Consideration of External Pressure in the Design and Pressure Rating of Subsea 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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Introduction

For pressure-containing equipment, as defined by API 6A and API 17D, where external pressure is constant and acting on the outside of the component, it is reasonable to include the external pressure effects when designing and rating the equipment. Examples would be piping, valve body, bonnet, and similar items, which are always wetted by the seawater or fluid, resulting in an external pressure equal to ambient seawater pressure at the installed water depth.

For pressure-controlling equipment (see API 6A and API 17D), external pressure (or in some case, backpressure) may not always be present downstream of the pressure-controlling element (closure mechanism), or the backpressure pressure magnitude may fluctuate. Example of this scenario is a closed valve or choke where downstream pressure of the closure mechanism may not always be equal to external ambient seawater pressure (e.g. a subsea flowline is blown-down to low pressure during a system shut-in to avoid hydrate formation in the flowline as its contents cool down).

Another example of external pressure assessment is equipment containing one-atmosphere pressure (or 14.7 psia) voids such as spaces between dual seals where the inner seal does not benefit from the external pressure effects. Pressure in trapped spaces between closed valves can decline significantly due to thermal effects when a hot system is shut-in and begins to cool down.

In certain cases where dual barriers are designed into the equipment (i.e. dual packings on valve stems, connector gaskets with primary and secondary seals, penetrators with internal and external seals, etc.), the effects of external ambient seawater pressure may not be present behind the primary seal during subsea operation, nor present during shop testing operations. If the pressure equipment is designed with consideration of external pressure due to ambient seawater pressure at depth, it may not be possible nor practical to perform FAT pressure test of the primary seal (inboard) for the dual barrier sealing arrangement to the maximum pressure that it will see in operation at depth without overstressing the pressure equipment since external pressure in the shop is only one-atmosphere. It is a proper quality assurance practice to test all seals to at least the differential pressure they will see in service, or higher. If such testing cannot be conducted, the manufacturer and equipment purchaser/end-user should address the associated risk of the utilizing external pressure in the design with dual barrier sealing configuration, and the potential risk of a seal defect not being detected during the FAT.

As illustrated above, the evaluation of pressure-controlling equipment and equipment containing trapped one-atmosphere void spaces can be more complicated than for pressure-containing equipment with consideration of external pressure. In all cases, a full system analysis is necessary, along with HAZID/HAZOP and FMEA/FMECA studies to ensure that external pressure conditions during all potential operating modes and scenarios are properly identified and evaluated. Additionally, equipment with trapped voids or dual barrier seals configuration may not have the beneficial effects of external pressure and this must be taken into consideration when assessing pressure ratings.

Consideration of External Pressure in the Design and Pressure Rating of Subsea Equipment

1 Scope

This technical report addresses issues related to the effects of external pressure acting on API Subcommittee 17 (SC17, Subcommittee on Subsea Production Equipment) subsea equipment installed in deepwater for containing or controlling wellbore fluids. External pressure at deepwater can significantly reduce the differential pressure acting on the wall of subsea equipment, and therefore, this can improve its internal pressure containment capability. External pressure is typically ambient seawater pressure, but in some cases, external pressure may be due to the hydrostatic head of drilling mud, completion fluids, or other fluids contained within risers or other conduits that connect the subsea equipment to surface facilities.

There is a need for guidelines on the application of external pressure during the design, validation and operation of subsea equipment. Guidelines are also needed to calculate and/or determine a modification to the working pressure limits at the installed water depth, using the selected equipment API rated working pressure (RWP).

API Technical Report 17TR12 (hereafter API 17TR12) provides guidance for subsea equipment designers/ manufacturers to properly account for external pressure (or in some cases, differential pressure) when designing and validating subsea equipment. Additionally, this technical report provides guidance to equipment purchaser/end-user to appropriately select rated equipment for their subsea systems with consideration to the effects of external pressure in addition to internal pressure, including differential pressure across a closure mechanism, and other applied mechanical or structural loads under all potential operating scenarios and functionality criteria.

NOTE API Technical Report 17TR4 (hereafter API 17TR4) provides additional information on the effects of external pressure on stresses generated within subsea equipment for the equipment designer.

API 17TR12 applies specifically to API SC17 equipment. API 17TR12 is to be used as a supplement to the equipment's applicable API product specification (e.g. API 6A, API 17D, API 17G), depending on its specific application, associated regulations, and project requirements. Other API product specifications may elect to adopt this technical report, subject to their component hardware, application-related design constraints and acceptance criteria. Specific subsea recommended practices, standards, and/or specifications may elect to adopt this technical report, also subject to their component hardware and application-related design constraints.

For this technical report, the term "equipment" also applies to the terms "part", "component", "sub-component" or "device" within a subsea system.

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 Christmas-Tree Equipment*, Twentieth Edition, October 2010

API Specification 17D, *Design and Operation of Subsea Production Systems—Subsea Wellhead and Tree Equipment*, Second Edition, May 2011

API Recommended Practice 17G, *Recommended Practice for Completion/Workover Risers*, Second Edition, July 2006