimal separator with the “comma” as the thousands separator. In graphics originating from the German speaking world, the “comma” character may be used as the decimal separator with the “dot” as the thousands separator.

British English is the main language used in this vgbe-Standard.

Preface to the third edition

Expanding on the second edition, the rating chart of this third edition includes an assessment of creep rupture damage on weld connections (circumferential and stub welds). This takes account of the high number of weld connections analysed by means of microstructure replication during periodic inspections. The metallophysical bases, presented in the second version, for developing creep rupture damage also apply to damage on weld connections.

Since creep damage on weld connections is localised, measures other than those taken for normally larger-scale damage in the base material generally have to be derived. For this reason, different nomenclature has been used in the rating charts in order to distinguish between damage to the base material and damage to the weld seam.

Many thanks to all those involved in the revision of this edition.

Preface to the second edition

The 2nd edition of the microstructure rating charts takes account of the revisions to VGB-R 509 “Wiederkehrende Prüfungen an Rohrleitungsbauteilen in fossilbefeuer-ten Wärmekraftwerken” [periodic inspections of pipeline systems in fossil-fuelled thermal power plants] in 2002 and the new 9%–12% Cr-steels, which up until now were not included in the rating charts. Furthermore, this edition now includes information obtained from more recent operational experiences and research projects into damage mechanisms, i. e. the relationship between the microstructure, deformation capability and damage behaviour.

No qualification/certification procedure for inspectors or inspection companies has been established. Instead, the detailed description of the preparation technique, which acts as an inspection requirement, is designed to ensure a high standard of quality.

Unlike in the first edition, the rating class 0 micrographs (“delivery condition, no thermal stressing”) are included in a separate section of the appendix of pictures and will in future no longer be described as a rating class. This should stop these rating charts from being used as an acceptance criterion during remanufacture, because only in very rare cases does a proven link exist between the microstructure visible with a light microscope and the expected creep rupture strength. For this reason, the micrographs represent just some examples of the possible microstructures in the initial condition. Classes 1 to 5 will still be used for the assessment of creep stress, although this edition also indicates that the pore density should, under certain conditions, additionally be used for assessing the damage condition. Besides the “initial conditions” and the “microstructure rating charts”, the picture section now includes a third section – “special cases” – describing in greater detail specific problems during the preparation process or material-specific characteristics.

A ring binder format ensures a flexible response to new information. This means that any additions or amendments – whether absolutely essential or merely desirable – can in future be included on additional pages or pages can be replaced as required.

Many thanks to all those involved in the revision of this edition.

Preface to the first edition

To determine the microstructural condition of a material and identify material fatigue, metallographic microstructure analyses are increasingly being conducted on power plant components that operate for extended periods in the creep range. These are based on the VdTÜV instruction sheet STEAM BOILERS 451-83/6 “Oberflächengefügeuntersuchung zeitstandbeanspruchter Bauteile gemäß TRD 508” [surface microstructure examination of creep-exposed components in accordance with TRD 508] [1] and VGB guideline VGB-R 509 “Wiederkehrende Prüfungen an Rohrleitungsanlagen in fossilbefeuerten Wärmekraftwerken” [periodic inspections of pipeline systems in fossil-fuelled thermal power plants] [2], which each contain schematic information on microstructure and damage classes. Experience has shown that a further subdivision of damage classes 2 and 3 makes sense. Furthermore, real micrographs of the material quality can help to avoid different ratings from different experts and misunderstandings between metallographers, experts and operators.

These rating charts are a summary of existing documentation, information and findings. They are designed to promote cooperation between the parties involved. Any liability, including for the factual accuracy of the information presented, is excluded. Likewise, it is the user's own responsibility to clarify issues regarding patent-protected and other proprietary rights.

The VGB headquarters requests that the experiences gained during the application of these rating charts as well as any potential for ambiguous ratings, shortcomings in presentation and suggestions for improvement be reported for evaluation. These could potentially form the basis for additions or amendments.

Many thanks to all those involved in creating the microstructure rating charts.

Authors

Persons involved/4th edition (2024)

Peter Körner, vgbe energy service GmbH.

Karl Maile, formerly Materialprüfungsanstalt Universität Stuttgart

Peter Seliger, Siempelkamp Prüf- und Gutachter-Gesellschaft mbH

Mirko Lieb, vgbe energy service GmbH

Jörg M. Bareiß, EnBW Energie Baden-Württemberg AG

Thomas Hansen, BASF SE

Jens Hälbig, RWE Power AG

Tim Kalbitzer, StandZeit GmbH

Patrick Kozlowski, Lausitz Energie Kraftwerke AG

Rudi Scheck, Materialprüfungsanstalt Universität Stuttgart

Fabian Schimmel, TÜV Rheinland Werkstoffprüfung GmbH

Martin Widera, formerly RWE Power AG

Dirk Wurzel, Evonik Operations GmbH

Gereon Lüdenbach, StandZeit GmbH

Christian Ullrich, vgbe energy service GmbH

Jens Ganswind-Eyberg, vgbe energy e.V.

Persons involved, 3rd edition (2014)

Thomas Gräb, Bilfinger Piping Technology GmbH

Jörg Gurski, TÜV NORD SysTec GmbH & Co. KG

Peter Körner, VGB PowerTech e.V.

Dieter Loog, TÜV Rheinland Werkstoffprüfung GmbH

Karl Maile, Materialprüfungsanstalt Universität Stuttgart

Joachim Schubert, ALSTOM Power Service GmbH

Peter Seliger, Siempelkamp Prüf- und Gutachter-Gesellschaft mbH

Ralf Uerlings, RWE Power AG

Christian Ullrich, VGB PowerTech e.V.

Dirk Wurzel, Evonik Industries AG

Persons involved, 2nd edition (2005)

M. Schwarz, BASF, Ludwigshafen

J. Schubert, Alstom, Mannheim

D. Loog, TÜV Rheinland Group, Köln

K. Maile, Materialprüfungsanstalt Universität Stuttgart

P. Seliger, Siempelkamp Prüf- und Gutachter-Gesellschaft, Dresden

P. Körner, G. Lüdenbach, VGB PowerTech e.V., Essen

Persons involved, 1st edition (1992)

H. Müsch und H. Remmert, Vereinigte Elektrizitätswerke Westfalen AG, Hamm

P. Körner und E. Tolksdorf, VGB-Geschäftsstelle/VGB-Headquarters, Essen

0. Wachter, PreussenElektra AG, Hannover

Table of contents