High-pressure High-temperature Design Guidelines

API TECHNICAL REPORT 17TR8
THIRD EDITION, JULY 2022

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed. The use of API publications is voluntary. In some cases, third parties or authorities having jurisdiction may choose to incorporate API standards by reference and may mandate compliance.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to ensure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Classified areas may vary depending on the location, conditions, equipment, and substances involved in any given situation. Users of this technical report should consult with the appropriate authorities having jurisdiction.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Users of this technical report should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

The verbal forms used to express the provisions in this document are as follows.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the standard.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the standard.

May: As used in a standard, “may” denotes a course of action permissible within the limits of a standard.

Can: As used in a standard, “can” denotes a statement of possibility or capability.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

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

Figures

Tables

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.