SLOVENSKI STANDARD
SIST-TP CEN ISO/TR 10400:2012

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Industrija za predelavo nafte in zemeljskega plina - Formule in izračuni lastnosti ohišij, cevi, vrtalnih drogovij in cevovodov (ISO/TR 10400:2007)

Petroleum and natural gas industries - Equations and calculations for the properties of casing, tubing, drill pipe and line pipe used as casing or tubing (ISO/TR 10400:2007)

Erdöl- und Erdgasindustrie - Formeln und Berechnungen der Eigenschaften von Futterrohren, Steigrohren, Bohrgestängen und Leitungsrohren (ISO/TR 10400:2007)

Industries du pétrole et du gaz naturel - Équations et calculs relatifs aux propriétés des tubes de cuvelage, des tubes de production, des tiges de forage et des tubes de conduites utilisés comme tubes de cuvelage et tubes de production (ISO/TR 10400:2007)

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75.180.10	Oprema za raziskovanje in odkopavanje	Exploratory and extraction equipment

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TECHNICAL REPORT

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Petroleum and natural gas industries - Equations and calculations for the properties of casing, tubing, drill pipe and line pipe used as casing or tubing (ISO/TR 10400:2007)

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This Technical Report was approved by CEN on 27 December 2010. It has been drawn up by the Technical Committee CEN/TC 12.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

The text of ISO/TR 10400:2007 has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" of the International Organization for Standardization (ISO) and has been taken over as CEN ISO/TR 10400:2011 by Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" the secretariat of which is held by AFNOR.

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Endorsement notice

The text of ISO/TR 10400:2007 has been approved by CEN as a CEN ISO/TR 10400:2011 without any modification.

TECHNICAL REPORT

ISO/TR 10400

First edition
2007-12-15

Petroleum and natural gas industries — Equations and calculations for the properties of casing, tubing, drill pipe and line pipe used as casing or tubing

Industries du pétrole et du gaz naturel — Équations et calculs relatifs aux propriétés des tubes de cuvelage, des tubes de production, des tiges de forage et des tubes de conduites utilisés comme tubes de cuvelage et tubes de production

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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ISO/TR 10400 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 5, *Casing, tubing and drill pipe*.

This first edition of ISO/TR 10400 cancels and replaces ISO 10400:1993, which has been technically revised.

Introduction

Performance design of tubulars for the petroleum and natural gas industries, whether it is formulated by deterministic or probabilistic calculations, compares anticipated loads to which the tubular may be subjected to the anticipated resistance of the tubular to each load. Either or both the load and resistance may be modified by a design factor.

Both deterministic and probabilistic (synthesis method) approaches to performance properties are addressed in this Technical Report. The deterministic approach uses specific geometric and material property values to calculate a single performance property value. The synthesis method treats the same variables as random and thus arrives at a statistical distribution of a performance property. A performance distribution in combination with a defined lower percentile determines the final design equation.

Both the well design process itself and the definition of anticipated loads are currently outside the scope of standardization for the petroleum and natural gas industries. Neither of these aspects is addressed in this Technical Report. Rather, this text serves to identify useful equations for obtaining the resistance of a tubular to specified loads, independent of their origin. This Technical Report provides limit state equations (see annexes) which are useful for determining the resistance of an individual sample whose geometry and material properties are given, and design equations which are useful for well design based on conservative geometric and material parameters.

Whenever possible, decisions on specific constants to use in a design equation are left to the discretion of the reader.

Petroleum and natural gas industries — Equations and calculations for the properties of casing, tubing, drill pipe and line pipe used as casing or tubing

1 Scope

This Technical Report illustrates the equations and templates necessary to calculate the various pipe properties given in International Standards, including

— pipe performance properties, such as axial strength, internal pressure resistance and collapse resistance,

— minimum physical properties,

— product assembly force (torque),

— product test pressures,

— critical product dimensions related to testing criteria,

— critical dimensions of testing equipment, and

— critical dimensions of test samples.

For equations related to performance properties, extensive background information is also provided regarding their development and use.

Equations presented here are intended for use with pipe manufactured in accordance with ISO 11960 or API 5CT, ISO 11961 or API 5D, and ISO 3183 or API 5L, as applicable. These equations and templates may be extended to other pipe with due caution. Pipe cold-worked during production is included in the scope of this Technical Report (e.g. cold rotary straightened pipe). Pipe modified by cold working after production, such as expandable tubulars and coiled tubing, is beyond the scope of this Technical Report.

Application of performance property equations in this Technical Report to line pipe and other pipe is restricted to their use as casing/tubing in a well or laboratory test, and requires due caution to match the heat-treat process, straightening process, yield strength, etc., with the closest appropriate casing/tubing product. Similar caution should be exercised when using the performance equations for drill pipe.

This Technical Report and the equations contained herein relate the input pipe manufacturing parameters in ISO 11960 or API 5CT, ISO 11961 or API 5D, and ISO 3183 or API 5L to expected pipe performance. The design equations in this Technical Report are not to be understood as a manufacturing warrantee. Manufacturers are typically licensed to produce tubular products in accordance with manufacturing specifications which control the dimensions and physical properties of their product. Design equations, on the other hand, are a reference point for users to characterize tubular performance and begin their own well design or research of pipe input properties.

This Technical Report is not a design code. It only provides equations and templates for calculating the properties of tubulars intended for use in downhole applications. This Technical Report does not provide any guidance about loads that can be encountered by tubulars or about safety margins needed for acceptable design. Users are responsible for defining appropriate design loads and selecting adequate safety factors to develop safe and efficient designs. The design loads and safety factors will likely be selected based on historical practice, local regulatory requirements, and specific well conditions.

All equations and listed values for performance properties in this Technical Report assume a benign environment and material properties conforming to ISO 11960 or API 5CT, ISO 11961 or API 5D and ISO 3183 or API 5L. Other environments may require additional analyses, such as that outlined in Annex D.

Pipe performance properties under dynamic loads and pipe connection sealing resistance are excluded from the scope of this Technical Report.

Throughout this Technical Report tensile stresses are positive.

2 Conformance

2.1 Normative references

In the interests of worldwide application of this Technical Report, ISO/TC 67 has decided, after detailed technical analysis, that certain of the normative documents listed in Clause 3 and prepared by ISO/TC 67 or other ISO Technical Committees are interchangeable in the context of the relevant requirement with the relevant document prepared by the American Petroleum Institute (API), the American Society for Testing and Materials (ASTM) or the American National Standards Institute (ANSI). These latter documents are cited in the running text following the ISO reference and preceded by or, for example, “ISO XXXX or API YYYY”. Application of an alternative normative document cited in this manner will lead to technical results different from the use of the preceding ISO reference. However, both results are acceptable and these documents are thus considered interchangeable in practice.

2.2 Units of measurement

In this Technical Report, data are expressed in both the International System (SI) of units and the United States Customary (USC) system of units. For a specific order item, it is intended that only one system of units be used, without combining data expressed in the other system.

For data expressed in the SI, a comma is used as the decimal separator and a space as the thousands separator. For data expressed in the USC system, a dot (on the line) is used as the decimal separator and a space as the thousands separator.

3 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.

ISO 3183:2007, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO 10405, *Petroleum and natural gas industries — Care and use of casing and tubing*

ISO 11960:2004, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

ISO 11961, *Petroleum and natural gas industries — Steel drill pipe*

ISO 13679, *Petroleum and natural gas industries — Procedures for testing casing and tubing connections*

ANSI-NACE International Standard TM0177, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H_2S Environments*

API 5B, *Threading, Gauging and Thread Inspection of Casing, Tubing, and Line Pipe Threads (US Customary Units)*

API RP 579, *Recommended Practice for Fitness-for-Service*, January 2000

API RP 5C1, *Recommended Practice for Care and Use of Casing and Tubing*

API RP 5C5, *Recommended Practice on Procedures for Testing Casing and Tubing Connections*

API 5CT, *Specification for Casing and Tubing*

API 5D, *Specification for Drill Pipe*

API 5L:2004, *Specification for Line Pipe*

BS 7910, *Guide to methods for assessing the acceptability of flaws in metallic structures*

4 Terms and definitions

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

4.1
Cauchy stress
true stress
force applied to the surface of a body divided by the current area of that surface

4.2
coefficient of variance
dimensionless measure of the dispersion of a random variable, calculated by dividing the standard deviation by the mean

4.3
design equation
equation which, based on production measurements or specifications, provides a performance property useful in design calculations

NOTE A design equation can be defined by applying reasonable extremes to the variables in a limit state equation to arrive at a conservative value of expected performance. When statistically derived, the design equation corresponds to a defined lower percentile of the resistance probability distribution curve.

4.4
deterministic
approach which assumes all variables controlling a performance property are known with certainty

NOTE Pipe performance properties generally depend on one or more controlling parameters. A deterministic equation uses specific geometric and material property values to calculate a single performance property value. For design formulations, this value is the expected minimum.

4.5
ductile rupture
failure of a tube due to internal pressure and/or axial tension in the plastic deformation range

4.6
e
Euler's constant
2,718 281 828

4.7
effective stress
combination of pressure and axial stress used in this Technical Report to simplify equations

NOTE Effective stress as used in this Technical Report does not introduce a distinct, physically defined stress quantity. Effective stress is a dependent quantity, which is determined as a combination of axial stress, internal pressure, external pressure and pipe dimensions, and provides a convenient grouping of these terms in some equations. The effective stress is sometimes called the Lubinski fictitious stress.