Protocol for Verification and Validation of High-pressure High-temperature Equipment

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

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1 Scope

1.1 Purpose

This report focuses on an evaluation process for high-pressure high-temperature (HPHT) equipment in the petroleum and natural gas industries which includes design verification analysis, design validation, material selection considerations, and manufacturing process controls necessary to ensure the equipment is fit-for-service in the applicable HPHT environment. HPHT environments are intended to mean that one or more of the following well conditions exist:

a) the completion of the well requires completion equipment or well control equipment assigned a temperature rating greater than 350 °F or a pressure rating greater than 15,000 psig;

b) the maximum anticipated surface pressure or shut-in tubing pressure is greater than 15,000 psig on the seafloor for a well with a subsea wellhead or at the surface for a well with a surface wellhead; or

c) the flowing temperature is greater than 350 °F on the seafloor for a well with a subsea wellhead or on the surface for a well with a surface wellhead.

NOTE In high-temperature, low-pressure applications, not all methodologies presented in this document may apply.

The design verification process focuses on the analytical methods to achieve design verification by calculating the performance limits of a design (system, subsystems, and components), including its service life and material selection. The design validation process focuses on evaluating the potential failure modes of the equipment, the effects/consequences of the failures and defining the appropriate test methods to evaluate the reliability of the equipment against the identified failure modes including validation of material performance. The material section defines the required input parameters for the verification process and recommends the procedures necessary to evaluate the material fitness-for-service in the service environment. Functional testing procedures specific to HPHT equipment are also included in this document.

The design verification and validation protocols in this report should be used as a guide by the various API subcommittees to develop new and revised standards on equipment specifications for HPHT service. This report is not intended to replace existing API equipment specifications but to supplement them by illustrating accepted practices and principles that may be considered in order to maintain the safety and integrity of the equipment. This report is intended to apply to the following equipment: wellheads, tubing heads, tubulars, packers, connections, seals, seal assemblies, production trees, chokes, and well control equipment. It may be used for other equipment in HPHT service.

Annexes to this report provide additional information on the following:

— Annex A provides example HPHT material property data,

— Annex B is a compendium of published metallurgical-related field failures,

— Annex C provides a detailed explanation of the failure mode and effect analysis (FMEA) process,

— Annex D contains technical information on the considerations for the selection of castings and forgings,