High-pressure High-temperature Design Guidelines

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Addendum 1

Table 3: *The table shall be replaced by the following*

Table 3—Material Tests for Fatigue Assessment and Environmental Effect Susceptibility

Type of Test	Barrier Category			
	Primary Barrier		Secondary Barrier	
	Fatigue	Non-fatigue	Fatigue	Non-fatigue
Slow-strain rate test/ strain limit damage test	Yes	Yes[1]	Yes	Yes[1]
Fracture toughness	Yes	Optional	Optional	Optional
Fatigue crack growth rate or S-N	Yes	N/A	Yes	N/A

[1] Required for elastic-plastic design methodology only.

NOTE SSRT, in the context of this document, is used as a screening tool to determine if the environment affects the material's fatigue characteristics. Differences in SSRT results between those in air and in a subject environment warrant additional fatigue material testing in that environment. The ductility ratios obtained from SSRT are used to determine knockdown factors to account for environmental degradation on the material's strain limit damage.

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Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

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Introduction

This technical report serves as a design guideline for high-pressure high-temperature (HPHT) equipment, specifically for subsea applications. The second edition includes two new subjects: 1) load-factors for extreme and survival conditions and 2) material testing protocols.

This document is not intended to be a stand-alone specification or standard. Rather it is presented as a technical guidance document so that specifications, standards, and recommended practices may reference this document, in part or in total, to augment their operating scope greater than 15,000 psi (103.5 MPa) and/or greater than 350 °F (177 °C) wellbore conditions as proffered by API 1PER15K-1.

It is necessary that users of this technical report be aware that additional or different requirements that can better suit the demands of a particular service environment, the regulations of a jurisdictional authority or other scenarios not specifically addressed in this technical report, may be applied as required. This document is a technical report, and it is not intended to replace sound engineering judgment.

The main topics for this technical report are categorized as follows.

1) Design Verification: The design verification process focuses on analytical methods. The specified requirements include verification of the mechanical integrity, life cycle, and other service requirements.

2) Materials for HPHT Equipment: The material section defines the required input parameters for the design verification process and recommends the procedures necessary to evaluate the material's properties for the intended service environment.

3) Seals and Bolting/Fasteners: The seals and bolting/fasteners sections provide guidance on these specific elements of the design as they impact or are impacted by the HPHT designs.

4) Design Validation: The design validation section focuses on demonstrating the integrity of the equipment's design and includes defining the appropriate validation methods to analyze and mitigate the failure modes identified from the failure modes, effects, and criticality analysis (FMECA).

5) Hydrostatic Test for HPHT Equipment: The hydrostatic test sections provide guidance on the applicable hydrostatic test pressure based on the design standard selected.

Application

The scope of this technical report is limited to equipment and components identified in API documents that focus on subsea production equipment while addressing one or a combination of the following loading conditions:

— internal and external pressure;

— ambient and elevated operating temperatures;

— static and dynamic mechanical loads;

— other pressure/temperature-induced loadings.

This technical report is intended to provide design guidelines for pressure-containing components, seals, and fastener components that come in contact with or are immediately adjacent to wellbore fluids operating at HPHT conditions. Intra-field piping systems (e.g. steel flowline and pipeline jumpers, manifold piping, valving, connectors, and tubing hanger), and intervention riser equipment are within the scope of this technical report.

The design methodology referenced in this technical report may also be applied to pressure-controlling components if the design methodology can appropriately assess the applicable failure mode(s).

This technical report does not cover the following:

— flexible pipes (bonded and unbonded);

— oil-country tubular goods (OCTG) for drilling or completing wells;

— downstream pipeline or production riser designs;

— downhole component hardware that may be subject to additional application-related design constraints;

— equipment covered by other API publications that specifically address HPHT applications;

— structural members or ancillary equipment associated with HPHT hardware but not working in close proximity to the HPHT environment;

— brittle materials (i.e. essentially no plastic deformation prior to failure, etc.).

High-pressure High-temperature Design Guidelines

1 Scope

The scope of this technical report is to provide design guidelines for oil and gas subsea equipment utilized in high-pressure high-temperature (HPHT) environments (refer to 3.1.21). For the purpose of the technical report, HPHT environments are intended to be one or a combination of the following well conditions:

1) the completion of the well requires completion equipment or well control equipment assigned a pressure rating greater than 15,000 psia (15 ksi, 103.5 MPa) or a temperature rating greater than 350 °F (177 °C);

2) the maximum anticipated surface pressure including shut-in tubing pressure is greater than 15,000 psia (15 ksi, 103.5 MPa) on the seafloor for a well with a subsea wellhead or at the surface for a well with a surface wellhead; or

3) the flowing temperature is greater than 350 °F (177 °C) on the seafloor for a well with a subsea wellhead or at the surface for a well with a surface wellhead.

NOTE There is no upper limit on service pressure ratings within the scope of this technical report. Service temperature ratings above 550 °F (288 °C) are outside the scope of this technical report.

This technical report is intended to serve as a general design guideline for HPHT application. Other subsea task groups and subcommittees may elect to adopt a portion or all of the presented guidelines for HPHT application, subject to their component hardware and application-related design constraints.

It is necessary that users of this technical report be aware of regulations from a jurisdictional authority that may impose additional or different requirements that better suit the demands of a particular service environment. This technical report provides additional considerations in HPHT equipment designs.

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.

API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*

API Specification 17D, *Design and Operation of Subsea Production Systems—Subsea Wellhead and Tree Equipment*

API Recommended Practice 17G, *Recommended Practice for Completion/Workover Risers*

API Specification 20E, *Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries*

API Specification 20F, *Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries*

API Standard 6X, *Design Calculations for Pressure-containing Equipment*, First Edition, March 2014

ANSI/ASME B1.1 [1,2], *Unified Inch Screw Threads*, 2003 Edition

ASME *BPVC* Section VIII, *Rules for Construction of Pressure Vessels Division 2—Alternative Rules*

[1] American National Standards Institute, 25 West 43rd Street, New York, New York 10036, www.ansi.org.

[2] American Society of Mechanical Engineers, Two Park Avenue, New York, New York 10016, www.asme.org.