

Overview of API Standards activity on HPHT

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Sept. 26-27, 2017

API Overview

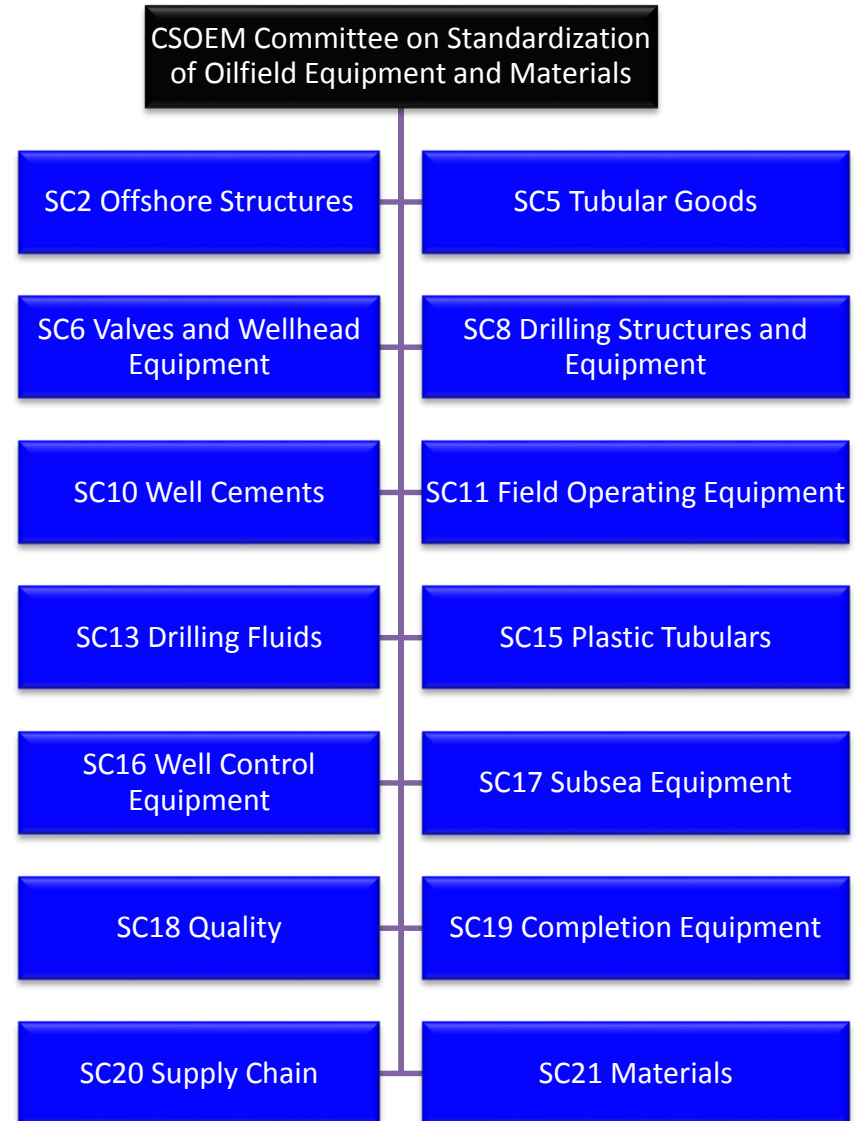
- API formed in 1919 as national trade association to support the U.S. oil and natural gas industry
- API Standards Department published first standard in 1924 covering pipe sizes, threads, and couplings
- Today, API maintains more than 600 standards with 240 on E&P activities
- API Standards in regulation
 - 88 standards referenced by BSEE in CFR
 - 130 standards referenced by US Government in total
 - 216 standards referenced by state governments
 - 225 standards referenced globally

API Overview

- 6 Committees developing standards
 - Committee on Standardization of Oilfield Equipment & Materials
 - Drilling and Production Operations
 - Committee on Refinery Equipment
 - Pipeline Standards Committee
 - Safety and Fire Protection Committee
 - Committee on Petroleum Measurement

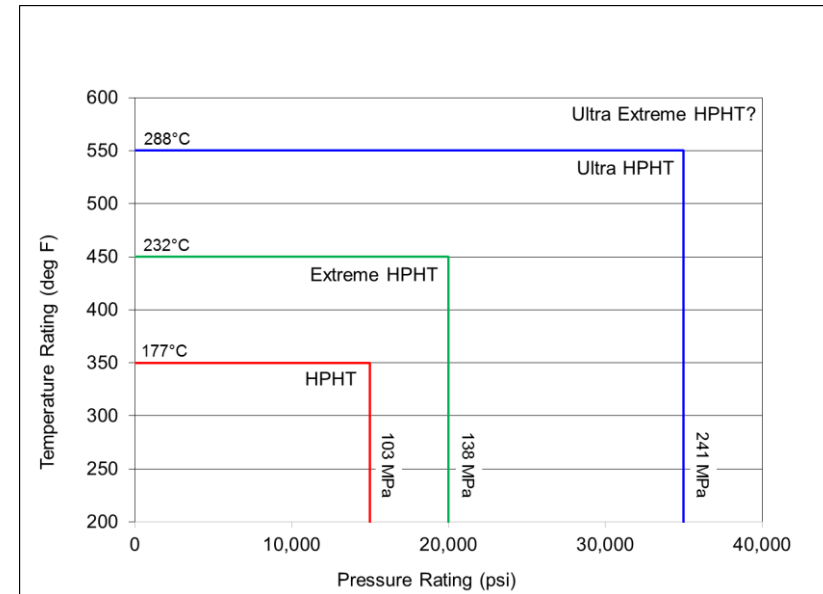
API CSOEM Organization

- Has 270 standards under it's purview.
- Roughly ½ of the standards are in development/revision.
- Each subcommittee develops and maintains standards through task/work groups according to established policies and procedures using volunteers.



HPHT Definition

- Various definitions in industry
 - Tier I, Tier II, Ultra-HPHT, etc.
- 30CFR250.804 also defines HPHT
 - >15,000 psi or >350°F
 - Used for today's activity

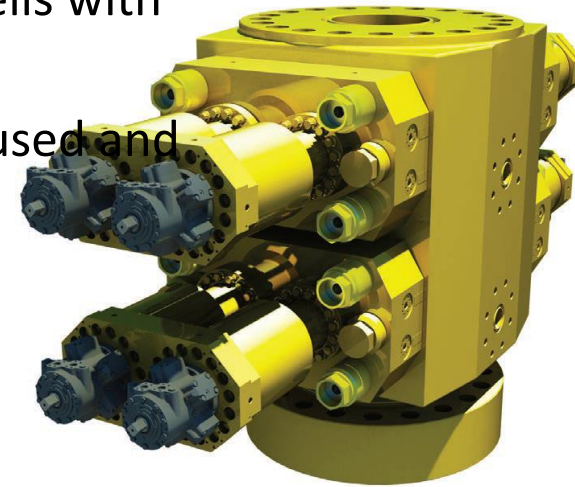


Activity Scope Limit

- Scope limit: Equipment typically used in well construction and production
 - does not include platforms, processing equipment, fire control systems, etc.
 - does not include documents which defer to normative references (e.g. API RP17W *Capping Stacks* defers to API 17G *Completion/Workover Risers* for pressure ratings)
 - Does not include other language versions of API publications
 - Does not include documents which COULD be used for HPHT conditions but contain no special requirements (e.g. RP19B *Evaluation of Well Perforators* or API 19G2 *Flow Control Devices*)

Examples from HPHT history

- HPHT is not new to the industry
 - 1974: Bertha Rogers 1 in Oklahoma encountered 24,850 psi and 475°F at 31,432 ft
 - 1979: Exxon Mongure in Mississippi used equipment rated at 30K psi and 350°F.
 - 1984-85: Both Shell and Arco drilled onshore wells with equipment rated at 30K psi and 350°F.
 - Last decade: Numerous sets of 20K equipment used and installed



CSOEM Standards Activity

- API TR 1PER15K-1 published 2013
 - Originally began under SC6 as RP6HP in 2005
 - Industry action to go back and clarify/re-codify the overarching principles to be used in developing HPHT equipment.
 - Early discussions about writing one document containing requirements for all products was abandoned.
 - Too many differences between downhole products and surface products (geometrical constraints)
 - Agreed path was Technical Report followed by product-specific requirements in product specifications

HPHT in SC2

- STD 2RD – Dynamic Risers for Floating Production Systems
 - Does not list HPHT equipment.
 - Does not preclude HPHT equipment.
 - Defers to API 5CT and 5L for pipe requirements
 - Contains extensive stress calculation requirements
 - Contains fatigue assessment requirements

HPHT in SC5

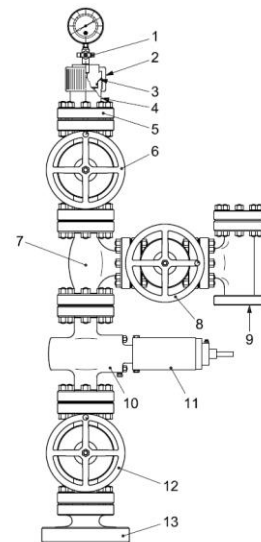
- API TR5C3 - Technical Report on Equations and Calculations for Casing, Tubing, and Line Pipe Used as Casing or Tubing; and Performance Properties Tables for Casing and Tubing
 - Provides technical guidance for the determination pipe performance properties for all casing/tubing size, weight, and grade combinations
 - Axial Strength
 - Collapse Resistance
 - Internal Pressure Resistance
 - Ductile Rupture
 - Lists 51 pipe size/wall/grade combinations with pressure ratings >15K psi
- API RP 5C5 Recommended Practice on Procedures for Testing Casing and Tubing Connections
 - Exposes the connections to both ambient and elevated temperature in all four quadrants on varying geometries and make up conditions.
 - Includes elevated temperature (356°F) testing for both CAL III and CAL IV

HPHT in SC5

- API RP7G - Recommended Practice for Drill Stem Design and Operating Limits
 - Lists 37 drill pipe size/wall/grade combinations with pressure ratings >15K psi

HPHT in SC6

- History of requirements in standards
 - AWHEM published the first draft of 15,000 psi flange dimensions in 1957.
 - 20K wellhead equipment first appeared in API Spec 6A in the 9th edition which was published in 1972.
 - API Spec 6AB covering 30,000 psi flanged wellhead equipment was published in 1983.
- API Spec 6A - Specification for Wellhead and Christmas Tree Equipment
 - 21st edition in draft
 - Adding boarding shutdown valves with minimum PSL 3
 - Clarifying requirements for “safety valves” (SSV, USV, BSDV), making PR2F testing and 6AV1 validation normative
 - Changing PSL 4 to be more aligned with HPHT material and NDE requirements for CRA materials



HPHT in SC6

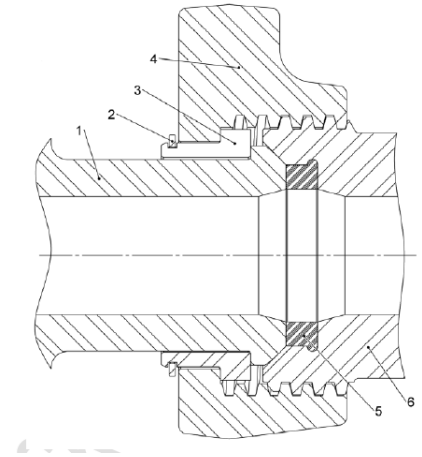
- API Std 6X - Design Calculations for Pressure-containing Equipment
 - Introduction gives a good history of pressure containing equipment calculations for both API SC6 and ASME BPVC
- API TR 6AF - Technical Report on Capabilities of API Flanges Under Combinations of Load
 - Includes 69 rating charts for Type 6BX flanges with pressure vs. bending moment with tension (including 20K and 30K flanges) but no temperature
- API TR 6AF1 - Technical Report on Temperature Derating on API Flanges Under Combination of Loading
 - Similar work to TR 6AF but with ratings at 350°F and 650°F for 4 grades of materials. Does not include 30K flanges.

HPHT in SC6

- API TR 6AF2 - Technical Report on Capabilities of API Integral Flanges Under Combination of Loading—Phase II
 - Similar work to TR 6AF but with ratings at 250°F internal and 30°F external. Does not include 30K flanges.
- API TR 6MET - Metallic Material Limits for Wellhead Equipment Used in High Temperature for API 6A and 17D Applications
 - Yield strength degradation charts for 11 common alloys from 300°F to 450°F
- API TR 6F1 - Technical Report on Performance of API and ANSI End Connections in a Fire Test According to API Specification 6FA
 - Includes both predicted results and actual results
- API Spec 6FA - Specification for Fire Test for Valves
- API Spec 6FB - Specification for Fire Test for End Connections
- API Spec 6FD - Specification for Fire Test for Check Valves

HPHT in SC8

- API Spec 7K - Drilling and Well Servicing Equipment
 - WI 3201 to add 20K cement hoses in process
- API Spec 7HU2 – Hammer Unions
 - Document in process
 - Contains complete dimensional and material requirements for hammer unions
 - Includes 20K rated products for standard service
 - Refers to API Spec 6A and ASME BPVC Section VIII, Div 2, Part 5 for design



HPHT in SC10

- API RP10B-2 – Recommended Practice for Testing Well Cements
 - Includes high temperature tests based on well depths and temperature gradients
- API Std 65-2 - Isolating Potential Flow Zones During Well Construction
 - Includes guidelines and requirements for all cementing operations
- API RP10F - Recommended Practice for Performance Testing of Cementing Float Equipment
 - Includes testing requirements at 400°F and 5,000 psi
 - In revision to move to specification for equipment



HTHP in SC13

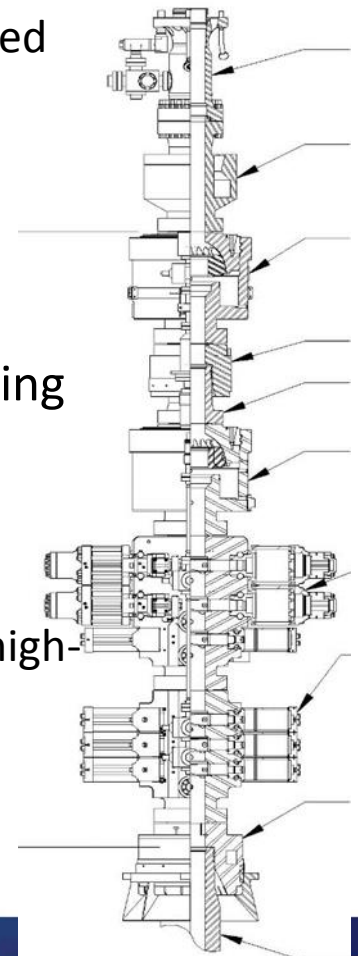
- API RP 13D - Rheology and Hydraulics of Oil-well Fluids
 - Contains basis understanding and guidance about drilling fluid rheology and hydraulics
 - Gives equations and methods for estimating fluid density for HTHP wells
 - Describes use of HTHP viscometer (40K psi, 600°F) for measuring fluid properties
- API RP13B-2 Recommended Practice for Field Testing Oil-based Drilling Fluids and API RP 13I - Recommended Practice for Laboratory Testing of Drilling Fluids
 - HTHP testing of filtrate properties to 500°F

HPHT in SC16

- API Spec 16A - Specification for Drill-through Equipment
 - 20K drill-through equipment first appeared in API 6A 9th edition in 1972. 16A 1st edition was published in 1982.
 - 4th edition published
 - Contains 7 sizes with 20K pressure ratings and temps up to 350°F
 - Includes extensive testing and fatigue testing requirements
 - 20K, 25K, and 30K BOPs have been produced and installed
- HPHT workgroup in process to write HPHT requirements for BOPs as annex to API 16A, 4th Edition
 - Initial ballot out for comment.
 - Projected completion in late 2017

HPHT in SC16

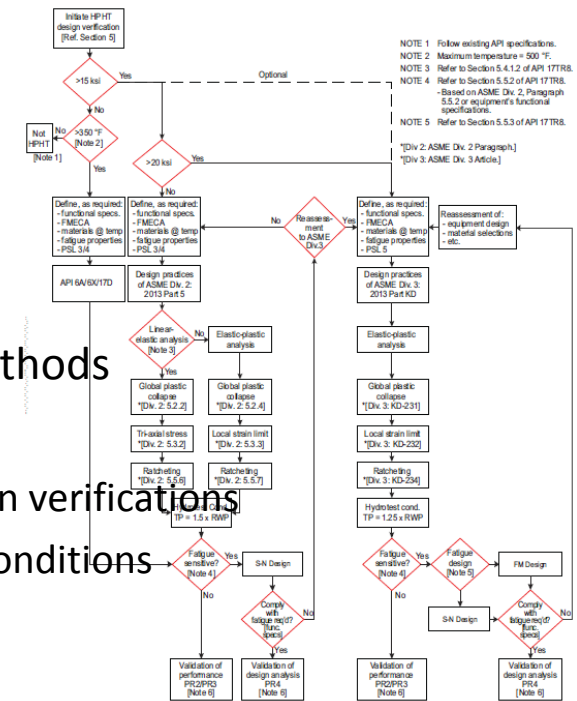
- API Spec 16C - Choke and Kill Equipment
 - Includes 5 sizes of equipment to 20K; 3 sizes of union/articulated line sizes to 20k; and 4 sizes of flexible line sizes to 20k
 - Defers to API 6X, API 6A, and API 16A for many items
 - Requires hydrostatic testing to 1.5x RWP
- API Std 53 - Blowout Prevention Equipment Systems for Drilling Wells
 - Includes 20K, 25K, and 30K equipment ratings for surface and subsea BOPs
 - Requires consideration of elastomeric seal compatibility with high-pressure, high-temperature conditions.



HPHT in SC17

- API TR 17TR8 - High-pressure High-temperature Design Guidelines

- Design guidelines for oil and gas subsea equipment
- Limits temperature considerations to 550°F
- 3 verification methods provided
- 2 fatigue assessment methods
- Material selection and property testing listed
- Seals and bolting
- Design validation recommendations
- Hydrostatic testing multiplier tied to verification methods
- Revision in process to:
 - Standardizing material testing protocols used in design verifications
 - Identifying design margins for Extreme and Survival conditions
 - Develop annex for fatigue analysis input parameters.



HPHT in SC17

- API Spec 17D - Design and Operation of Subsea Production Systems - Subsea Wellhead and Tree Equipment
 - 20K wellheads are available from at least 3 suppliers with at least 12 installed.
 - Revision of 17D planned to address specific requirements for HPHT
- API RP17G - Recommended Practice for Completion/Workover Risers
 - Includes 20K psi ratings and up to 650°F temperature ratings
 - Contains extensive stress calculation and fatigue assessment requirements
 - Currently in revision

HPHT in SC19

- API Spec 14A – Specification for subsurface safety valve equipment
 - Includes HPHT annex with additional requirements for
 - Materials (both metal and non-metal)
 - Design Verification including fatigue screening
 - Extensive design validation
 - Limits of design scaling
 - Quality plan for manufacture
 - Final design review
- API Spec 11D1 – Packers and Bridge Plugs
 - Includes HPHT annex with requirements similar to API Spec 14A
 - Includes annex with requirements for HPHT operating tools
- Others in revision to add HPHT annex
 - API Spec 14L – Specification for Lock Mandrels and Landing Nipples
 - API Spec 19AC – Completion accessories
 - API Spec 19G1 – Side-pocket mandrels



NE™ Tubing-Retrievable
Safety Valve (TRS)

HPHT in SC19

- API TR 19TR1 – HPHT Guidelines
 - Document in process to standardize the approach to writing HPHT requirements for SC19 equipment. All requirements are additional to “front matter”.
 - Includes:
 - More elaborate functional specifications (e.g. environment details)
 - More stringent technical specifications (e.g. elastomer compound assessments)
 - Enhance design verification analyses (FEA to ASME codes)
 - Enhanced design validation tests (no specifics, each product spec writes this section)
 - More stringent manufacturing requirements (NDE, welding, etc.)

HPHT in SC20

- Documents set qualification levels for sub-suppliers and extend requirements into supply chain for base products and processes.
 - API Spec 20A - Carbon Steel, Alloy Steel, Stainless Steel, and Nickel Base Alloy Castings for Use in the Petroleum and Natural Gas Industry
 - API Spec 20B - Open Die Shaped Forgings for Use in the Petroleum and Natural Gas Industry
 - API Spec 20C - Closed Die Forgings for Use in the Petroleum and Natural Gas Industry
 - API Spec 20E - Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries
 - API Spec 20F - Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries
 - API Std 20D - Nondestructive Examination Services for Equipment Used in the Petroleum and Natural Gas Industry
 - Many others in process

HPHT Research in API

- Conducted as part of normal standards development
- SC5 – Tubular Goods
 - Investigating temperature effects on modulus of elasticity
 - Investigating collapse of 9-7/8 and 11-7/8 sizes at elevated temperature
 - Investigating alternative calculation methods for high-collapse pipe
- SC8 – Drilling Structures and Equipment
 - Verification FEA analysis for hammer union designs
- SC10 – Well Cements
 - Investigating measurement methods on static gel strength development to reduce variation.
- SC21 – Materials subcommittee
 - Temperature de-rating of material yield strength
 - Grade 660 bolting elevated temperature testing
 - Near-yield cycle testing

Closing remarks

- 34 standards reviewed containing HPHT requirements.
- The industry has a wealth of historical use information; even on HPHT.
- Standards follow innovations and learning. Changes to standards are normal and to be expected.
- Participation in standards development is welcomed and necessary.
- Our next API meeting is in San Antonio!