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

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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, bending, tension, and thermal loads. It intends to expand upon the work documented in API Technical Report 6AF2 by recommending methods using more advanced analysis modeling, such as 3D geometry, nonlinear 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 Technical Report 6AF2, but using nonlinear 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.

Fatigue is intended be added to this document later under a future revision.

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1 Scope

The scope of this document is to provide design guidelines for API 6BX style flanges used 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.

Service temperature ratings above 550 °F (288 °C) are outside the scope of this document.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) 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*

API Technical Report 17TR8,*High-Pressure High-Temperature Design Guidelines*

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*

3 Terms, Definitions, Acronyms, Abbreviations, and Symbols

3.1 Definitions

For the purposes of this document, the following terms and definitions, and those terms and 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 B.2.5.

3.2 Acronyms, Abbreviations, and Symbols

For the purposes of this document, the following acronyms, abbreviations, and symbols apply.

FEA finite element analysis