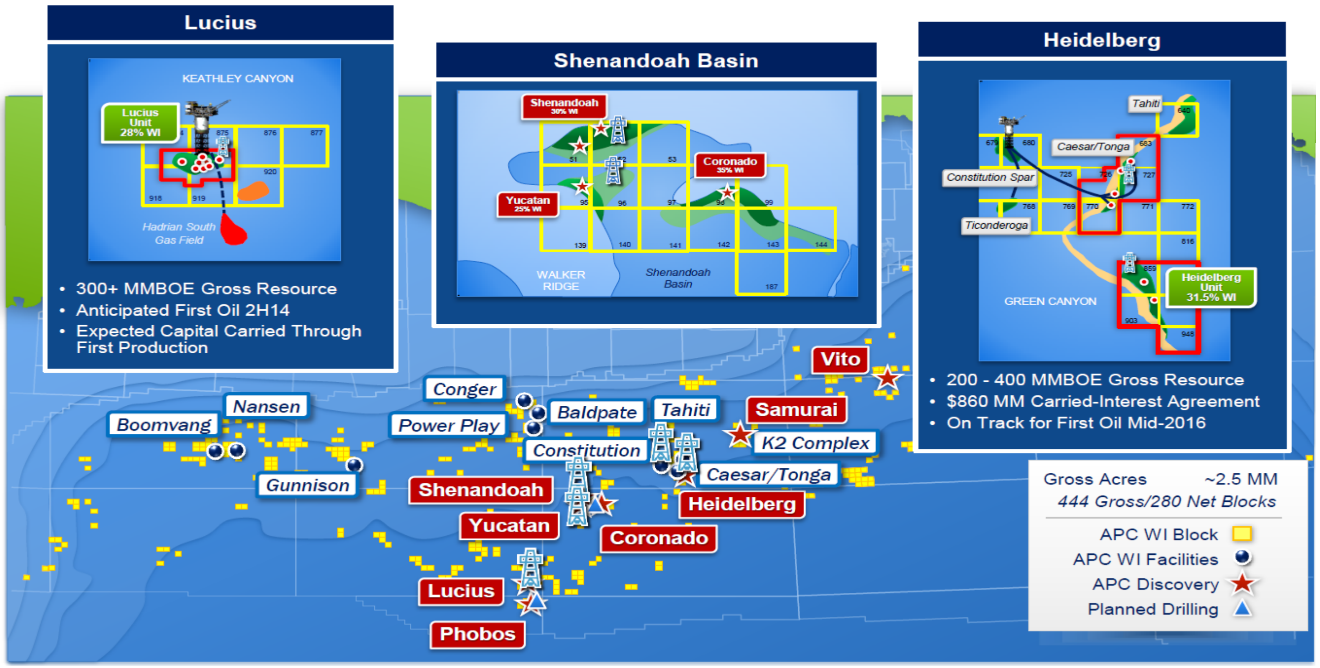
Developing Industry Solutions for 20,000 psi Subsea Developments

Jim Raney
Anadarko Petroleum Corporation
19 November. 2014

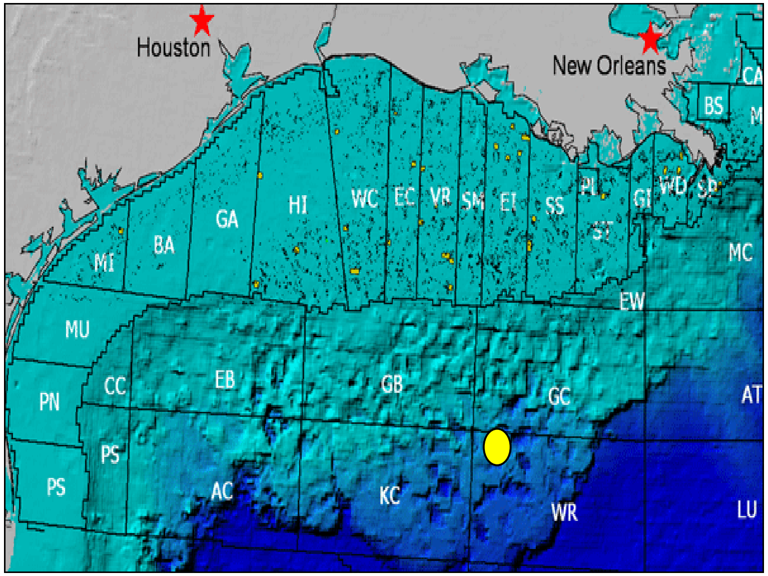
Anadarko - Gulf of Mexico

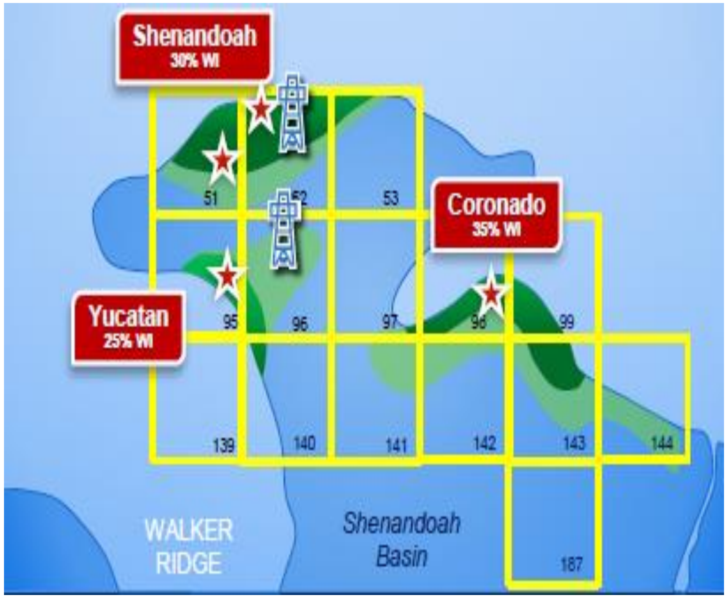


Lucius Spar & Topside

Shenandoah Basin

- In 2013, Anadarko announced the success of its Shenandoah-2 appraisal well – potentially Anadarko's largest-ever oil discovery in the deepwater Gulf of Mexico.
- Currently drilling Shenandoah-3 well.

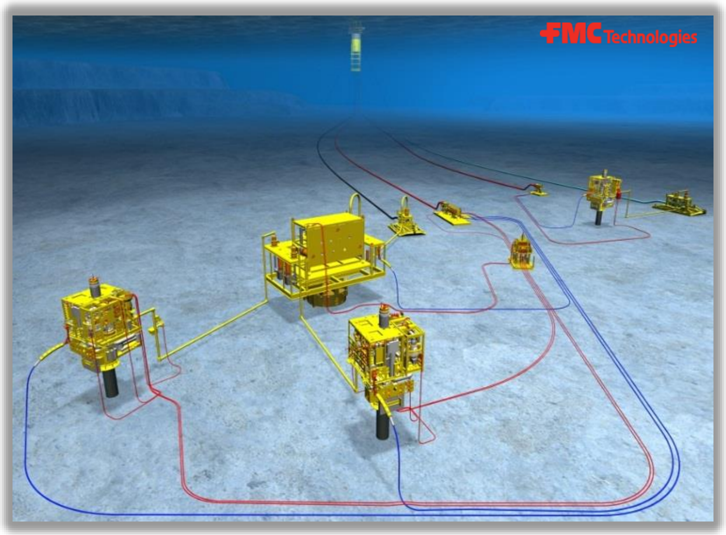


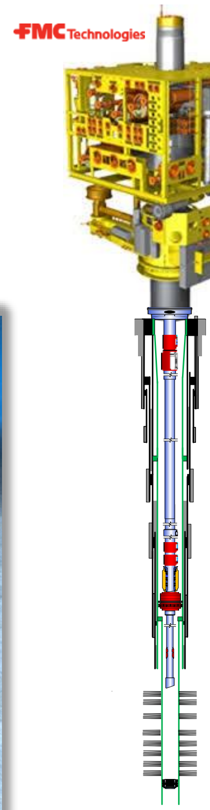


Greater than 15K psi and less than 250°F at the mudline

"20A" Work Streams

- MODU
- BOPE & Riser
- Completions
- Subsea Facilities





Blade Energy

Diamond Offshore

“20A” Project Mission

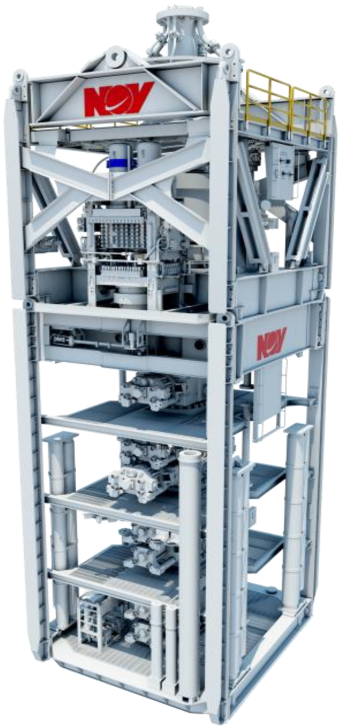
- *Develop functional requirements and review the supplier’s technical specifications*
- *Oversee design verification and testing validation to meet the Anadarko and regulatory requirements*
- *Monitor the manufacture, factory acceptance testing and inspection*

Developing Industry Solutions

- Collaborating with operators, contractors, and suppliers
- Focusing on industry standards
- Helping each other understand the existing and evolving standards & regulations

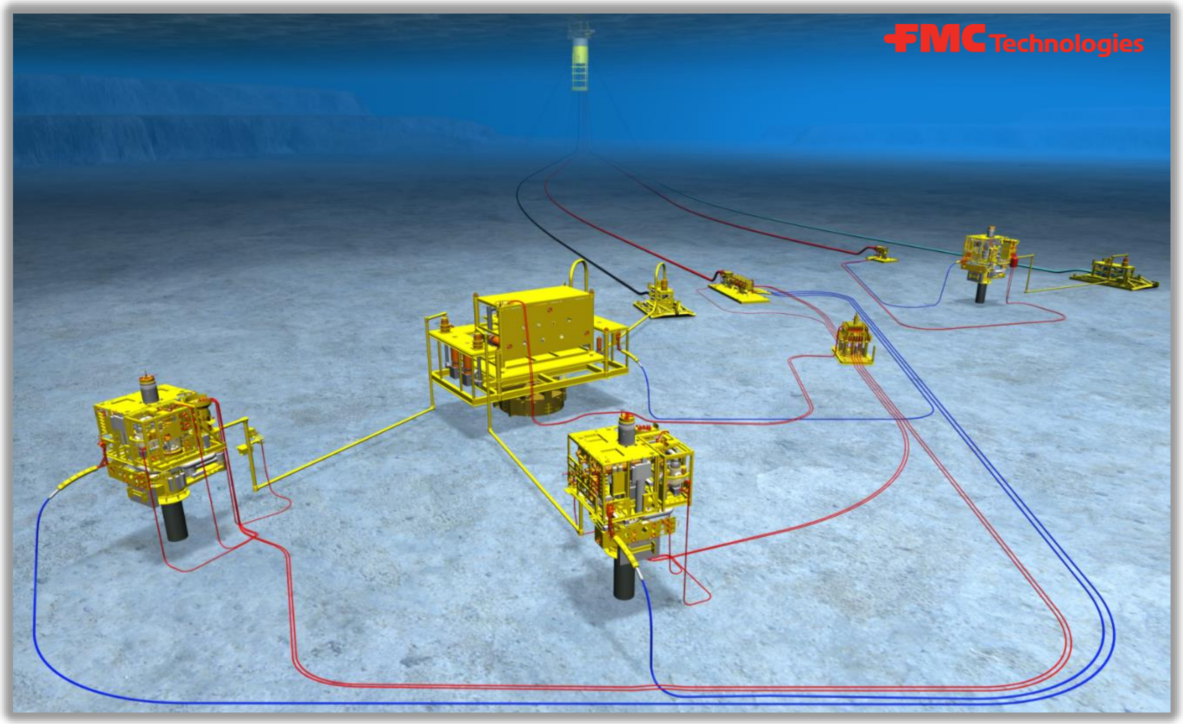
MODU / BOP / Riser Collaboration

- ✓ *Functional Specifications*
  - **Five rig contractors & three equipment suppliers**
  - Strong emphasis with the draft *API 17 TR8* document
  - Issued for comments, obtained feedback from all, & re-issued
- ▶ *Technical Specifications* & proposals 4th Qtr 2014
- ▶ Work with the selected parties to progress forward



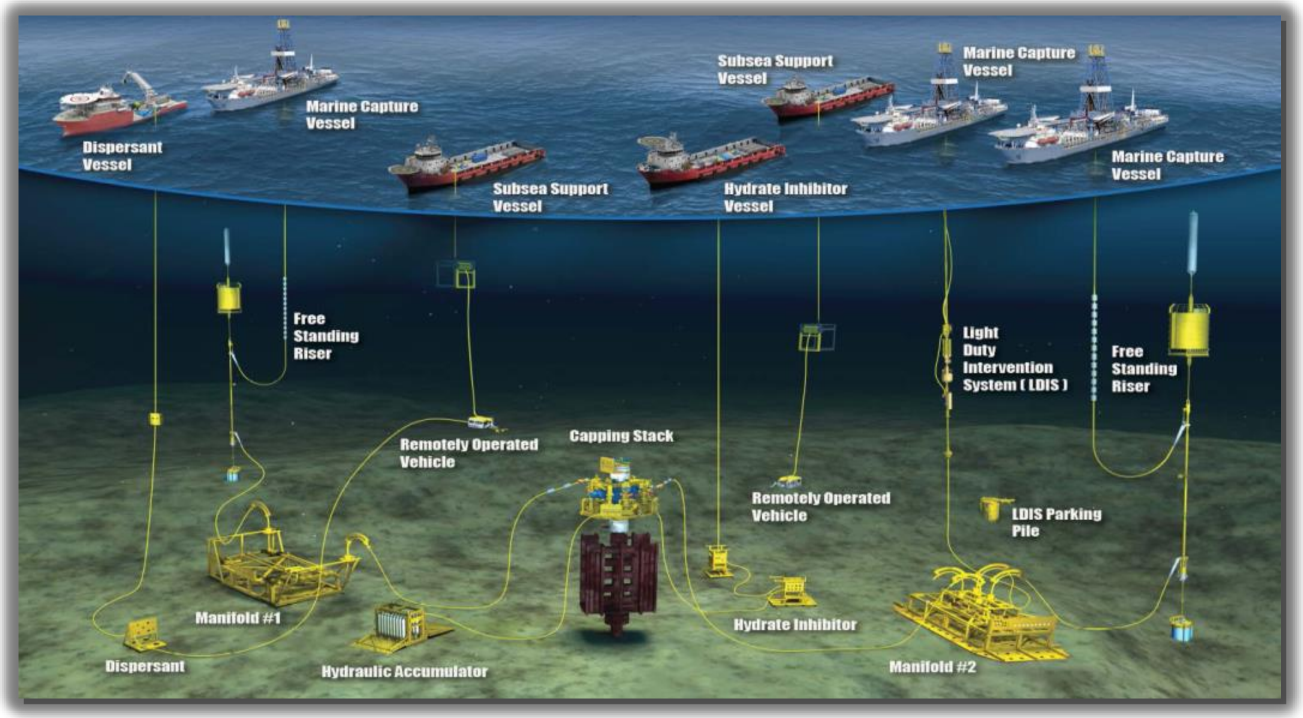
Subsea Facilities Joint Development Agreement

- FMC Technologies
- Anadarko
- BP
- ConocoPhillips
- Shell



20ksi Containment Cap & Top Kill Equipment

- Initial discussions held with other interested operators within the MWCC to develop the necessary equipment

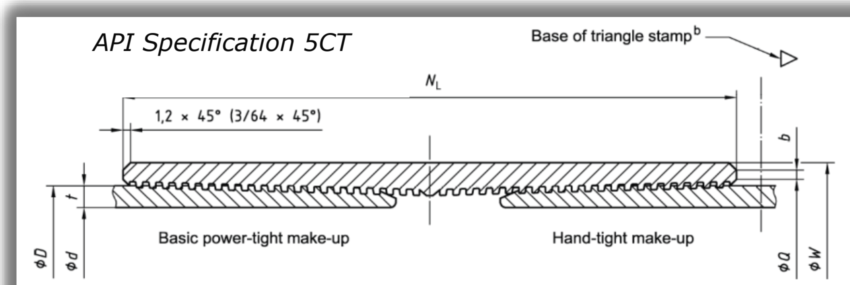


MWCC

Possible Other Collaborations ???

- Intervention systems (LRP/EDP/CWOR)
- Coiled Tubing
- Connection Testing
- Completion Equipment

API Specification 5CT



a On special-clearance couplings, the inside and outside edges of the bearing face shall be broken or rounded. A 10° bevel (both ends) shall be furnished only when specified on the purchase order.

b A 9,52 mm (3/8 in) high equilateral triangle die-stamp or paint band shall be placed at a distance of A1 from each end of buttress casing. See Table C.23 or Table E.23 for pipe dimensions, Table C.33 or Table E.33 for coupling dimensions and API Spec 5B for A1.

Figure D.3 — Buttress-thread casing and coupling

Draft API Specification 17G

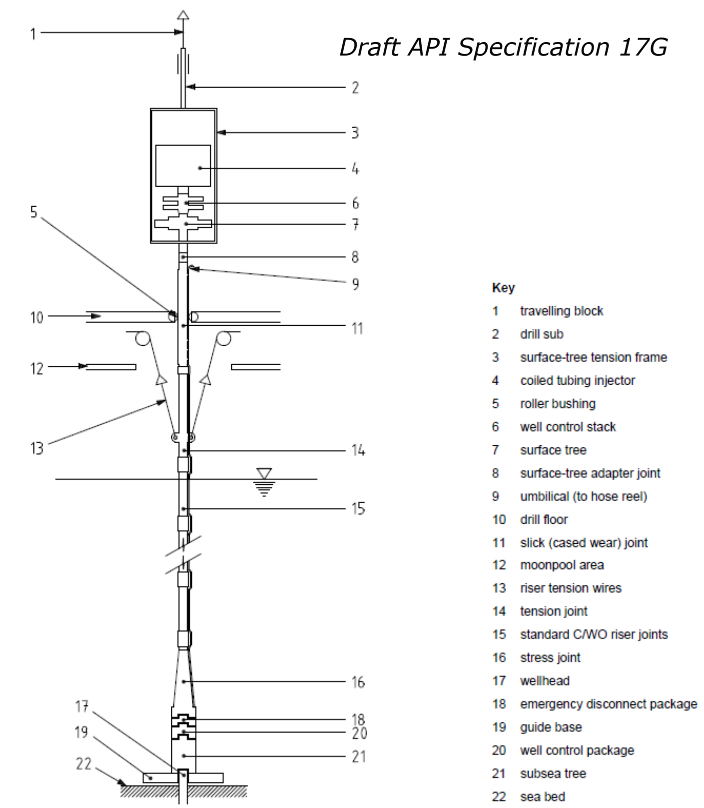


Figure 4-2: Typical subsea well intervention system general arrangement open-water intervention mode

- API 1PER15K-1: *"Protocol for Verification and Validation of High-pressure High-temperature Equipment"*
- API 17TR8: *"High-Pressure High-Temperature (HPHT) Design Guidelines"* ***(April 2014 ballot)***
- Guidance documents for:
  - Materials selection
  - Verification analysis
  - Validation testing

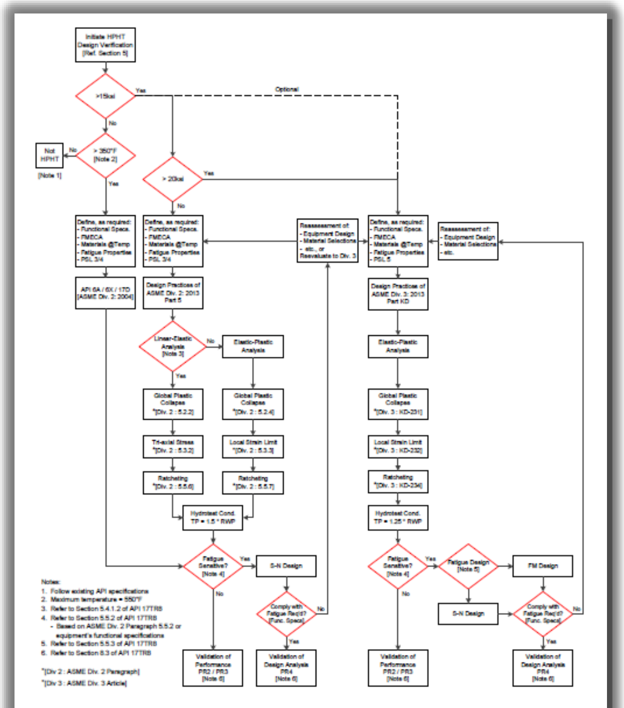


Figure 1: HPHT Design Flow Chart

Draft API 17TR8

BSEE Engagement

20A PROJECT

Director Brian Salerno

BSEE Director

BSEE Office of Congressional Affairs

BSEE Office of Public Affairs

BSEE Deputy Director CFO

Deputy Director Margaret Schneider
Chief of Staff Tom Lillie

Office of Offshore Regulatory Programs

Doug Morris

Oil Spill Response Division

Environmental Enforcement Division

Charles Barbee

BSEE Alaska OCS Region

BSEE Gulf of Mexico OCS Region

Lars Herbst

BSEE Pacific OCS Region

Director, Washington D.C

- **Confer with Director and staff on 20 A**
- **Explain our 20A concepts**
- **Review 20A project scope**
- **Review TRL's**
- **Establish Acceptance Criteria**

Herndon, VA

- **Offshore Regulatory Programs (ORP)**
- **Emerging Technologies Branch (ETB)**
  - **Best Available and Safest Technologies (BAST)**
  - **Technology assessments**

Regional, New Orleans, LA
Gulf of Mexico Region Director & Staff

Regulatory Approval

Deepwater Intervention Forum Aug. 13, 2014

“ The Future of HPHT” – Russell Hoshman (BSEE)

- *The approval process will be very complex until the requirements of HPHT equipment design cascades through the engineering standards such as:*
  - *API Spec 6A - Wellheads and Christmas Trees Equipment*
  - *API Spec 17D - Subsea Well Heads and Tree Equipment*
  - *API RP 17G – Subsea Completion/Workover Risers*
  - *API Spec 16A – Drill Through Equipment (BOPs)*
  - ***API Spec 14A – Subsurface Safety Valve Equipment***
  - *API Spec 11D1 – Packers and Bridge Plugs*
  - *API RP 5C5 (ISO 13679) – Procedures for Testing Casing and Tubing connections*
  - *Etc.*

Regulatory Approval Approach

BSEE TAS Considerations

Category 1 – Pressure Containing & Pressure Controlling

Category 2 – Pressure Containing

Category 3 – Non-critical equipment and/or equipment not permanently installed or used as a barrier

→

Additional internal / reliability requirements

→

Design Standards

Acceptance Criteria

Verification & Validation Requirements

Risk evaluations

↓

Technology Readiness Level (TRL) Tracking

Cat 1 vs. Cat 2 difference example:

Fatigue considerations

ASME BPVC, Sect VIII, Div 1/2/3 – Industry Workshop

- BSEE TAS guidance (Cat 1/2/3)
- API/ASME approach described with current industry gaps & guidance on 'what to do'
- HPHT analysis considerations; material, qualification, & testing requirements
- Approaches, load cases, safety margins, & failure modes to show fitness-for-purpose
- Interactions among design, analysis, material requirements, QA/QC, & verification and validation
- API 17TR815

HPHT Requirements and Implications for Operators and Equipment Suppliers

Overview
The seminar and discussions will cover HPHT analysis considerations, material qualification, and testing requirements. The seminar will discuss various approaches, load cases, safety margins, and failure modes. A demonstration example of the qualification process will be given based on a surface-controlled subsea safety valve (SCSSV).

Goals
The seminar will focus on completion equipment and the associated recommended work needed to show fitness-for-purpose. BSEE statements and goals and API and ASME approaches will be described along with current industry gaps in guidance (and what to do). The seminar will discuss the interactions among design, analysis, material requirements, QA/QC, and verification and validation.

Agenda

Topic
Introduction
Demonstrate Qualification Process through a Surface-Controlled Subsurface Safety Valve, SCSSV, Example
Service Environment / Design Conditions / Design Considerations
Example Failure Modes
Load Cases
Design Verification – Appropriate Approaches
LRFD/Elastic-Plastic Analysis (ASME Section VIII, Div.3)
Elastic Analysis – ASME Section VIII, Div.2, API 6A
S-N Fatigue / Fracture Mechanics
Validation of Design Methods
Material Qualification
Pre-qualified Materials (Typical HPHT Materials)
Qualification Procedure for Materials Lacking Data or Experience
QA/QC - Traceability
Testing/Validation
Seals
Functional Testing

Pre-Seminar Homework
For the most efficient use of our time and for participants to get the most out of the day, we will assemble a slide packet of relevant background material prior to the seminar.

Follow-Up Meetings
For clarifications and to allow for more in-depth discussions of specific situations (analyses, materials, etc.), follow-up meetings are anticipated.

STRESS ENGINEERING SERVICES INC.

Technology Development (TRL Designations)

Industry Reference Only		TRL 1, 2, 3		TRL 4	TRL 5	TRL 6, 7	TRL 8	TRL 9
Summary & Supporting Information (NASA, DoE, DoD)	Basic principles observed and reported: Transition from scientific research to applied research. Essential characteristics and behaviors of systems and architectures. Descriptive tools are mathematical formulations or algorithms. Published research that identifies the principles that underlie this technology. References to who, where, when. Technology concept and/or application formulated: Applied research. Theory and scientific principles are focused on specific application area to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application. Publications or other references that outline the application being considered and that provide analysis to support the concept. Analytical and experimental critical function and/or characteristic proof-of-concept: Proof of concept validation. Active Research and Development (R&D) is initiated with analytical and laboratory studies. Demonstration of technical feasibility exercised with representative data. Results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical … these tests and comparisons were performed.			Component/subsystem validation in laboratory environment: Stand-alone prototyping implementation and test. Integration of technology elements. Experiments with full-scale problems or data sets.	System/subsystem/component validation in relevant environment: Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces. How does the "relevant environment" differ from the expected operational environment? How do the test results compare with expectations? What problems, if any, were encountered?	Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume. How did the test environment differ from the operational environment? Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level? Engineering feasibility fully demonstrated in actual system application. Results from testing a prototype system in an operational environment. Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level? Well integrated with collateral and ancillary systems. Limited documentation available.	Results of testing the system in its final configuration under the expected range of environmental conditions in which it will be expected to operate. Assessment of whether it will meet its operational requirements. What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before finalizing the design?	Actual system "mission proven" thorough successful mission operations (ground or space): Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed. **Successful operational experience.** Sustaining engineering support in place. OT&E (Operational Test and Evaluation) reports.

NASA, DoE, DoD

	TRL 0	TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7
API 17N - Recommended Practice for Subsea Production System Reliability and Technical Risk …	Unproven Concept. Basic scientific/engineering principles observed and reported; paper concept; …	Proven concept - Technology concept and/or application formulated. Concept and functionality proven by analysis or reference to features common with/to existing technology. No design …	Validated concept - Concept design or novel features of design is validated by a physical model, a system mock-up or dummy and functionality tested in a laboratory environment; no design history; no environmental tests; … construction.	Prototype Tested - Item prototype is built and put through (generic) functional and performance tests; reliability tests are performed including ; reliability growth tests, accelerated life tests and robust design development test program in … benefits and risks are demonstrated. HAZID.	Environment Tested (Pre-Production system environment tested). Meets all requirements of TRL3; designed and built as a production unit (or full scale prototype) and put through its qualification program in simulated environment (egg, hyperbaric chamber to simulate pressure) … be met in the intended operating condition and external environment.	System Tested (Production System interface tested) - Meets all requirements of TRL 4; designed and built as production unit (or full scale prototype) and integrated …	**System Installed** (Production System Installed and tested). - Meets all requirements of TRL 5; production unit (or full scale prototype) built and integrated into the intended operating system; **full interface and function test program** … months.	**Field Proven** - Production System proven. Production unit integrated into intended operating system, **installed and operating for** …

API 17N – Recommended Practice for Subsea Production System Reliability & Technical Risk Management

API TR8 (Revision 04/23/2014)	Section 1 - Project Scoping & Application	Section 4 - Analytical Analysis (Analytical methods, HT Effects, HP Effects, Combined HPHT Effects, Loading Conditions, Unique to Subsea?). Section 5 - Design Verification (Input Parameters, Design Analysis, Life-Cycle Estimation, Systems/Components, Manufacturer's Technical Specifications)		Section 6 - Materials for HPHT Environment (Environmental Effects, Material Properties for Design Verification, Material Properties for Fatigue Assessment, Cladding/Overlay, NDE). Section 7 - Seals, Bolting, Fasteners. Section 8 - Design Validation (Minimum Design Validation Requirements, Additional Validation Requirements, Revalidation of Existing Designs, Use of Equipment Subjected to Validation Testing, Validation Considerations). Annex B - Material Selection. Section 8.8 - Validation of Analytical Methods. Annex C - Material Quality Control		Section 9 - Hydro Test for HPHT Equipment, as applicable; (Pressure Rating </= 20ksi or pressure rating > 20ksi). Final determination if product meets project requirements.	*NOTE: API 17N Definition defines that upon installation, and once well is 'brought on line', it then becomes TRL 6....(ie, in service less than 3 years). TRL 7 is reached ONLY after being in service for three-* Section 8.7 - In-Service Validation, Annex A - Load Monitoring.	

API 17TR8 – High-Pressure High-Temperature (HPHT) Design Guidelines

ANADARKO GLOBAL ENGINEERING TECHNOLOGY Oil Field Product (Typical Example)	(1). FEED (Front-End Engineering Development) Studies. (2). Assess prospective supplier(s) readiness for project application, including (basic) calculative studies to verify principle(s), application, and architecture of product application for given pressure, temperature , operational considerations.	(1). Concept studies initiated, inclusive of manufacturing capabilities for product/components/sub-systems. (2). Full, classical engineering/analytical studies (on paper) performed, not necessarily to (all) known project conditions. (3). Industry application researched (eg, SPE, World Oil, etc) publications. (4). Project applications (eg, Pressure, Temperature, Setting Depth, Gas/Oil, etc.) understood for further analysis/application of product.	(1). Design review verification activities (all engineering, planning, manufacturing, test plans), to initiate full-scale prototype development of actual size/type/model product.	(1). 'Bench' testing of sub-assemblies, basic operational testing of assemblies/sub-assemblies, not necessarily with specific materials for final end-product. (2). Testing at subassembly level to provide demonstrated performance results. (3). Are there extensions of existing technology, but different size/type/models? Utilization of these extensions of technology for proof of concept?	(1). Manufacturing engineering studies f/actual end-product material (eg, Inc-945X) to ensure manufacturability for system/sub-system/components. (2). Completion of manufacturing studies with relevant materials for end-product. (3). Basic concept testing at component level. Pressure & Temperature and (some) loading conditions simulation testing in 'near' conditions; materials may/may not be end product type. (4). Conceptual testing performed on assemblies, sub-assemblies. All noted testing inclusive of full-scale assembly pre-testing prior to moving to next TRL level to commence full-scale operational, actual/near conditions endurance testing of system.	(1). Combined load, full-scale verification testing, API Specification (and Annex) testing, endurance testing complete, at or near (as close as possible) to actual service conditions. (2). All design validation & verification completed. (3). Demonstrated performance testing for both sub-assembly and final assembly including relevant tools. (4). All demonstrated performance testing for anticipated project conditions completed. (5). All design engineering complete, including manufacturing engineering & test. **Ready** for full-scale production/manufacture for installation.	Product installed for specified project, all pre-production tests complete, valve is in-service, and well on production. All relevant well close-out documentation completed. 'Concept' is in service for less than three-3 years.	Product In-service for 3+ years.

What you can do

- Support your company's API participation
- Collaborate, share ideas, and listen for understanding
- Seek opportunities to further-next generation technology


20A
PROJECT
Thank you