Pressure Effects on Subsea Hardware During Flowline Pressure Testing in Deep Water

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Introduction

Subsea hydrotesting demonstrates the structural integrity of the flowline system to tolerate the maximum allowable operating pressure (MAOP), and it confirms the sealing integrity of the pipeline system and subsea hardware components to contain hydrocarbon production. These subsea hardware components may include, but are not limited to, integral and flanged valves; flanged connections and other-end connections (OECs); jumper and flowline connectors and hubs; pressure caps and their vent valves; pressure/temperature sensors; chemical injection valves and porting; electrical penetrators; tees; crosses; pipe bends; fittings; and any similar items that will be pressurized during the subsea flowline pressure testing operations.

For subsea systems where the pressure source is at the wellhead, the MAOP is typically assigned to be equal to the wellhead shut-in tubing pressure (WHSITP). Present regulations do not allow the owner/operator to consider the gradient of produced fluids to determine a variable design pressure along flowline and riser as a function of elevation if flowline and riser are not separated by physical barriers. For more details on this issue see:

— 30 *Code of Federal Regulations* (*CFR*) 250 Subpart J, Paragraph 250.1002;

— Notice to Lessees (NTL) 2009-G28, *Alternate Compliance and Departure Requests in Pipeline Applications*;

— OTC Technical Paper 25087, *Formulating Guidance on Hydrotesting Deepwater Oil and Gas Pipelines*.

Pre-commissioning leak testing demonstrates the sealing integrity of the barriers for a fully assembled subsea production system to contain hydrocarbon production fluids (or injection fluids). The leak test pressure is normally applied as internal pressure within the flowline itself, but leak testing of individual connections may be applied as a backside seal test using test pressure from a remotely operated vehicle (ROV) or other remote pressure source. The preferred use of a backside seal test is a preliminary or cursory test to verify the integrity of a connection joint before an internal pressure test of the system. The backside pressure test is typically performed with agreement between the operator and manufacturer. The backside seal test port can also be used to monitor an individual connection for leakage during an internal pressure test (during diagnostics or troubleshooting).

There is a need to distinguish between surface shut-in tubing pressure (SSITP) and WHSITP. Standard subsea flowline hydrotest pressure typically exposes the flowline system to a differential pressure between 1.25 × MAOP and 1.5 × MAOP of the flowline at all locations and elevations. In some cases, the surface test pressure can be based on a calculated SSITP taking into account the hydrostatic head within the riser. In other cases, the surface test pressure may have to be 1.25 (or 1.5) times the full WHSITP at the seabed, with no reduction allowed for density of produced fluids in the riser. **Thus, it is important to confirm whether the surface test pressure must be based on WHSITP or if it can be reduced, based on SSITP, considering density of produced fluids in the riser.**

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1 Scope

This document provides guidance to the industry on allowable pressure loading of subsea hardware components that can occur during hydrotesting of subsea flowlines and risers and during pre-commissioning leak testing of these systems. There are potential problems with confusion arising from high hydrostatic pressure in deep water, partially due to the variety of applicable test specifications and partly from the inconsistent use of a variety of acronyms for pressure terminology.

With guidance, owner/operators can avoid unexpected loading conditions and the resulting potential for equipment damage, failure, or leakage (either immediate or delayed leaks) or reduced service life.

This document and the examples provided give the user guidance for evaluating subsea hydrotesting scenarios where test pressures are often well above maximum allowable operating pressure (MAOP).

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 Technical Report 17TR8, *High-pressure High-temperature Design Guidelines*

API Technical Report 17TR12, *Consideration of External Pressure in the Design and Pressure Rating of Subsea Equipment*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1.1
absolute pressure
Absolute pressure inside the components being tested, measured in “psia.”

3.1.2
barrier
Element forming part of a pressure-containing envelope that is designed to prevent unintentional flow of produced/injected fluids, particularly to the external environment.

3.1.3
differential pressure
Difference between the absolute pressure inside a component and the absolute pressure outside of the component at that location, measured in “psid.”

NOTE For the purposes of discussions in this document, “psig” and “psid” are the same if at the same water depth.