

Steel — Determination of yield strength increase by the effect of heat treatment [Bake-Hardening-Index]

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National foreword

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Steel - Determination of yield strength increase by the effect of heat treatment [Bake-Hardening-Index]

Aciers - Détermination de l'augmentation de la limite apparente d'élasticité due à un traitement thermique (index de durcissement à la cuisson [Bake-hardening])

Stahl - Bestimmung der Streckgrenzenerhöhung durch Wärmebehandlung (Bake-Hardening-Index)

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Foreword

This document (EN 10325:2006) has been prepared by Technical Committee ECISS/TC 1 "Steel - Mechanical testing", the secretariat of which is held by AFNOR.

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1 Scope

This document specifies the method for the determination of yield strength increase by the effect of heat treatment (Bake-Hardening-Index) for steel.

NOTE This test is applied in particular, to steels showing a mechanism of bake hardening, which are specially intended for automotive industry.

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 10002-1:2001, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature*

3 Terms and definitions

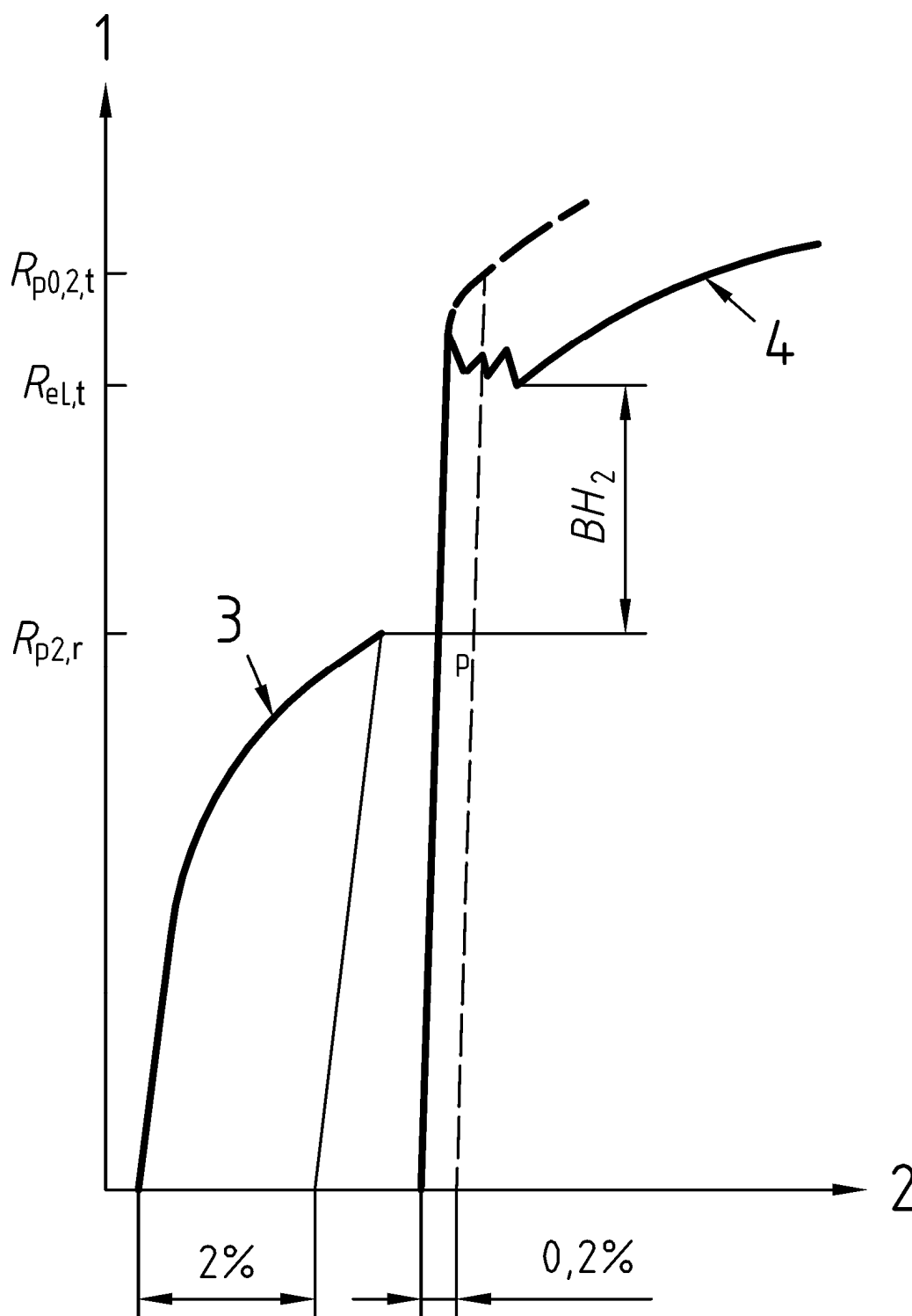
For the purposes of this document, the terms and definitions given in EN 10002-1:2001 and the following apply.

NOTE However it should be noted that in the context of this document, the term "yield strength" also covers 0,2 % proof strength in addition to its definition in EN 10002-1.

3.1 Bake-Hardening-Index

(BH_2) increase of yield strength between a reference condition after a 2 % plastic pre-strain and the condition obtained after a heat treatment simulating the usual industrial paint processes (see Figure 1)

NOTE The heat treatment of simulation is specified in 8.2.

**Key**

- 1 Stress
- 2 Strain
- 3 Application of a 2 % plastic pre-strain
- 4 Tensile test after heat treatment on the same test piece

Figure 1 — Illustration of the determination of BH_2

4 Symbols and designations

The symbols used in this document and the corresponding designations are given in Table 1.

Table 1 — Symbols and designations

Symbol	Unit	Designation
$R_{p2,r}$	MPa ^a	Stress corresponding to a 2 % plastic prestrain measured on the test piece
$R_{eL,t}$	MPa	Lower yield strength measured on the test piece initially prestrained at 2 % and then heat treated
$R_{p0,2,t}$	MPa	0,2 % proof strength measured on the test piece initially prestrained at 2 % and then heat treated
BH_2	MPa	Bake-Hardening-Index
^a 1 MPa = 1 N/mm ² .		

5 Principle

The test determines an index giving the increase of yield strength of a test piece submitted to a 2 % plastic pre-strain, then to a specified heat treatment.

6 Test equipment

The test equipment shall be in accordance with EN 10002-1.

7 Test pieces

The test pieces shall be according to EN 10002-1.

8 Testing procedure

8.1 Testing conditions

The tensile test shall be performed according to Annex A of EN 10002-1:2001. The testing rate given in EN 10002-1 for the beginning of the tensile test, shall only be increased after the determination of R_{eL} or $R_{p0,2}$. During the pre-straining of the test pieces, the testing rate shall be kept constant up to a plastic pre-strain of $(2 \pm 0,05) \%$. All tensile tests used to characterize a steel shall be performed with the same actual testing rate.

8.2 Heat treatment conditions

A test piece temperature of 170 °C shall be achieved within 7 min. The heat treatment time of $(20 \pm 0,5)$ min commences when a test piece temperature of 168 °C is achieved. The heat treatment equipment used shall be capable of keeping the prescribed test piece temperature (i.e. 170 °C) at ± 2 °C. The temperature measuring device shall have a resolution of no more than 1 °C with a maximum measuring uncertainty of ± 2 °C. After the holding time, the test piece shall be air cooled to room temperature, i.e. (23 ± 5) °C.

8.3 Determination of Bake-Hardening-Index (BH_2)

The BH_2 -Index is the difference between the proof strength, $R_{p2,r}$, of the 2 % plastically strained test piece (modulus of elasticity of steel considered to be 200 000 MPa) and the lower yield strength, $R_{eL,t}$, or the proof strength, $R_{p0,2,t}$, of the same test piece after an additional heat treatment at 170 °C with a holding time of 20 minutes. Determining $R_{eL,t}$ or $R_{p0,2,t}$ after heat treatment, the cross-sectional area of the test piece after a plastic pre-strain shall be used.

$$BH_2 = R_{eL,t} \text{ (or } R_{p0,2,t} \text{)} - R_{p2,r} \quad (1)$$

9 Test report

9.1 If testing of BH_2 is carried out in combination with the conventional test according to EN 10002-1, the Bake-Hardening-Index shall be added to the test report.

9.2 If testing of BH_2 is carried out separately, the test report shall contain at least the following information:

- a) reference to this European Standard;
- b) identification of the test piece;
- c) location and direction of sampling;
- d) test result.

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