Verification and Validation Challenges of HP/HT BOP and Well Control Equipment

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Outline

• Introduction
• HPHT Well Control Equipment
• ABS Technology Qualification Process
• Design Verification Challenges
• Design Validation Challenges
• Material Selection Challenges
• Summary
• Questions
Introduction

• Definition of HPHT
  • HPHT is greater than 15,000 psi and/or greater than 350°F/177°C

• Code and standards for Well Control Equipment
  • API Std. 53
  • API Spec. 6A, 16A – 4th Edition Draft
  • API Std. 16AR – First Edition Draft
  • API Spec. 16C – Second Edition
  • API Spec. 16D – Third Edition Draft
  • API RP 16Q – Second Edition Draft
  • API RP 17TR8
  • ASME BPVC Section VIII, Div. 2 and 3

• HPHT equipment design process
HPHT Well Control Equipment Diagram

- BOP Stack System
  - Wellhead connector
  - Ram BOP/ram blocks
  - C&K connectors, valves, lines
  - HPHT probes
  - LMRP mandrel
  - Gas bleed valves
- Riser System
- Surface Equipment/Piping
- Annular Preventer not HPHT
ABS Technology Qualification (TQ)

• Per API TR 17TR8 and API TR 1PER15K-1
  • **Qualification**: process of validation and verification of the technology against certain offshore and marine industry standards and practices
    • Qualification = Risk reduction through risk study:
      • HAZID/HAZOP/FMECA + Design Verification + Validation Testing
  • **Verification**: to confirm that HPHT equipment design or development activity is in compliance with its functional specifications and there is adequate protection against failure modes identified
  • **Validation**: to demonstrate that the equipment meets the mechanical integrity and functionality/operability requirements as per the functional/design specifications
Overall TQ Flow Process

2. Technical Design Specification (System/Equipment/Component)
3. Design Verification
4. Material Selection and Design Analysis
5. Material Validation and Prototype Testing
6. Risk and Reliability Studies
7. Design Validation
8. Design meets FDS
   - Yes: Production
   - No: Manufacturing, Inspection, and Testing
9. Installation and Commissioning
10. In Service Monitoring and Life Cycle Management
11. Lessons Learned
    Continuous Improvement
Overall Challenges

• HPHT conditions exceed capabilities of current drilling equipment
  • 15,000 psi and 250°F are current limitations
• Lack of codes, standards and/or regulations specific to HPHT system/equipment design and manufacturing
  • API 17TR8 Guidelines for production systems
  • API 16A – Annex for HPHT
• Unknown risk associated with equipment design and operations
• Regulatory uncertainty and newly proposed regulations
• Lack of field data and industry experience
Design Verification Challenges

- Design standards used and types of analysis chosen
- Design exceeds or deviates from existing engineering standards
- FEA verification and calibration with test result
- Design analysis methods for welding and cladding planned for any equipment or components
- Calibration with test results
Design Verification Challenges

• Appropriately defined functional design specification/ technical design specification
• Load cases in the analysis and sequence of applied loads
• Thermal load analysis and effects
• Fatigue analysis
• Verification of sealing components (elastomeric sealing materials)
Design Validation and Prototype Production

Design Validation Testing with Survey

- FMEA/FMECA Action Items
- Material Qualification testing

Fabrication of prototype per Approved Specs.

Pre-test Inspection/NDE

Design Validation Testing per Approved Procedures

Post-test Inspection/NDE

- Meet Acceptance Criteria? All Comments Closed?

ABS Final Engineering Review of prototype Test Results/

ABS Survey TQ Report

Survey

Preliminary Review on Design verification procedures

Approved Test Procedures (Engineering & Survey)

Engineering

Client Involvement and Interaction
Design Validation Challenges

- Test equipment, cost and time
- Test equipment calibration prior to test/recalibration after test
- Testing fluids – stability and suitability at high temps
- Application of strain gauges in test – use of and placement
- High temperature testing – testing to simulate environmental temps
- Bolting validation test requirements
- Failure of associated equipment during testing
- Load sequencing
- Detailed procedures and recording required for testing
- Testing facilities for prototypes
Material Selection Challenges

- Temperature
- Chemistry
- Manufacturing procedure
- Material properties
- Exposure to environment: seawater, wellbore, drilling and completion fluids
- General and localized corrosion
- Erosion
- Elastomers
- Design life
- Creep at high temperatures
- Material interactions
Design Verification and Material Selection

- Material properties
  - True stress
  - Strain curves
  - Fracture toughness values
  - Fatigue properties
  - De-rating factors due to HT exposure
- Loading histogram
Material Design Validation

• Test conditions during test (temperature, loading conditions, strain rates, etc.)
• Test coupon sampling
• Welding procedure concerns
• Heat treatment sensitivity studies – if new alloys are developed
• NDE acceptance criteria
  • Probability of detection
  • Agreement on all parties on technique
• Qualification of manufacturers
Summary

• Guidance for HPHT equipment is increasingly necessary in the oil and gas industry

• Current standards, codes, and regulations provide a high level overview for environments above 15,000psi and/or 350°F; however, further detailed descriptions and guidance are in need

• The Technology Qualification process provides confidence and guidance for the owner, operator, and manufacturer to safely and systematically utilize their equipment

• Questions