# World Oil® HPHT

## DRILLING, COMPLETIONS & PRODUCTION CONFERENCE

September 26–27, 2017

Norris Conference Centers – CityCentre, Houston, Texas

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# API 17TR8 – Two Years On

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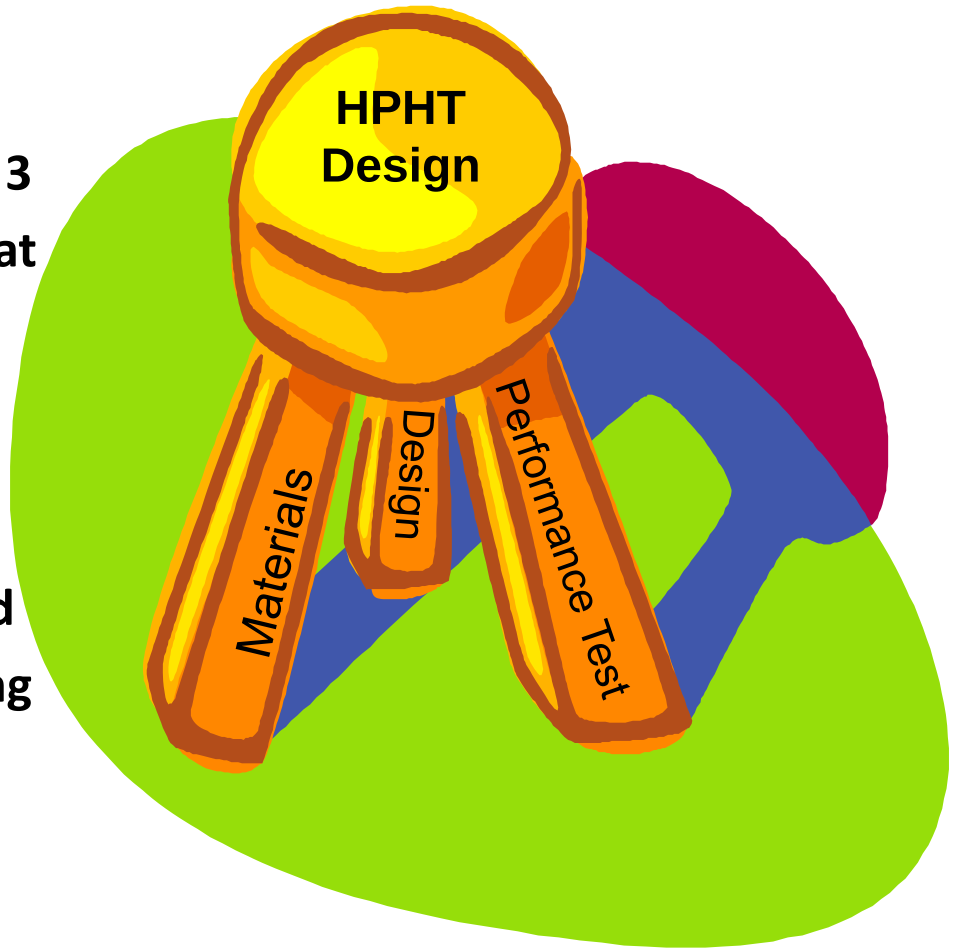
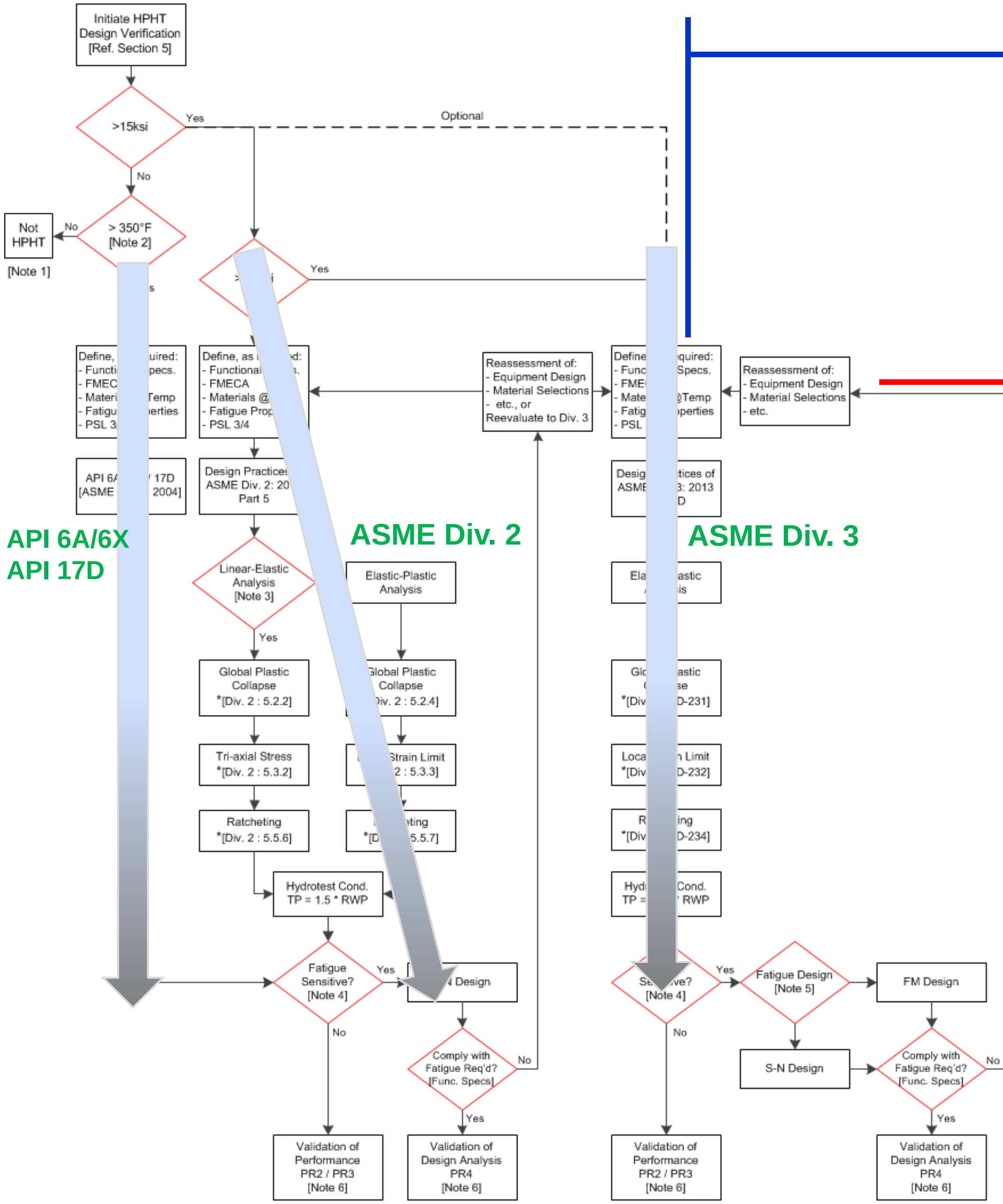
World Oil® HPHT
DRILLING, COMPLETIONS & PRODUCTION CONFERENCE

# 17TR8: The HPHT Method - February 2015

- Design Methodology – roadmap for transition from API 6X and 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 17TR8: HPHT Design Flow Chart

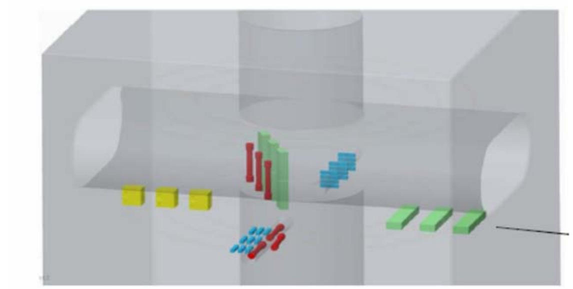



Scope of Equipment (based on API Pressure Rating, RWP)

- ≤ 15 ksi
- > 15 ksi (HP)

Define:

- Functional Specifications
- Failure Modes, Effects and Criticality Analysis (FMECA)
- Material Properties (at Temperature)
  - < 350F
  - ≥ 350F (HT)



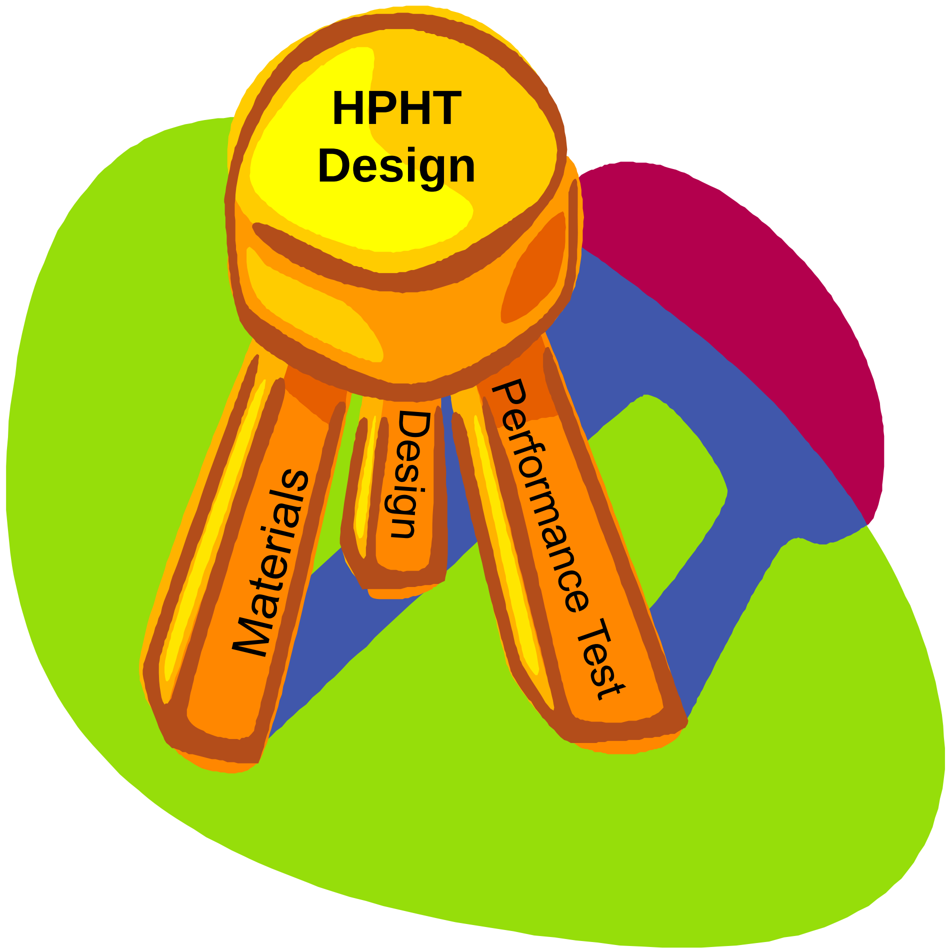
Design Verification (for failure modes)

- Plastic Collapse
- Local Strain Limit
- Ratcheting
- Fatigue and fracture assessment

Design Validation

# 17TR8: The HPHT Method – Second Edition

- Design Methodology – roadmap for transition from Div 2 to Div 3
  - Add Normal/Extreme/Survival criteria
  - Expand Fatigue Assessment criteria
- Oil field material data sheets at elevated temperatures
  - Recognize and incorporate new Materials Standards
  - Establish generic physical environment
- Expanded Annex on Load Monitoring

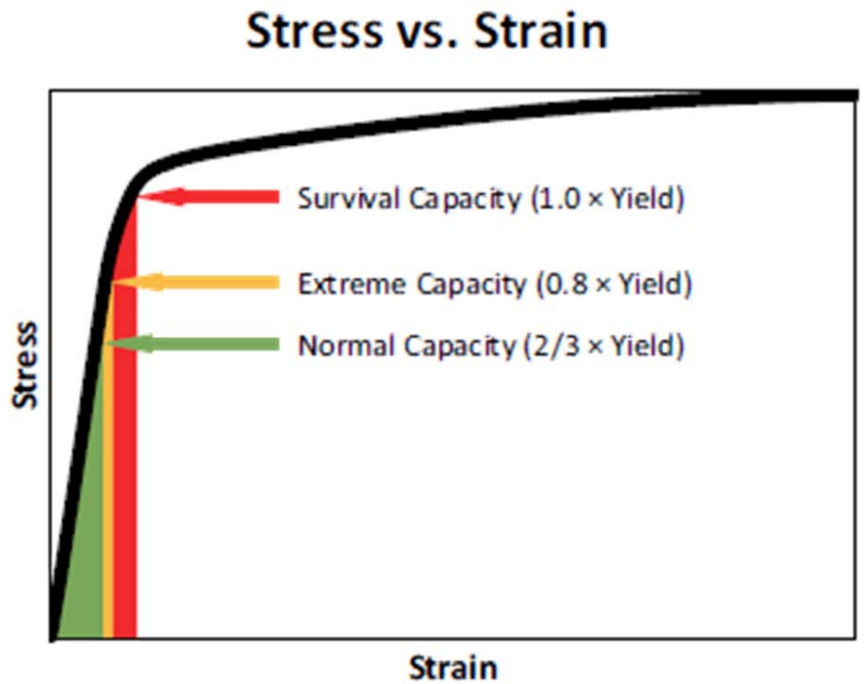


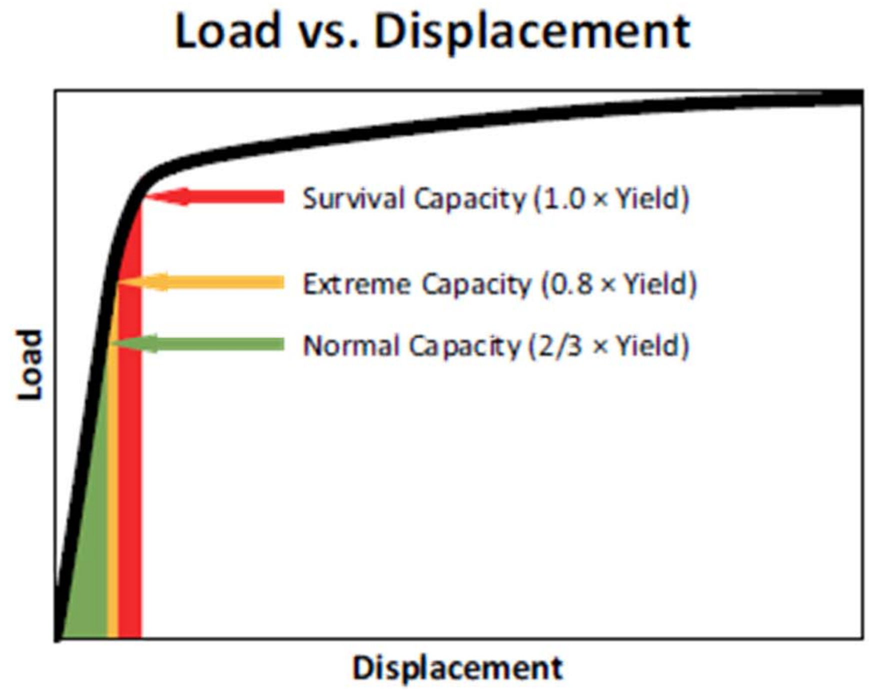
# Code Updates Since 2015

- API Spec 20 B and C on forgings
- DNV RP 34 on forgings for subsea applications
- API Spec 20 E and F on bolting
- API 579-1 adding strain based fatigue analysis [Level 3]

# Normal/Extreme/Survival - LRFD Capacities

| Operating Conditions | Elastic |
|---|---|
| Normal | 0.67 × Yield |
| Extreme | 0.80 × Yield |
| Survival | 1.00 × Yield |

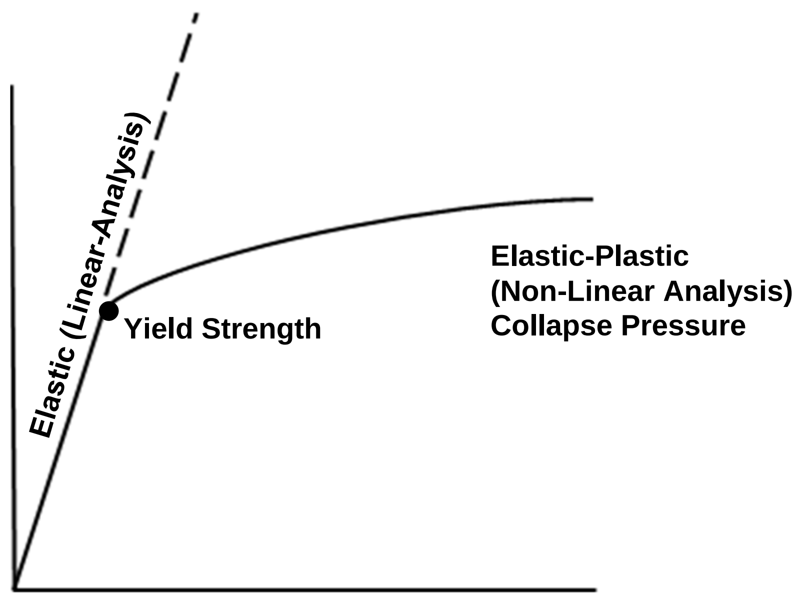


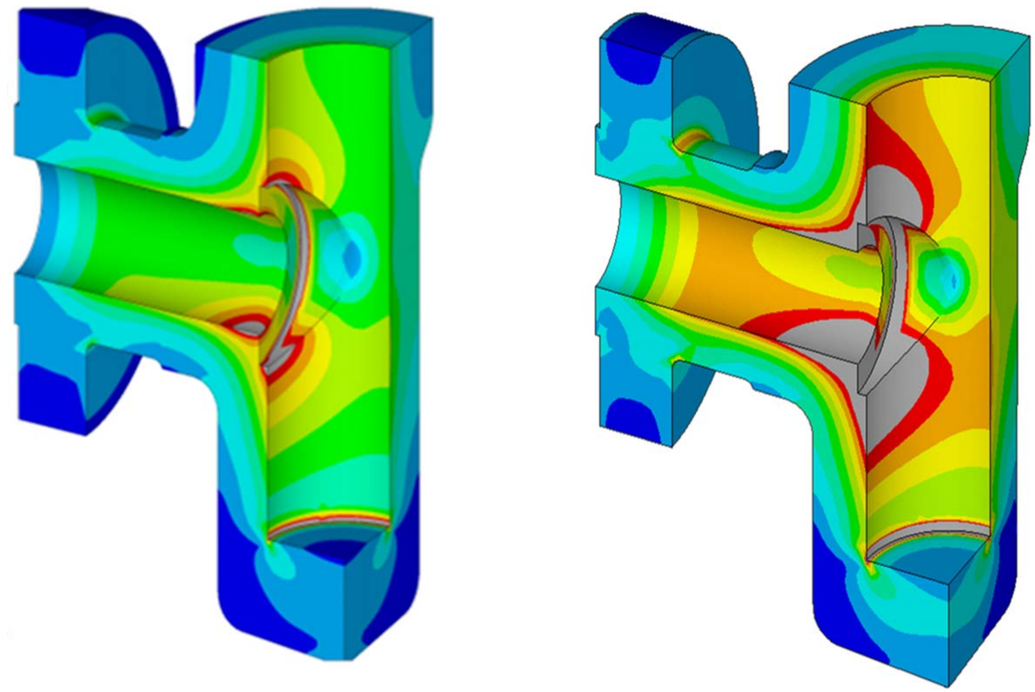

***Yield Strength must be minimum value over range of operating temperatures***

# Normal/Extreme/Survival - LRFD Capacities

| Operating Conditions | Elastic | "Div. 2" Elastic-Plastic | "Div. 3" Elastic-Plastic |
|---|---|---|---|
| Normal | 0.67 × Yield | 2.40 | 1.80 |
| Extreme | 0.80 × Yield | 2.00 | 1.50 |
| Survival | 1.00 × Yield | 1.60 | 1.20 |



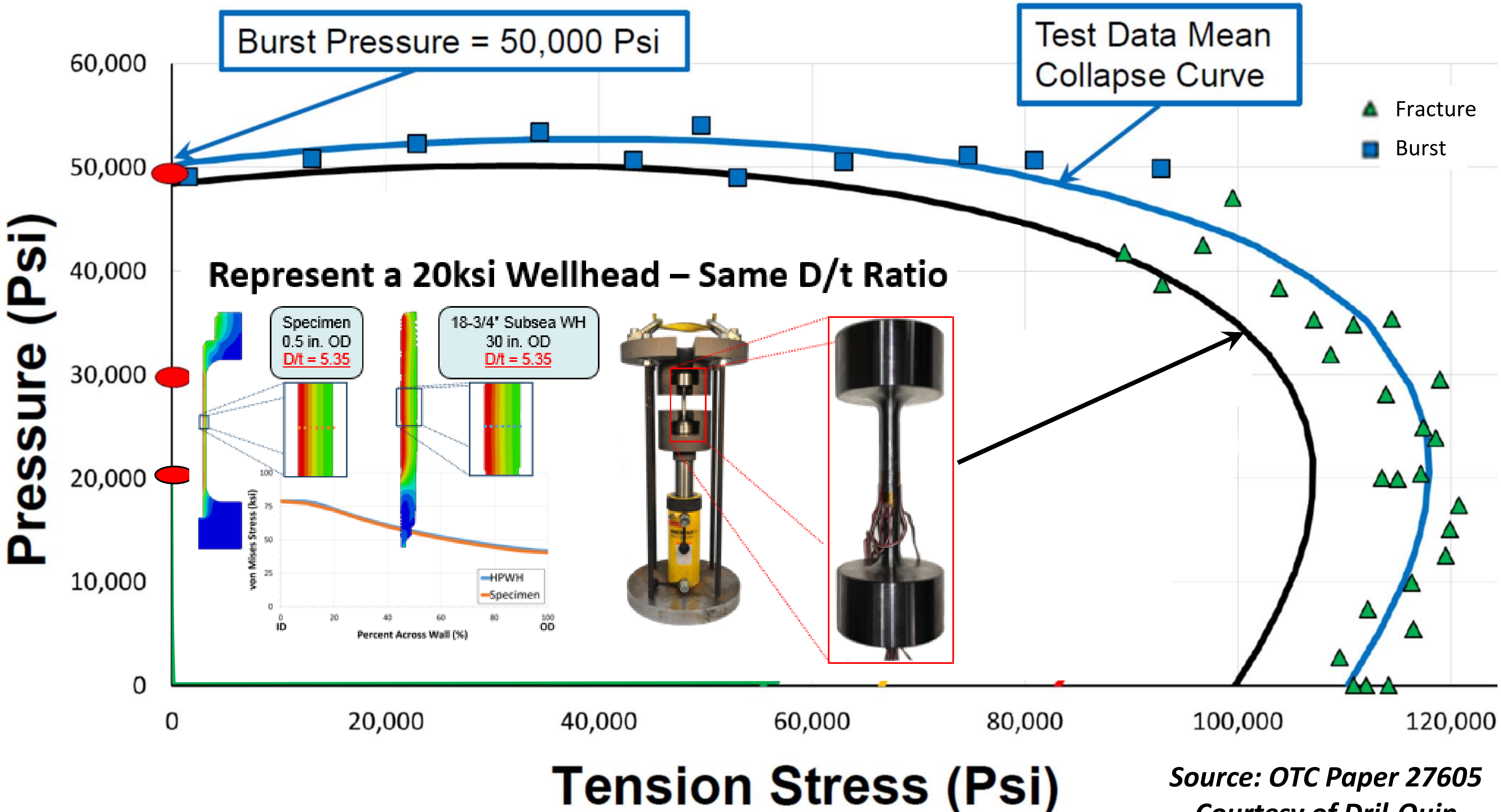

Material Stress-Strain Curve - Example



***Yield Strength must be minimum value over range of operating temperatures***

# Performance Envelope

API 17TR8 Validated with 50-SampleTesting




***Source: OTC Paper 27605***
***Courtesy of Dril-Quip***

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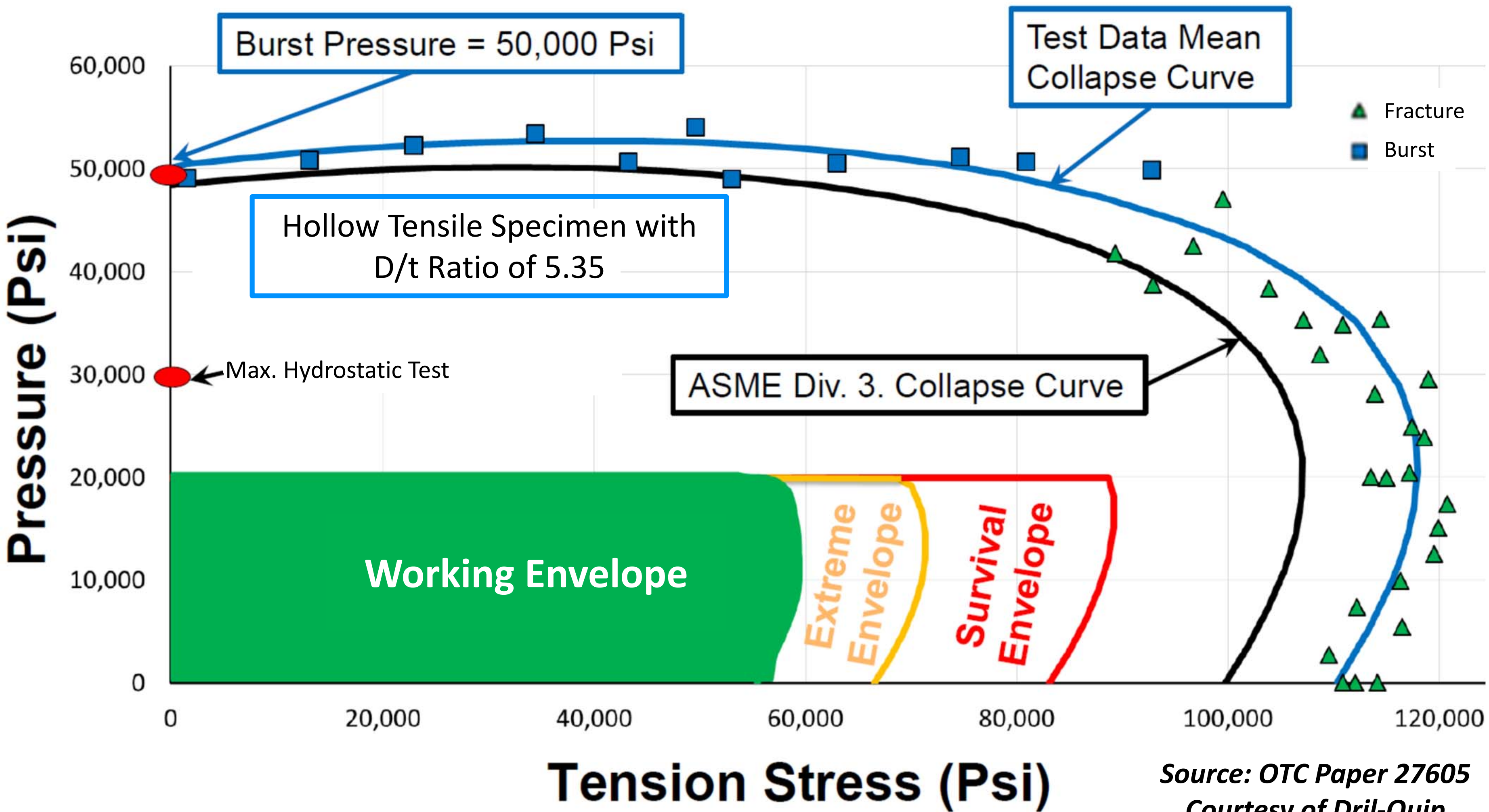


***Source: OTC Paper 27605***
***Courtesy of Dril-Quip***

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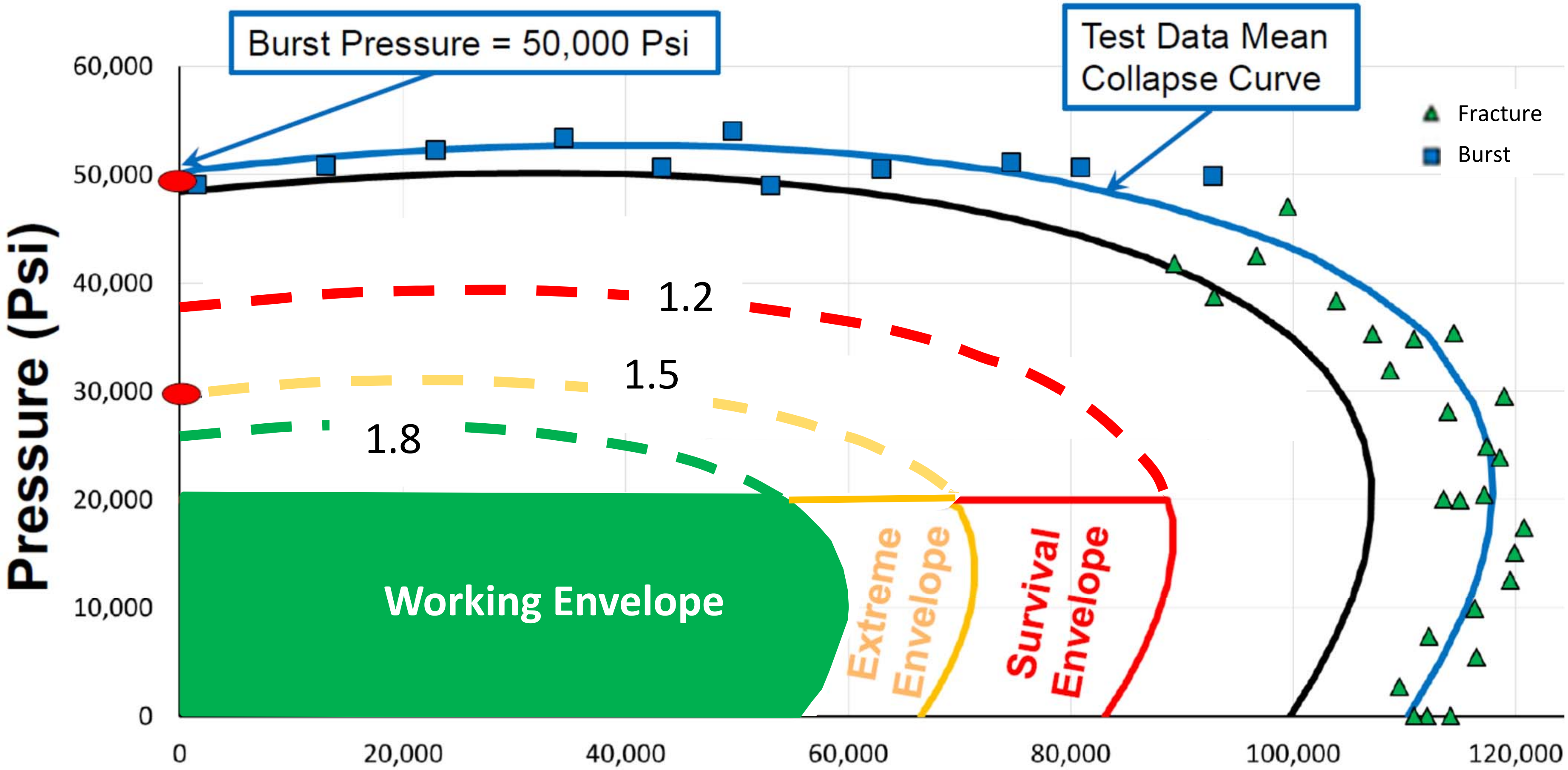
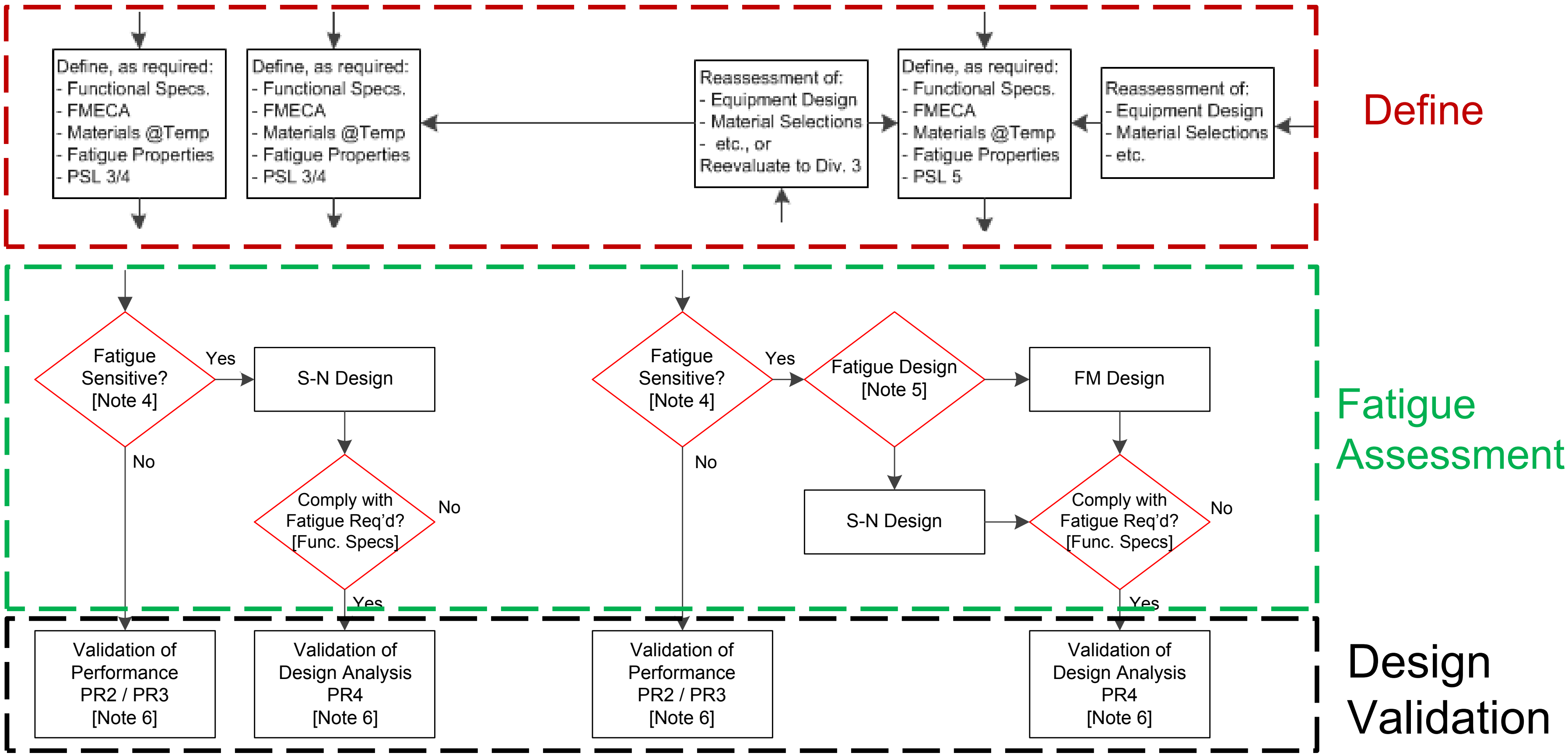



*Source: OTC Paper 27605*
*Courtesy of Dril-Quip*

# 17TR8: Design Flow Chart – Tug-of-War



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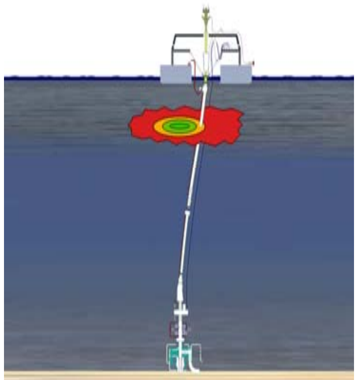
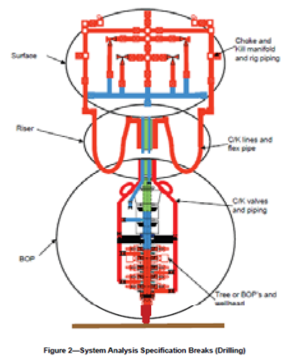
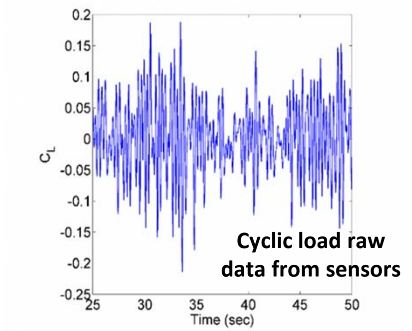


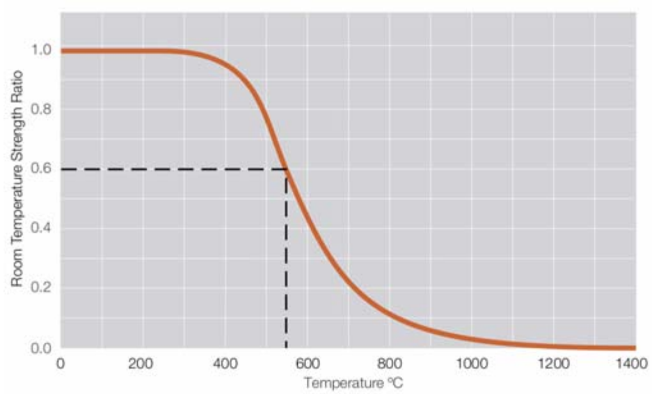
What metocean, vessel watch circle and well operations define Normal-Extreme-Survival conditions



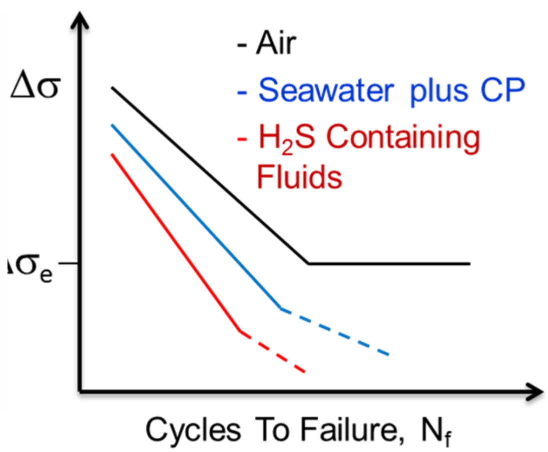

Where component used defines "criticality" and may add more FMECA criteria



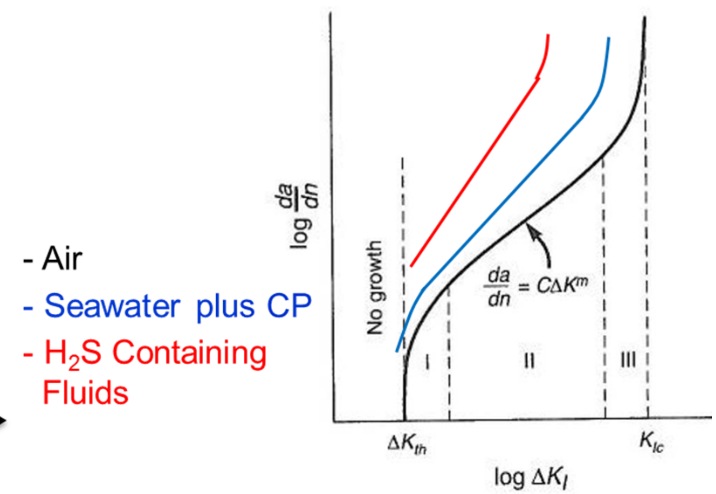

Production Log Histogram




Material Strength vs. Temperature

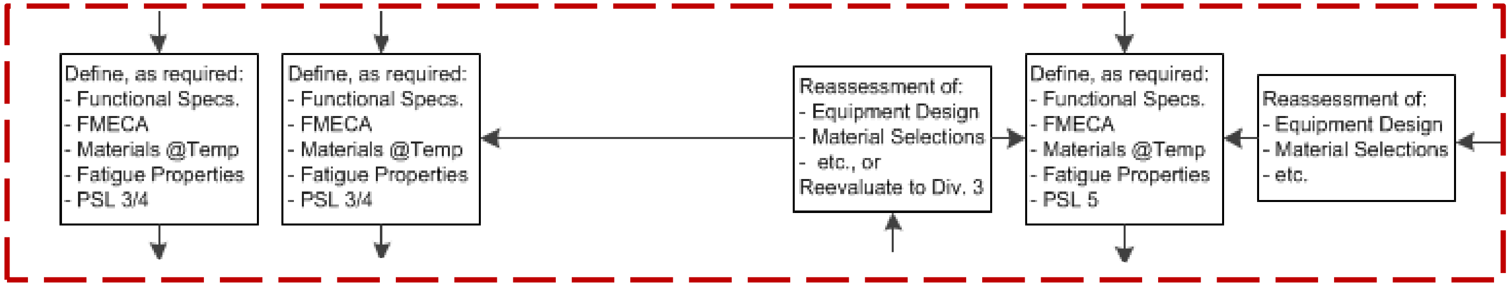



S-N Fatigue Curve




Fatigue Crack Growth Rate (FCGR)

# Material Characterization Protocol




Define

**6.1.2.2 Produced/Condensed Fluids**

For exposure to produced/condensed fluids in HPHT applications where the actual field specific environmental conditions are not available, material testing and correlation should be performed using one of the following standard fluids, as applicable:

1) NACE TM0177 with Test Solution A or Test Solution B;

2) NACE MR0175/ISO 15156-3, Annex E (nominated sets of test conditions to help determine acceptable limits for the application of CRAs and other alloys).

**6.1.2.3 Seawater and Cathodic Protection**

For external exposure to seawater and CP, the following should be considered for material testing and correlation to confirm material resistance to HISC (duplex stainless steels) and HAC (CRAs such as Ni-based alloys and other alloys):

1) testing in synthetic seawater produced in accordance to ASTM D1141;

2) CP voltage between –950mV to –1100mV (versus Ag/AgCl) or current density requirements as referenced in NACE SP0176, Table A1 for the specific region.

First Edition

**Table D.1 — Recommended GoM Production Environments**

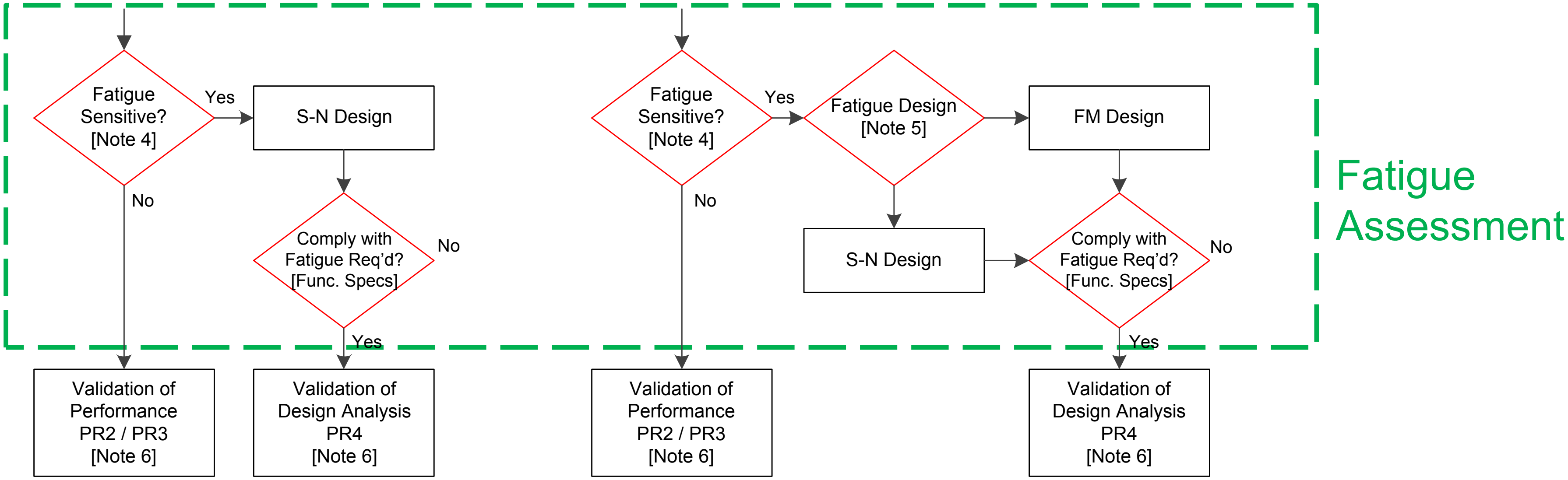
| | Gas Field | Oil Field |
|---|---|---|
| Chloride ($Cl^-$) | 5,000 ppm | 100,000 ppm |
| $CO_2$ gas | 20 mol % | 5 mol % |
| $H_2S$ gas | 50 ppm | 50 ppm (water flooding not considered) |
| pH | 3.5 | 5.0 |
| Temperature | • 40 °F for CS and LAS<br>• Maximum Design Temperature for CRA | • 40 °F for CS and LAS<br>• Maximum Design Temperature for CRA |

**Table D.2 — Recommended Seawater Test Environments**

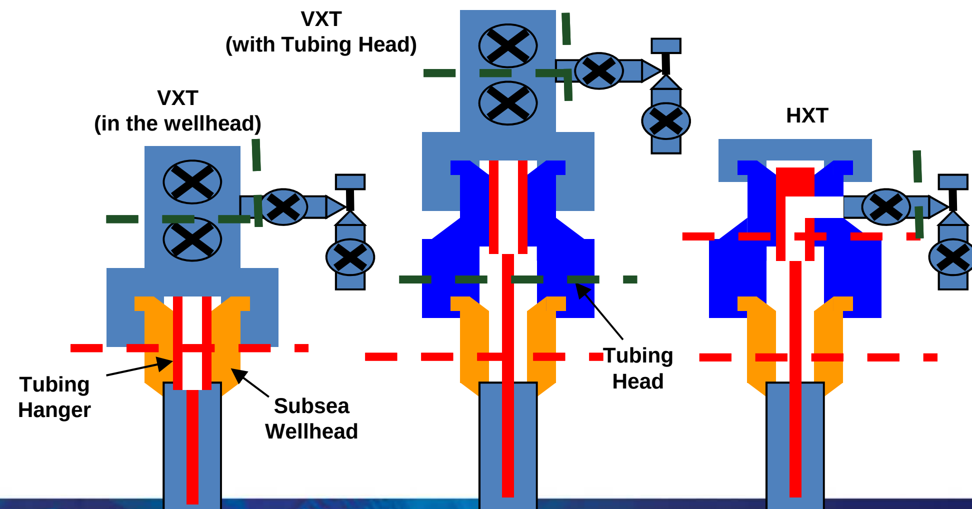
| | | |
|---|---|---|
| NaCl | 3.5 wt% dissolved in water or ASTM D1141 | Ambient (40 °F) |
| pH | 8.2 (adjusted with NaOH) | Ambient (40 °F) |
| Electrode Potential | -1000 to -1100 mV vs Ag/AgCl | Ambient (40 °F) |

Second Edition

# 17TR8: Design Flow Chart – Fatigue Assessment




- Loss of Barrier analysis
  - Fracture Mechanics or S-N
- Stress based fatigue assessment
  - ASME VIII-2, section 5.5.2
  - ASME VIII-3, Article KD-3



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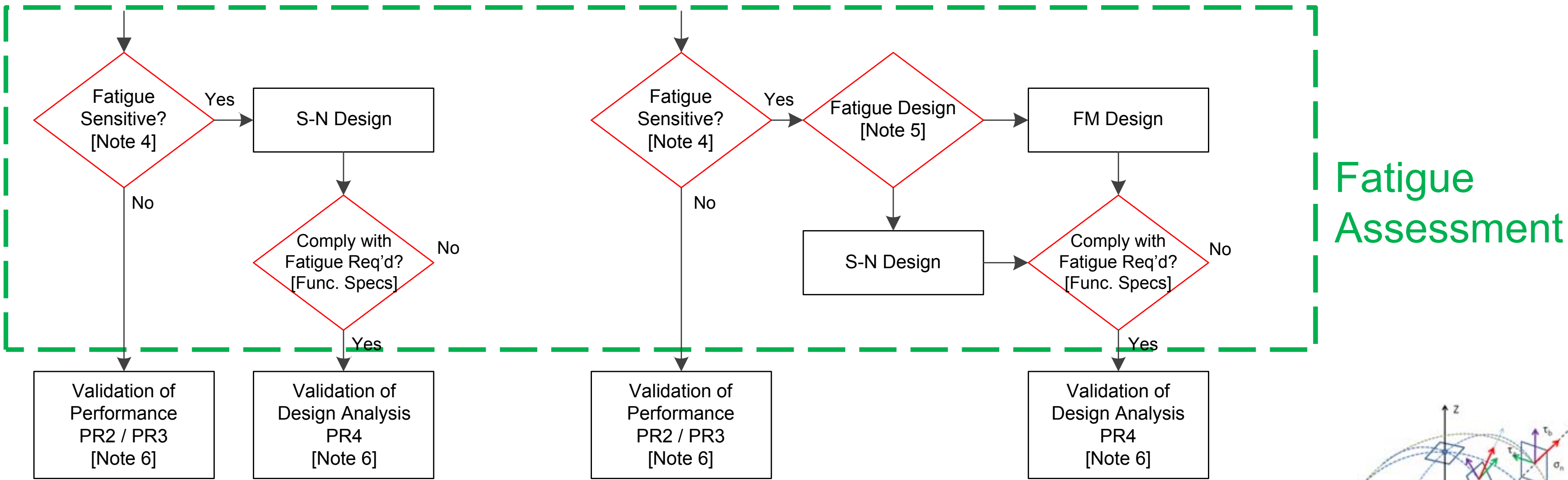
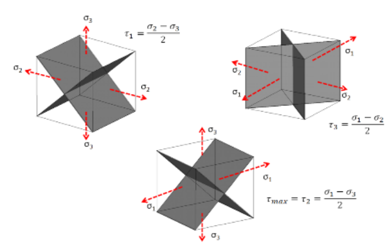
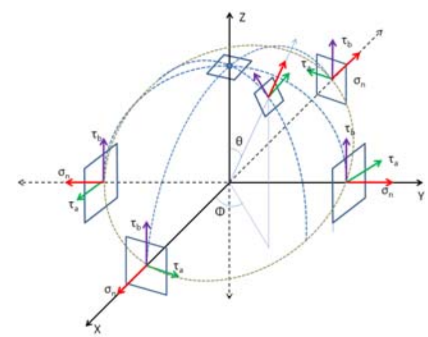
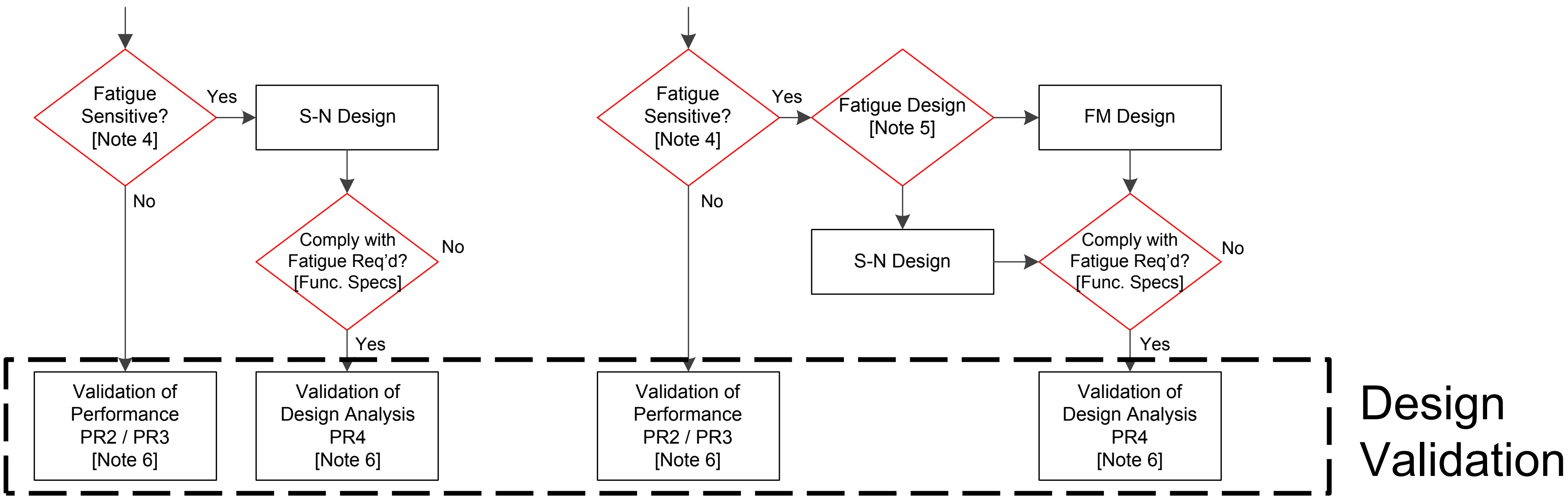




- Stress based fatigue analysis
  - ASME VIII-2, 5.5.2 or VIII-3, KD-3
- Strain based fatigue analysis
  - API-579-1 ASME FFS-1, Part 14, Level 3
- These two methods uses multiaxial stress/strain and also account for mean stress
- Both elastic and elastic plastic FEA results can be used with these two methods
- Any beneficial residual stress can be accounted with these two methods (Example: Autofrettage, hydrotest)

# 17TR8: Design Flow Chart – Design Validation



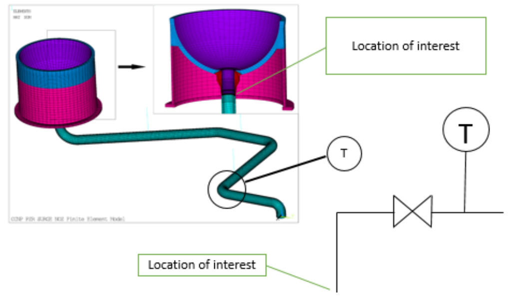

Performance Requirement (PR)

- PR2: Performance-based, minimum [functional cycle testing]
- PR3: Performance-based [PR2 + additional validation testing identified by design FMECA ]
- PR4: Design Analysis Validation [PR3 + additional procedures associated with validating the design verification process with respect to fatigue sensitive component]

# Other updates

- Annex A on load monitoring expanded
- Annex D on material characterization protocol added
- Several OTC and ASME PVP papers added to bibliography

Loading Transfer Functions



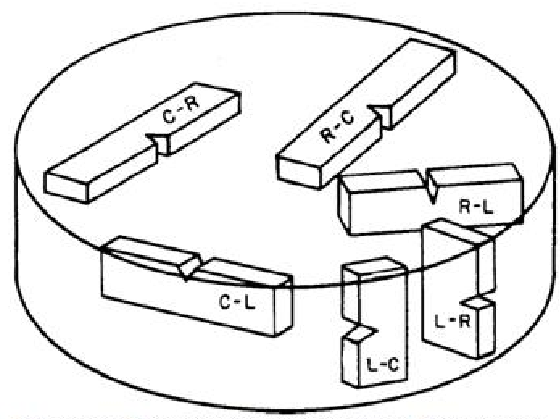




FIG. 3 Crack Plane Orientation Code for Bar and Hollow Cylinder

# Conclusions and Future of 17TR8


- Second Edition passed and going through comment resolution
- Next step is how to incorporate specifics into specifications / standards
- Tug-of-War will continue at specification level because of HPHT's stochastic requirements (who wins, who pays?)
- 17TR8 Task Group will stay on as a group

# Thank You

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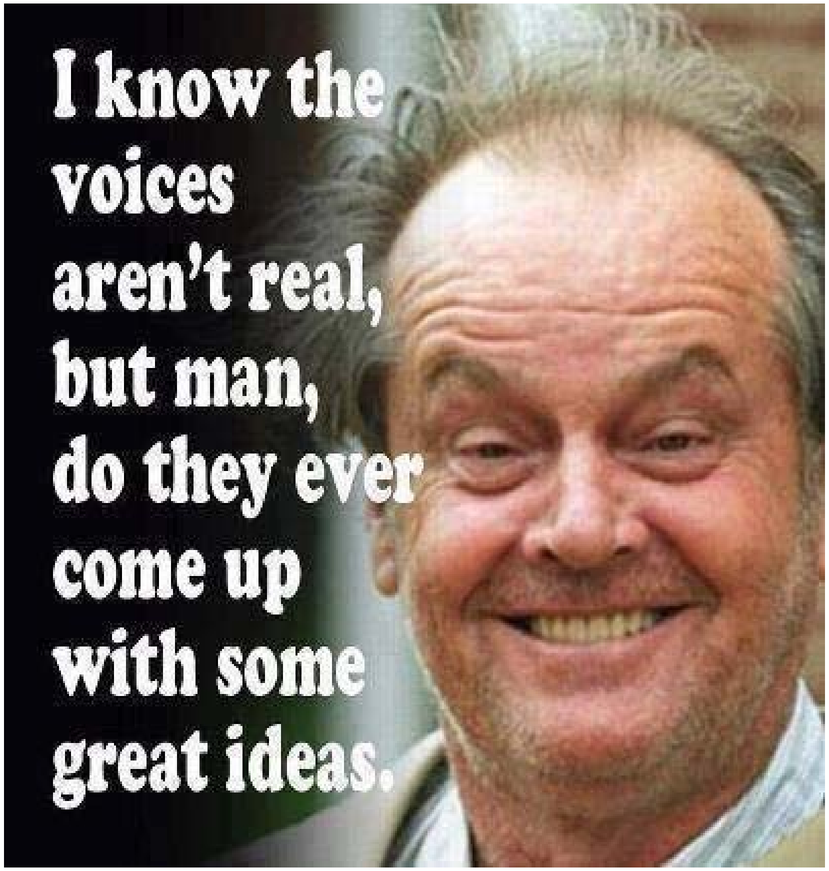
*Acknowledgement and Thanks:*
*Man Pham – Anadarko*
*Jim Kaculi – Dril-Quip*
*Kumarswamy Karpanan - TechnipFMC*

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