High-pressure High-temperature (HPHT) Flange Design Methodology

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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.

Preface

This technical report is the first of several editions to serve as a design guideline for high-pressure high-temperature (HPHT) flanges. This first edition is offered in hopes of bringing relevant state-of-the-art practices, needed by the oil and gas industry, to address emerging projects while the task group continues to work on specific problems requiring additional time to research and resolve issues such as thermal, cyclic loading conditions 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 TR 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, certain topics have been difficult to resolve. 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 so far based on the initial charge, and alert the reader to the work still to be resolved; highlighting that there could be changes to the technical report in subsequent editions.

Extreme and Survival loading conditions are not in scope of the initial release of this document.

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Introduction

This document is intended to provide design guidance for high-pressure high-temperature (HPHT) API 6BX style flanges. The current revision of this document focuses on recommending methods for quantifying flange capabilities subjected to combinations of pressure and bending. It intends to expand upon the work documented in API 6AF2 by recommending methods using more advanced analysis modeling, such as 3D geometry, non-linear material models, and large displacement theory. It also provides guidance on initial sizing of flange geometry based on the work presented in Robert Eichenberg's ASME paper 57-PET-23 "Design Considerations for AWHEM 15,000 psi Flanges" of 1957 and his Journal of Engineering for Industry paper of 1964. Eichenberg's work established the foundations for the API 6BX style flange.

It is not the intent of this document to restrict users from performing project or application specific analyses that could provide capabilities different to those using the methodology summarized herein. Alternative methods may be acceptable if justified by alternative industry accepted design codes. When other industry-approved HPHT design methods are employed, the methodology presented here shall not be viewed as an extra requirement nor is it intended to supplant other industry-approved HPHT design methodologies.

The intent of this design guideline is to enable the user to generate baseline capability charts similar to those seen in API 6AF2, but using non-linear FEA models, methods, and criteria.

The methodology is demonstrated on the API 6BX 5 in. 15K flange in Annex B. Annex C contains capability charts for all the 20K API 6BX flanges using a possible interpretation of the method described in the guideline.

At the time of writing, not all methodologies in this document have been validated. Therefore, this document serves as an example of the types of calculations and considerations necessary to define capabilities of API 6BX flanges.

Thermal gradients, thermal effects, and tension loadings are intended be added to this document at a later date under a future revision.

High-pressure High-temperature (HPHT) Flange Design Methodology

1 Scope

The scope of this document is to provide design guidelines for API 6BX style flanges utilized as end and outlet connectors in high-pressure, high-temperature (HPHT) surface and subsea applications. For this document, HPHT applications are intended to mean Flanges assigned a temperature rating greater than 350° F or a pressure rating greater than 15,000 psi.

The current version of this guideline does not address thermal effects including gradient effects or subsea production equipment. Service temperature ratings above 550 °F (288° C) are outside the scope of this technical report. The flange designer should address thermal effects when designing flanges rated for high temperatures.

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 Standard 6X, *Design Calculations for Pressure-containing Equipment*

API Technical Report 6AF, *Technical Report on Capabilities of API Flanges under Combinations of Load*

API Technical Report 6AF1, *Technical Report on Temperature Derating on API Flanges under Combination of Loading*

API Technical Report 6AF2, *Technical Report on Capabilities of API Integral Flanges under Combination of Loading—Phase II*

ASME Boiler and Pressure Vessel Code Section VIII, Division 2—*Alternative Rules*

ASME Boiler and Pressure Vessel Code Section VIII, Division 3—*Alternative Rules for Construction of High Pressure Vessels*

Robert Eichenberg, "*Design Considerations for AWHEM 15,000 psi*," ASME Paper 57-PET-23, 1957

Robert Eichenberg, " Design of High-Pressure Integral and Welding Neck Flanges with Pressure-Energized Ring Joint Gaskets, Journal of Engineering for Industry, 1964

Joe R. Fowler, "Sealability of API R, RX & BX Ring Gaskets," PN 90-21, Stress Engineering Services, Inc., Report prepared for API, January 1994

3 Terms, Definitions, Acronyms, Abbreviations, and Symbols

3.1 Definitions

For the purposes of this document, the following definitions, and those definitions in API 6A, apply.

3.1.1
Stiffness ratio
Stiffness of the bolt divided by the stiffness of the bolt plus the stiffness of the flange body.

NOTE Refer to Section B.2.5.