

High-pressure High-temperature Design Guidelines

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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.

Contents

1	Scope.....	1
2	Normative References	1
3	Terms, Definitions, Acronyms, Abbreviations, and Symbols	2
3.1	Terms and Definitions	2
3.2	Acronyms and Abbreviations	6
3.3	Symbols	8
4	Addressing Issues Posed in API 1PER15K-1.....	10
4.1	General	10
4.2	High-pressure Effects, High-temperature Effects, and High-pressure High-temperature Effects	10
4.3	Loading Conditions—What Is Unique to Subsea?	14
4.4	Functional Requirements—Normal, Extreme, and Survival Conditions	15
5	Design Verification.....	15
5.1	General	15
5.2	High-pressure High-temperature Design Flowchart	17
5.3	Input Parameters for Design Analysis	19
5.4	Design Analysis	21
5.5	Fatigue Assessment/Life-cycle Estimation	25
5.6	Ancillary Components and Assemblies	31
5.7	Manufacturer’s Technical Specifications	32
6	Materials for High-pressure High-temperature Equipment	32
6.1	General	32
6.2	Environmental Conditions and Effects.....	32
6.3	Material Properties for Design Verification	34
6.4	Integral Cladding/Weld Metal Overlay.....	36
6.5	Nondestructive Examination	39
7	Seals and Bolting/Fasteners	40
7.1	Seals	40
7.2	Bolting and Fasteners	46
8	Design Validation	52
8.1	General	52
8.2	Minimum Design Validation Requirements	52
8.3	Additional Design Validation Requirements	53
8.4	Revalidation of Existing Designs	54
8.5	Use of Equipment Subjected to Validation Testing.....	54
8.6	Validation Considerations.....	54
8.7	In-service Validation	55
8.8	Validation of Analytical Methods.....	55
9	Hydrostatic Body Test for High-pressure High-temperature Equipment.....	56
9.1	General	56
9.2	Pressure Rating \leq 20 ksi.....	56
9.3	Pressure Rating $>$ 20 ksi	56
	Annex A (informative) Load Monitoring	58
	Annex B (informative) Material Selection	65
	Annex C (normative) Material Quality Control.....	70
	Annex D (informative) Material Characterization Protocols.....	77
	Annex E (informative) Strain Limit Damage Material Evaluation.....	93
	Bibliography	95

Figures

1	High-pressure High-temperature Design Flowchart	16
2	Environmental Effects for Qualification of Overlay Weld Qualification	38
D.1	An Example of an S-N Fatigue Curve Development.....	83
D.2	Example of Published Design Curve Validation by Using the Target Curve Approach	84
D.3	An Example of the Qualification of a New S-N Curve for More Severe Environment.....	87
D.4	Comparison of Limited Environment Test Data with In-air Curve and Target Curve	88
D.5	Comparison of Forced Fit Environmental Data with In-air Data	89
D.6	In-air and In-environment Combined Data Fit Curves.....	90
D.7	An Example of Validating an Existing Design Curve	91

Tables

1	Global Plastic Collapse Design Margins/Load Factors.....	23
2	Essential Variables for Environmental Qualification of Overlay Weld	37
3	Industry Standards for Determination of Plastic Properties	44
4	Industry Standards for Determination of Rubber Properties	45
5	Industry Standards for Determination of Low-alloy Steel Bolting Material Properties and Quality Control Tests.....	49
B.1	H₂S Concentration (in ppm) to Equal 0.05 psia Partial Pressure at Standard Rated Working Pressures	66
C.1	Industry Standards Applicable to Quality Control Tests	70
D.1	Example of a Sour Production Environments	78
D.2	Recommended Seawater with Cathodic Protection Test Environment	78
D.3	Fracture and Fatigue Testing Guideline for Developing New Curves/Parameters	80
D.4	Fatigue Testing Guideline for Validating Existing Curves/Parameters	81

Introduction

This technical report serves as a design guideline for high-pressure high-temperature (HPHT) equipment, specifically for subsea applications.

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

Revision History

The intended scope of this technical report has not changed since its inception and through its two subsequent revisions. As a technical report, this document is intended to be a design guideline, highlighting the novel design methods and material characteristic changes associated with structural and pressure integrity of components working at elevated pressures and/or temperatures. It continues to serve as a guide for other standards and specifications to cite and use for their specific scopes operating in an HPHT realm. The second and now third editions are a reflection of what has been learned and refined about HPHT in terms of:

- clarifying intent and use of this technical report as a design guideline;
- identifying events (normal, extreme, survival), and refinement of various design and assessment methodologies with respect to these events, such as listing design factors associated with combined loads during these events;
- clarifying fatigue assessment design methodology and material characterization protocols;
- providing informational annexes on instrumentation and small bore tubing design.

The third edition also makes editorial changes to specific product specification and PR levels of referenced API documents that recognize HPHT.

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 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 (for example, 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 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 (see 3.1.24). 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 Tree Equipment*

API Specification 17D, *Specification for Subsea Wellhead and Tree Equipment*

API Standard 17G, *Design and Manufacture of Subsea Well Intervention Equipment*

API Specification 20B, *Open Die Shaped Forgings for Use in the Petroleum and Natural Gas Industry*

API Specification 20C, *Closed Die Forgings for Use in the Petroleum and Natural Gas Industry*

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*

ANSI/ASME B1.1 ^{1,2}, *Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms)*

¹ American National Standards Institute, 1899 L Street, NW, Washington, DC 20036, <https://ansi.org>.

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