SLOVENSKI STANDARD
SIST EN 10373:2021

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Ugotavljanje fizikalnih in mehanskih lastnosti jekel z uporabo modelov

Determination of the physical and mechanical properties of steels using models

Berechnungsmodell für die Datenbereitstellung von physikalischen und mechanischen Eigenschaften für Stähle

Détermination des propriétés physiques et mécaniques des aciers à l'aide de modèles

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English Version

Determination of the physical and mechanical properties of steels using models

Détermination des propriétés physiques et mécaniques des aciers à l'aide de modèles

Ermittlung physikalischer und mechanischer Eigenschaften von Stählen mittels Anwendung von Modellen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 10373:2021) has been prepared by Technical Committee CEN/TC 459 SC 12 “General issues”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by December 2021, and conflicting national standards shall be withdrawn at the latest by December 2021.

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Introduction

Since the physical and mechanical properties of steels are ultimately based upon the metallurgical transformations during the production process, there have been numerous efforts of the manufacturers in the past, to design models for providing property data for the whole product, in order to improve the control of the increasingly complex processes during the manufacturing of steel products.

In doing so, the use of models not only helps to reduce the amount of testing in the scope of factory production control, but it gives a more representative overview of the material properties of steels, since models can use all available data, determined during the production process, whereas conventional material testing represents in principle a spot check of the material properties at the time of sampling and at the place where the samples were taken.

1 Scope

This document specifies the method for the verification of models for the determination of the property data of steels and the validation of the modelling process. It is applicable where modelling of mechanical or physical properties is used to substitute conventional testing for specific inspection. Models can be based on statistical data, thermo-physical data or indirect measurement (e.g. measurement of magnetic or ultrasonic data), or a combination of these methods.

This document applies only for providing the properties of rolled and/or heat-treated products such as plates, sheets, strip, sections and bars.

This document is used to demonstrate the ability of the model to supply property data which is equivalent to data, measured by conventional testing.

Any self-learning system is excluded from the scope.

NOTE A self-learning, in the spirit of an auto-adaptive model, is a model which changes its internal parameters by itself.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 10021, *General technical delivery conditions for steel products*

EN 10204, *Metallic products - Types of inspection documents*

NOTE At the time of the first release of this standard, no publications concerning statistical analyses of manufacturing processes and/or statistical methods have been identified, which could have been cited as normative references in this document. The bibliography contains references to technical literature, which can be taken into account.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at https://www.electropedia.org/

3.1
model
documented system for the generation of output data using input data

Note 1 to entry: A unique set of input values to the model will always result in the same calculated output value(s).

Note 2 to entry: The model calculates physical and/or mechanical property data from input data, the results of which can also be determined by physical and/or mechanical testing.

Note 3 to entry: An example of a linear model for calculation of tensile strength is given in Annex A.

3.2
input data
measurement data, or data which is related to those parts of a manufacturing process, which are relevant to the product properties to be calculated

3.3
output data
physical and/or mechanical property data of a steel product according to the scope, which is generated by a model according to 3.1

3.4
manufacturing process
entirety of all process steps (including all time periods between them), that leads from a starting product (e.g. raw material, or a semi-finished product) to an end product

3.5
model verification
documented system of initial comparative testing and analysis procedures, carried out by the manufacturer, proving the ability of a model to replace conventional testing of product properties by output data

Note 1 to entry: An example for a model verification with sampling size n = 6 is given in Annex B.

3.6
modelling process validation
validation of the process by which the applicability and accuracy of models for prediction of specified properties is confirmed by an independent body

3.7
model monitoring
documented system of regular checks, using data analysis procedures of input and output data, part of the modelling process, as well as regular comparative testing, to ensure the accuracy and reliability of modelled product properties

3.8
application range
range of steel products, chemical composition, manufacturing conditions and all additional conditions affecting the model accuracy for which the model has been verified

4 Requirements on the application of models

4.1 General

Models can be based on direct measurement data (thermo-physical data), indirect measurement data (e.g. measurement of magnetic or ultrasonic data), statistical data generated from indirect and/or direct measurement data, or a combination of these methods.

The output data, determined by models, shall be equivalent to the results of conventional testing, within the limits of allowable deviations, distinctively specified for each physical and mechanical property. To define the allowable deviations is under the responsibility of the manufacturer.

Models shall be validated before they can be used for the release of products.

4.2 Application range

4.2.1 General

Models for determination of property data are intended to be used for quality control in the production process of steel products with specified physical properties, which are documented in standards or other specifications and which can be alternatively determined by physical testing.

The application range of the model shall be described and documented in reference to the steel products, in terms of chemical composition and manufacturing conditions and all additional conditions, that have an influence on the model accuracy, and for which the model has been verified.

4.2.2 Conditions for the application of models

The following restrictions shall apply to models:

a) Manufacturing processes shall run under control of a quality management system and shall produce input data, representative for the products and in a sufficient amount to apply appropriate documented statistical methods in the scope of the control and monitoring of models according to Clause 6 (e.g. large scale production).

NOTE Quality management systems in accordance with EN ISO 9001, or comparable systems, meet this requirement.

b) The application range of a model shall be explicitly defined and documented with respect to the considered products.

c) The model outputs shall only be used for product release if the model is used within the application range.

d) Determination of physical and/or mechanical properties by a model shall be in accordance to the requirements of a written specification (e.g. national, or international standards, or other appropriate technical documentation).

e) For certain inspection types according to EN 10204 only input data, which can be related explicitly to the test unit according to the applicable written specification or product standard shall be used.

f) The modelling process shall have been validated by an independent body before any initial application of any model according to Clause 5 of this document.

4.2.3 Conditions for extension of the application range of models

An extension can only be considered if the model itself, including any internal parameter, does not change.

Any extension of the application range which requires modification of the model or its internal parameters shall be treated as a new model.

In case of the extension of the application range of a model for the determination of physical and mechanical properties of steels, it shall be ensured, that:

a) the extension of the application range of a model is explicitly defined and documented in terms given in 4.2.2;

b) the application of the extended model is in accordance with the conditions of 4.2.2;

c) the validation according to Clause 5 of this document has been repeated for the extended application range of the model, prior to its regular use (e.g. for the manufacturers factory production control).

4.3 Requirements on input data

4.3.1 General

For all measured input data, indispensable for the application of a model, the measurement methods shall be in accordance with accepted national or international standards or written internal documentation.

NOTE 1 Input data can also be data from another model, which describes an earlier process step.

NOTE 2 An example is given in Annex C.

4.3.2 Measurement equipment

All measurement equipment shall be uniquely identified and documented with respect to their positions in the manufacturing process, or parts thereof.

The unit of measurement, the accuracy and the range of valid results for each measured input shall be specified by the manufacturer.

4.3.3 Measurement methods

For the measurement of input data, appropriate direct or indirect measurement methods shall be applied. The fundamentals of metrology, as well as the requirements for the analysis of measured parameters and of measurement uncertainties, shall be given by appropriate national or international standards. When non-standardized metrology methods are used, these shall be described in the quality management system documentation of the manufacturer.

The choice of suitable measurement methods is at the discretion of the manufacturer and shall fulfil the rules of the quality management system.

4.4 Requirements on output data

The output data determined by the model shall be the calculated physical and/or mechanical property values, according to the requirements, defined in the agreed specification. The unit of measurement, the accuracy and the range of valid results for each output parameter shall be specified by the manufacturer. They shall be in the scope of the application range of the model.

NOTE Physical and/or mechanical property data are for example proof strength, tensile strength and elongation, as defined in the respective technical standard product specification, agreed at time of enquiry and order.

5 Requirements on model verification and application

5.1 General

The manufacturer is responsible for the accuracy and reliability of the modelled output data. For this purpose, he shall take the necessary actions, to determine the accuracy of the model, to define the allowable deviations and to prove by means of appropriate comparative conventional testing, that the required confidence level is met for the whole application area of the model.

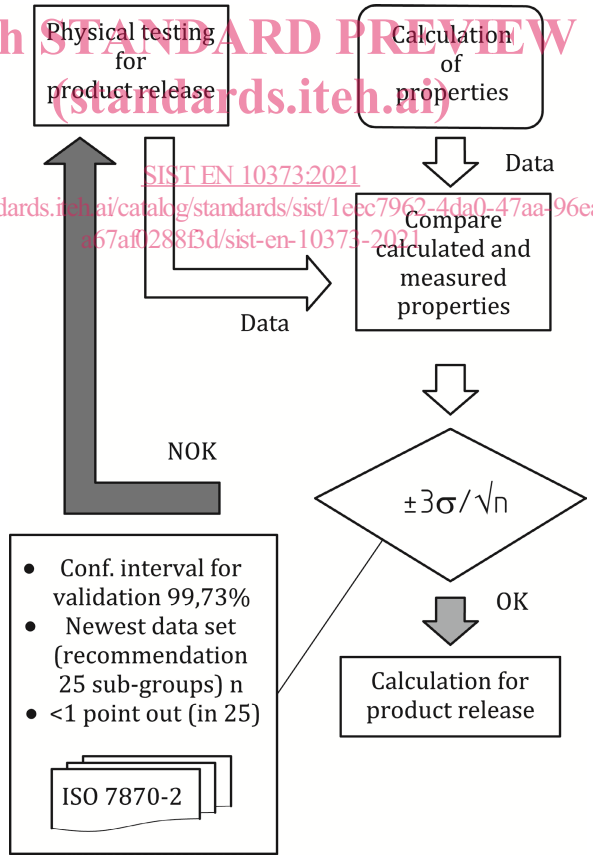
To be an applicable method for the determination of physical and mechanical properties, a model shall be verified by the manufacturer. Before the initial application of any model the modelling process shall be validated by an independent body. The validation of the modelling process should take place once a year. During this validation, the independent body should have the possibility to check models in the same way the manufacturer does during the verification process.

A flowchart for the model verification is given in Figure 1. The elements of the modelling process validation are presented in 5.3.

The extent of tasks of the manufacturer and the independent body in the scope of model verification and modelling process validation are specified in Table 1.

Table 1 — Assignment of tasks in the scope of assessment and survey of models for FPC

Task		Extent of task
Tasks for the manufacturer	Factory production control (FPC)	Determination and analysis of input data, the results of comparative testing and output data, related to application and control of a model
	Determination of the application range of a model on the basis of data, type testing (including sampling), data analysis, or descriptive documentation	
	Further testing of final product samples, according to a prescribed test plan	Determination and analysis of output data and results of comparative testing related to the application of a model
Tasks for the independent body	Initial inspection of manufacturer processes in relationship with the modelling and FPC	Validation of functionality, reliability, availability, traceability and accuracy of processes, related to the application and control of a model
	Continuous surveillance of FPC (once per year – see 5.3)	



Key

σ residual standard deviation from the data set used in the model construction

n sampling size

Figure 1 — Flowchart for the model verification