API 17TR8 – HPHT Design Guideline for Subsea Equipment
API 17D Future with HPHT

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In the Beginning...

**API 6HP** – primarily focused on burst before leak and 25k BOP equipment being too heavy – 1.5 x RWP vs. 1.25 x RWP? External hydrostatic pressure to compensate?

Next was **API PER 15K** to identify all wellbore issues and challenges associated with HPHT (anything above 15k RWP) from sand face to pipeline – looked at things holistically.

But PER 15K points to the problems that each API Subcommittee needs to address – never intended to “solve” them... *it is not a design guideline*

**API 17TR8** is Subsea’s attempt at providing some of the guideline solutions.
Holistic View – 1PER15K-1

Figure 1—System Analysis Specification Breaks (Completion)

Figure 2—System Analysis Specification Breaks (Drilling)
How is HPHT Defined? What Code Rules?

Source: OTC 17927, 23943, 25376
Thicker wall sections change the "pressure vessel model", but where? Don't know where leak before burst ends and fast fracture failure begins.

Source: OTC 23621
17TR8: The HPHT Method

- Design Methodology – roadmap for transition from Div 2 to Div 3
- Populate oil field material data sheets at elevated temperatures
  - Establish physical properties and QA lists
- Establish HPHT validation tests
  - Extended function testing standard
  - Guidance for project specific testing
API 6A, 17D

ASME Div 2


ASME Div 3

Design Practices of ASME Div. 3: 2013 Part KD

Path selected determines:
Test pressure,
Design margins, QA

“All codes are created equal: some more equal than others”
Quality and Qualification Requirements

“Buckets” to capture physical properties and performance tests:

PSL 5 to address tighter QA requirements in material strength (+/- range), ovality, cross section thinning, chemistry, prolongations, stress relaxation properties, etc.

PR 3 to address extended functioning component at HPHT conditions; gas test medium, blow down safety, more temperature cycles, etc.

PR 4 to address cyclic loading, fracture mechanics S-N fatigue, criticality and project specific cyclic design life
17TR8: HPHT Materials Properties

Design Properties *

- Mechanical Properties
  - Tensile Properties (including tensile modulus)
  - Fracture Toughness ($K_{1c}$)
  - Crack Growth Rate ($da/dN$)
  - Fatigue S–N curve

- Physical Properties
  - Thermal conductivity
  - Specific heat capacity
  - Density
  - Thermal expansion
  - Poisson Ratio
  - NACE Test (2% or defined strain limit)
  - Stress Relaxation

Quality Control **

- Chemistry / Composition Requirements
- Mechanical Properties
  - Tensile Properties (tight range)
  - Charpy, CTOD
  - Hardness

- Microstructure and Grain Size
  - NDE
  - Minimum Crack Size

- Process Control
  - Melting, Forging
  - Heat Treatment, QTC Prolongation Testing
  - Dimensional – Ovality, Thinning

* For discrete temperatures 75, 350, 450, 550, 650 F
** For QC temperatures defined by ASME VIII, Div 3
Fatigue Assessment:

- Determine if equipment is fatigue sensitive
  - ASME fatigue screening criteria (ASME Div. 2 Section 5.5.2)
    - internal – pressure/temperature; external – mechanical

- Fatigue analysis:
  - S–N approach
  - Fracture Mechanics (FM) approach

- May require:
  - Load–monitoring
  - NDE method capability and its probability of detection (PoD) to identify flaws
  - Multiple flaws assessment

Non-uniform stress field – gray “above yield”
Autofrettage Effect
Source: OTC 23063, 23621
Both Leak or Burst are catastrophic events because it’s hard to turn off a reservoir.

• Need a different differentiator
• Oil industry has “two barrier” rule for safe operation.
• Locations where a fatigue failure could compromise primary barrier are critical and more detailed analysis – fracture mechanics

Loss of Barrier

VXT
(with Tubing Head)

VXT
(in the wellhead)

HXT and EHXT

Tubing Head

Subsea Wellhead

Tubing Hanger

Critical break

Less critical break – but where do you draw the lines?
17TR8: HPHT Validation

- Can define within a “standard”
- Additional Function Testing
  - Extended testing at Temperature

- Can’t define within a “standard”
- Fatigue Design Requirements
  - S–N Curve for machined parts, welds, notches, etc.
  - Fracture Mechanics
    - Define crack size, material toughness
  - Define cycle life and cyclic testing
- FMECA of Critical Components
  - Additional project specific tests
HPHT Future of 17D

- Task Group to start Next Revision in 2015 – 16 time frame
- Task Group’s intent is to stay synchronized with API 6A; especially manufacturing
- HPHT intent is to offer higher RWP and Operating Temperature by expanding tables.
  - Keep 5ksi increments
  - 50 or 100 °F temperature class increments
- Decide how much extended testing at temperature (% more) is required for PR 3
- Intent is to cite as much of 17TR8 and 6A/6X instead of re-writing
  - 15ksi & below – API 6X
  - 25ksi & above – Div 3 path of 17TR8
  - 20ksi? – but can’t have multiple paths or test pressures
Future of 17TR8

- First edition to be balloted for publication in 2014
- Second edition – work still to be done in 2014 – 15
  - Welding and cladding and associated crack design issues
  - Reconcile ASME and NACE
  - Refine cyclic and fatigue analysis
  - Add Sensors and Monitoring for cycle life
  - Systems engineering of spec breaks and interfaces
  - Work with ASME Div 3 to submit a “code case”
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Questions?