

# Overview of API Standards activity on HPHT

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# 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

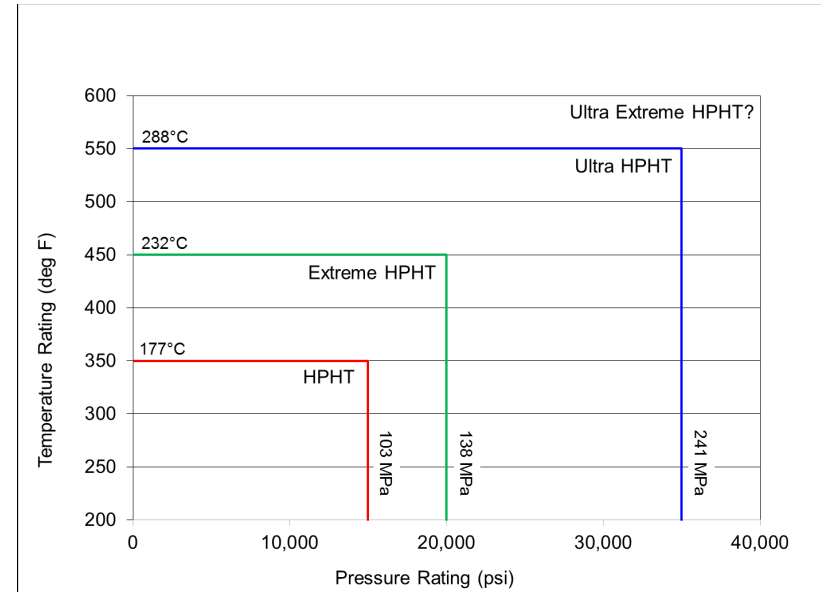
# API CSOEM Organization

- Has 292 standards under its purview.
- 142 standards are in development or revision with 55 being first editions.
- 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

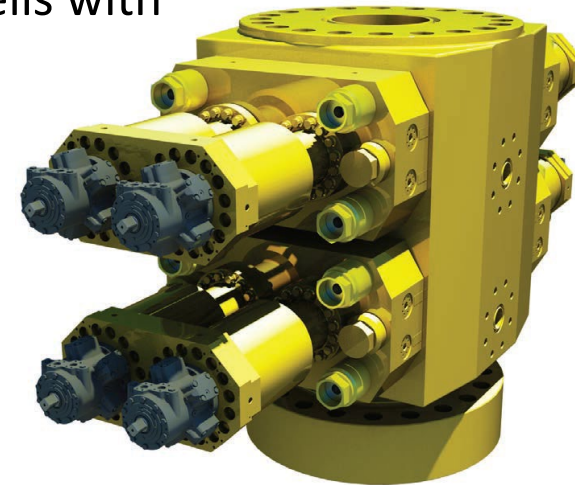


# HPHT Scope Limit

- 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 today 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 - Protocol for Verification and Validation of High-pressure High-temperature Equipment (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 (2013)
  - 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
  - **Currently in revision**

# HPHT in SC5

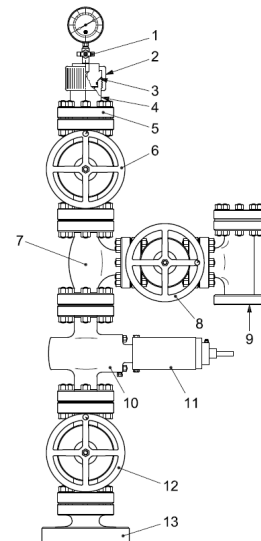
- API TR5C3 - Technical Report on Equations and Calculations for Casing, Tubing, and Line Pipe Used as Casing or Tubing; and Performance Properties Tables for Casing and Tubing (2018)
  - Provides technical guidance for the determination pipe performance properties for all casing/tubing size, weight, 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 (2017)
  - 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 (1998)
  - Lists 37 drill pipe size/wall/grade combinations with pressure ratings >15K psi
  - In revision

# 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
  - **21<sup>st</sup> edition in revision**
  - 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

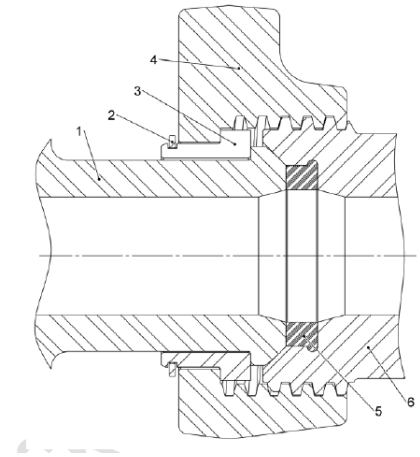
- API Std 6X - Design Calculations for Pressure-containing Equipment (2014)
  - Introduction gives a good history of pressure containing equipment calculations for both API SC6 and ASME BPVC
  - **In revision**
- API TR 6AF - Technical Report on Capabilities of API Flanges Under Combinations of Load (2010)
  - 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 (1998)
  - 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 (2013)
  - 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 (2018)
  - 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 (1999)
  - Includes both predicted results and actual results
- API Spec 6FA - Specification for Fire Test for Valves (2018)
- API Spec 6FB - Specification for Fire Test for End Connections – in revision
- API Spec 6FD - Specification for Fire Test for Check Valves – in revision

# HPHT in SC8

- API Spec 7K - Drilling and Well Servicing Equipment (2015)
  - WI 3201 to add 20K cement hoses in process
- API Spec 7HU2 – Hammer Unions
  - **Document in development**
  - 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 (2013)
  - Includes high temperature tests based on well depths and temperature gradients
- API Std 65-2 - Isolating Potential Flow Zones During Well Construction (2010)
  - Includes guidelines and requirements for all cementing operations
- API RP10F - Recommended Practice for Performance Testing of Cementing Float Equipment (2018)
  - Includes testing requirements at 400°F and 5,000 psi
  - **In revision** to move to specification for equipment



# HTHP in SC13

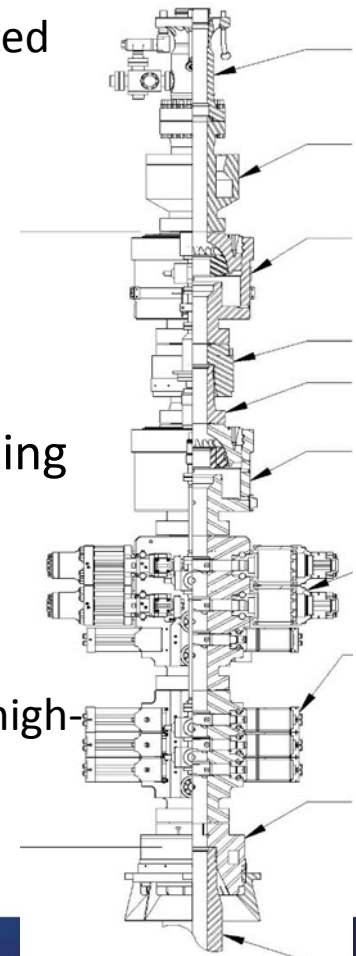
- API RP 13D - Rheology and Hydraulics of Oil-well Fluids (2017)
  - Contains basis understanding and guidance about drilling fluid rheology and hydraulics
  - Gives equations and methods for estimating fluid density for HTHP wells
  - Describes use of HTHP viscometer (40K psi, 600°F) for measuring fluid 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 (2014)
  - HTHP testing of filtrate properties to 500°F
  - In revision

# HPHT in SC16

- API Spec 16A - Specification for Drill-through Equipment (2017)
  - 20K drill-through equipment first appeared in API 6A 9<sup>th</sup> edition in 1972. 16A 1<sup>st</sup> edition was published in 1982.
  - 4<sup>th</sup> 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
  - In revision to create 5<sup>th</sup> edition
- HPHT workgroup in process to write HPHT requirements for BOPs as addendum to API 16A, 4th Edition
  - Comment resolution in process.
  - Projected completion in late 2018.

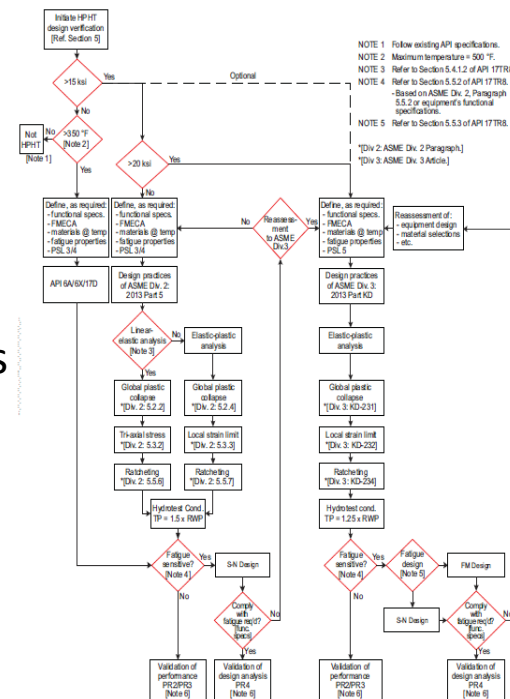
# HPHT in SC16

- API Spec 16C - Choke and Kill Equipment (2015)
  - 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
  - In revision
- API Std 53 - Blowout Prevention Equipment Systems for Drilling Wells (2016)
  - Includes 20K, 25K, and 30K equipment ratings for surface and subsea BOPs
  - Requires consideration of elastomeric seal compatibility with high-pressure, high-temperature conditions.
  - In revision



# HPHT in SC17

- API TR 17TR8 - High-pressure High-temperature Design Guidelines (2018)
  - Design guidelines for oil and gas subsea equipment including Extreme and Survival conditions
  - 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



# HPHT in SC17

- API Spec 17D - Design and Operation of Subsea Production Systems - Subsea Wellhead and Tree Equipment (2011)
  - 20K wellheads are available from at least 3 suppliers with at least 12 installed.
  - **In revision** to address specific requirements for HPHT
- API RP17G - Recommended Practice for Completion/Workover Risers (2006)
  - 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 (2015)
  - 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
  - **In revision** to add Annular Safety Valves
- API Spec 11D1 – Packers and Bridge Plugs (2015)
  - Includes HPHT annex with requirements similar to API Spec 14A
  - Includes annex with requirements for HPHT operating tools
  - **In revision** for general update



NE™ Tubing-Retrieval  
Safety Valve (TRSV)



# HPHT in SC19

- **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
- API TR 19TR1 – HPHT Guidelines (2018)
  - SC19 resource document to standardize the approach to writing HPHT requirements for SC19 equipment. All requirements are additional to “front matter”.
  - Topics:
    - Functional specifications
    - Elastomer compound assessments
    - Design verification analyses (FEA to ASME codes)
    - Enhanced manufacturing requirements (NDE, welding, etc.)

# 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

- 35 standards reviewed containing HPHT requirements.
  - 9 have been published in the last 2 years
  - 19 are currently in revision.
- 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!