



World Oil[®] HPHT
DRILLING, COMPLETIONS & PRODUCTION CONFERENCE

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Case Study: Deepwater Development and Testing for HPHT Tubing Hanger Plugs

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Agenda

- Operator's Requirements
- Qualification Specifications
- Basis of Design
- Verification
- Validation
- Reporting
- Plan Forward

Operators Requirements

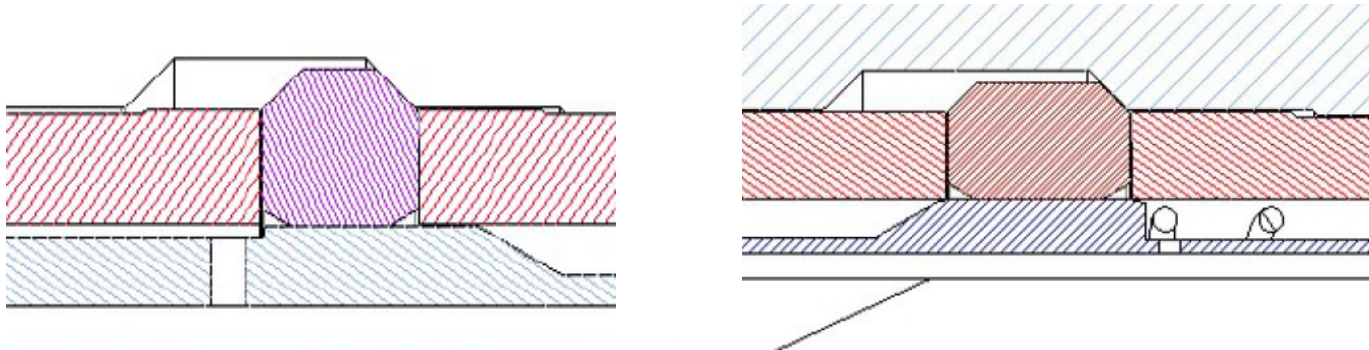
- 4.500-in. tubing hanger plug (back-pressure valve)
 - Portfolio development with 4 additional nipple and lock mandrel sizes.
- Temperature range 40°F to 250°F
- Pressure rating 20Ksi above and below
- API Monogrammed to 14L 2nd Edition V-1
- Independent third party (I3P) review and BSSE I3P reports

Qualification Specifications

- API 14L 2nd V1
 - API 14L revision in process that addressed HPHT requirements, as does API 14A and 11D1
 - API 19HPHT near completion, addressing HPHT requirements for completion equipment.
 - Additional documents in draft were considered for HPHT guidance.
 - Not API 6A

Basis of Design

- Product line design history
 - Standard key and profile was used.
 - No standard polish bores (132 different profile sizes have been designed during the last 30 years)
 - Key to profile interface load calculations done on every size.
 - No-go is not pressure load bearing.

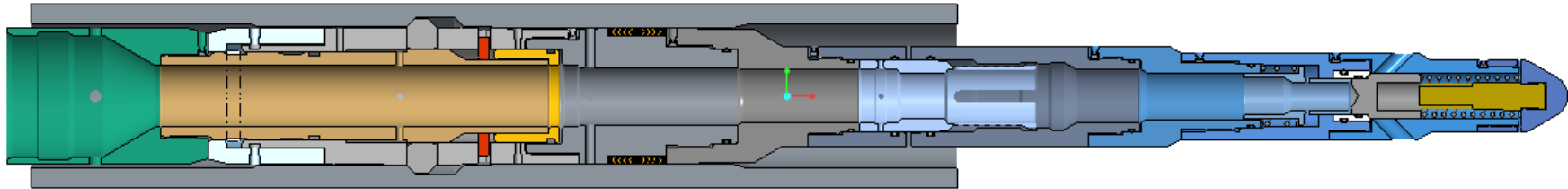
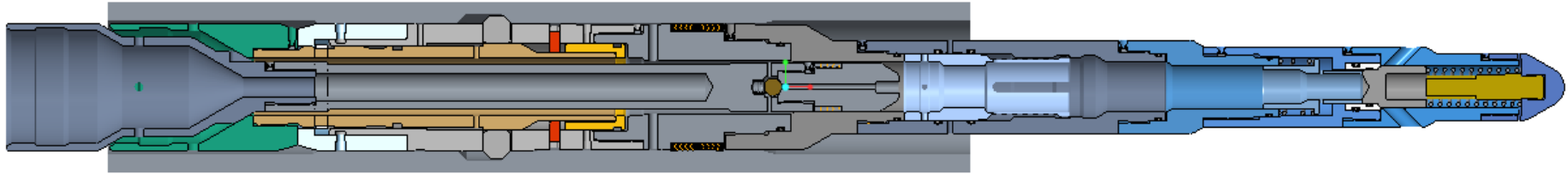


Basis of Design – Continued

- All seal bores at 4.500 in. and lower use original standard key & profile designs at 20Ksi ratings.
 - 20Ksi 4.688 THP in 2002
 - 20Ksi 2.813 THP in 2008
 - Plug system design has more available x-section.
- Material: Alloy 718 120 Ksi
- Seals: HNBR, PTFE & Peek end rings
- Plug systems are easier to design.
- No Scaling was used.

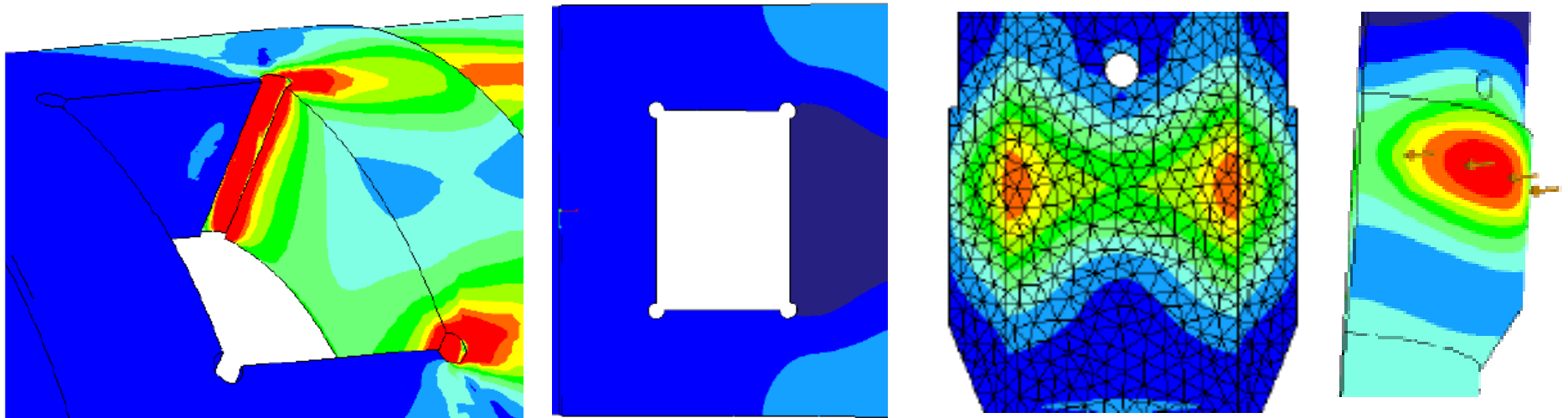


4.500-in. Lock, Equalizing Sub & BPV



Verification

- Failure Mode and Effect Analysis-FMEA
- Finite Element Analysis
- Ratchet Analysis was not required.
 - Required only if critically loaded components were above .2% strain.



Stress (left) and Displacement (right) – Main Body Windows

Stress (left) and Displacement (right) – Inner Mandrel

Validation

- API 14L V1 requires validation test pressure to be the stated working pressure at temperature.
- Our standard internal process is:
 - Testing at 10% above our stated working pressure at temperature.
 - Test the entire plug system, not just the lock.
- Back pressure valve was cycle tested.
- After passing the API validation testing in fluid, we repeated the validation testing in gas and passed the zero-bubble acceptance criteria.

Reporting

- I3P review conducted on:
 - Basis of design
 - Material selection and qualification
 - Design verification
 - Validation testing
 - Quality Plan / ITPs
- I3P generates Report 1A – 1G for equipment technical specification (non-site specific)
- Operator uses Report 1A – 1G for site-specific Well Equipment C Plan

Plan Forward

- Complete BSSE I3P report submittal process
- Manufacture to API Q1 and a customer-specific quality control plan (QCP).
- Our standard factory acceptance testing (FAT)
 - 22ksi test pressure in fluid at ambient temperatures.
- No installation concerns – uses standard running and pulling tools.

Conclusion and Results

- API 14L V0 equivalent validation grade required extensive planning.
- Cooperation between Operator and Supplier for project requirements is key for API 14L V0 validation.
- 85 weeks from conceptual design to validation testing of complete 20Ksi portfolio – 5 sizes.
- Fully qualified API 14L V0 equivalent 20Ksi at 250F rating, CRQ & BPV.

Thank You, for Your Time

Questions