Calculating Performance Properties of Pipe Used as Casing or Tubing

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Addendum 1

Table of Contents: The entry for Table K.2 shall be changed to the following:

Table of Contents: The entry for Table L.2 shall be changed to the following:

Section 1 (Scope), 4th paragraph: The last sentence of the paragraph shall be changed to the following:

Similar caution should be exercised when using the performance equations for drill pipe or for collapse of cold-expanded API 5L pipe.

Section 3.1 (Terms and Definitions): The following terms/definitions shall be added to the section:

3.1.12
JCOE
An acronym-term referring to the process of forming pipe in which steel plate edges are formed into a "J," the full plate is then shaped into a "C," then an "O," welded together and finally expanded "E."

3.1.26
UOE
An acronym-term referring to the process of forming pipe in which steel plate is shaped into a "U," then an "O," welded together and finally expanded "E."

Section 8.6: The entire section shall be replaced with the following:

8.6 Application of Collapse Pressure Equations to Line Pipe

The collapse pressure equations presented in this section are empirical relations derived from tests on pipe representative of the casing and tubing inventories listed in API 5CT or ISO 11960. Application of these relations outside the range of yield strengths and D/t ratios contained in API 5CT or ISO 11960 is not recommended. These equations do not apply to cold expanded pipe because Bauschinger effects significantly reduce collapse resistance. Some line pipe grades listed in API 5L have a rough casing equivalent in API 5CT or ISO 11960. However, the API 5L pipe inventory contains D/t ratios that often exceed casing D/t ratios.

Cold-expanded line pipe—for example, UOE or JCOE line pipe—can exhibit collapse performance lower than the design equations in this clause. Pipeline design guidelines API 1111 and DNVGL-ST-F101 provide correlations that have been shown to yield more accurate collapse design rating predictions when compared to collapse test results. Both pipeline guidelines provide factors to add a design margin to the predicted collapse pressure, resulting in a design rating approach commensurate with this clause.

For line pipe that is not cold-expanded and has a yield strength and D/t falling within the limits of the sizes and thicknesses listed in API 5CT or ISO 11960, application of the equations in this section should yield reasonable estimates of minimum collapse pressure. Nevertheless, as with the application of any of the equations in this document, sound engineering judgment should prevail.

Section 10.3, Page 50: The paragraph above Equation (71) shall be changed to the following:

Since the external box diameter is always greater than the contact diameter, which in turn is always greater than the internal pipe diameter, p_2 will always be less than p_1. Therefore, when the total interface pressure $p_1 + p_2$ equals the internal pressure p_i, the connection has reached the interface pressure threshold p. In other words, if p_i were greater than $p_1 + p_2$, leakage would occur:

Annex K, Section K.2: The title of Table K.2 shall be changed to the following:

Table K.2—Performance Property Calculations—Interface Pressure of Casing Connections (SI Units)

Annex K, Page 260: The title of Table K.2 shall be changed to the following:

Table K.2—Performance Property Calculations—Interface Pressure of Casing Connections (SI Units)

Annex L, Section L.2: The title of Table L.2 shall be changed to the following:

Table L.2—Performance Property Calculations—Interface Pressure of Casing Connections (USC Units)

Annex L, Page 338: The title of Table L.2 shall be changed to the following:

Table L.2—Performance Property Calculations—Interface Pressure of Casing Connections (USC Units)

Bibliography: The following entries shall be added to the bibliography:

[123] API Recommended Practice 1111, *Design, Construction, Operation, and Maintenance of Offshore Hydrocarbon Pipelines (Limit State Design)*

[124] DNVGL-ST-F101, *Submarine Pipeline Systems*

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

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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) that are useful for determining the resistance of an individual sample whose geometry and material properties are given, and design equations that 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 user.

Calculating Performance Properties of Pipe Used as Casing or Tubing

1 Scope

This technical report illustrates the equations and templates necessary to calculate the various pipe properties, including the following:

- 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;
- 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 API 5CT or ISO 11960, API 5DP or ISO 11961, and API 5L or ISO 3183, 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 [CRS] 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, and so forth, with the closest appropriate casing/tubing product. Similar caution should be exercised when using the performance equations for drill pipe or for collapse of cold-expanded API 5L pipe.

This technical report and the equations contained herein relate the input pipe manufacturing parameters in API 5CT or ISO 11960, API 5DP or ISO 11961, and API 5L or ISO 3183 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 that 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.