

# High-pressure High-temperature Design Guidelines

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## Introduction

This technical report is the first of several editions to serve as a design guidelines for high-pressure high-temperature (HPHT) equipment, specifically for subsea applications. This first edition is offered in hopes of bringing relevant state-of-the-art practices to address emerging projects while the task group continues to work on specific problems requiring additional time to research and resolve issues such as welding, CRA cladding, QA, sensors, etc.

This document is not intended to be a standalone 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 (103.43 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 which 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.

In the development of this technical report, the items below are recognized as on-going work for resolution. Many will require additional discussion and debate, between governing API and ASME standards and their associated design/manufacturing processes. Rather than wait and hold up the publication of the first edition of this technical report, until everything is resolved, the task group elected to release the work it has accomplished to far, and alert the reader to the work still to be resolved; highlighting that there could be changes to the technical report in subsequent editions.

- 1) Materials QA/QC differences between API, and ASME standards: The task group acknowledges that the QA/QC requirements found in ASME and API standards are not aligned, and additionally, may not be aligned between API sub-committees. It is beyond the scope of this technical report to close this gap. As further work is conducted and information comes to light, it is envisioned that the gaps will progress to convergence. It is recommended that these gaps be documented in a FMECA as input to the verification process, and included in the development of a documented design validation program to address the gap.
- 2) Inclusion of external loading: The task group has authored this technical report to provide specific guidance to utilize design codes which are applicable for the inclusion of external loading.
- 3) Where the design codes (e.g. ASME *BPVC* Section VIII, Div. 2 and Section VIII, Div. 3) are referenced in this technical report for subsea applications, these design codes and this technical report provide guidance for applicable loads, static, dynamic, and cyclic.
- 4) Hydrostatic body test pressures: API Specifications typically require a hydrostatic body test on single-equipment units and this technical report recommends different minimum hydrostatic test pressures depending on the design verification method chosen. This could result in two or more components being assembled where ASME Section VIII, Div. 2 component(s), tested to 1.5xRWP, combined with ASME Section VIII, Div. 3 component(s), tested to 1.25xRWP into an assembly/system. However, system integration testing (SIT) of an assembly/system is not in the scope of this technical report.
- 5) Application of “Extreme” and “Survival” loading conditions: The task group acknowledges differences between API and ASME *BPVC* loading conditions and allowable limits for these loading conditions. Currently, it is the task group’s opinion that there is insufficient correlation to provide specific recommendations of the treatment and acceptance criteria of these load cases. It is recommended that, if these loading conditions are present during HPHT applications they should be documented in the FMECA process, inputted to the design verification process, and included in the design validation program, as needed to address this gap.

**Cautionary note:** It should be understood that some of the text on design methodology, material performance data, and qualification/validation requirements published in this first edition may be modified (i.e. changed, added, deleted, etc.) as continuing topics are resolved and as new information and technology become available in subsequent editions.

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# High-pressure High-temperature Design Guidelines

## 1 Scope

### 1.1 Scope of Technical Report

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 3.1.16). 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, 103.43 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, 103.43 MPa] on the seafloor for a well with a subsea wellhead or tied back to the surface and terminated with surface operated equipment; or
- 3) the flowing temperature is greater than 350 °F (177 °C) on the seafloor for a well with a subsea wellhead or tied back to the surface and terminated with surface operated equipment.

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.

### 1.2 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 and connectors, intervention liner 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:

- flexible pipes (bonded and unbonded);
- oil-country tubular goods (OCTG) for drilling or completing wells;