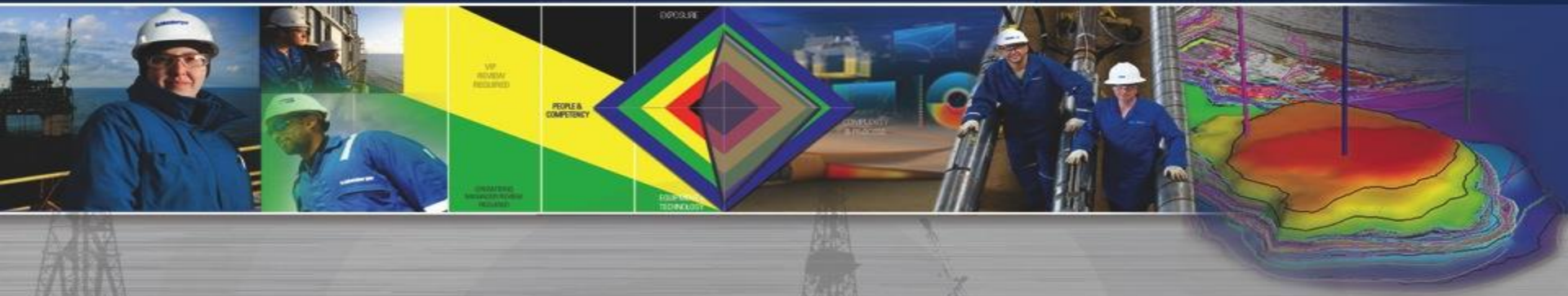
# Well Construction Operation Integrity

## IEA – GOT IA

## April 21-22 University of Western Australia

Deep Water

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# Regulatory and Industry Changes

**Requirements**

- *affect mainly Operators*
- *affect Operators & Service Providers*

*Environmental Assessments* required for all deepwater wells, no more "Categorical Exclusions"

All contracts require a "*Marine Well Containment*" solution

*Worst Case Discharge calculations* required. They drive the Oil Spill Response Plan & Financial Viability evaluations

&

*Well casing & cement design* certification

Implementation of a *Safety Management System* "SEMS" by Nov 2011

&

Establishment of an industry lead *Center for Offshore Safety*,

*BOEMRE splits into BOEM and BSEE*

*"SEMS II"* regulations proposal released for comments

# Well Integrity – Regulations and Standards

- Regulatory and Industry Changes
- Industry Standards, and Recommended Practices
  - API RP 75 Environmental Offshore
  - API RP 65 Part 2 Flow Zone isolation
  - API RP 90 Annular Casing Pressure Management
  - API Standard 96 – Deepwater Design Considerations
  - API Bulletin 97 Well Construction Interface Document (WCID)
- Service Company Standards

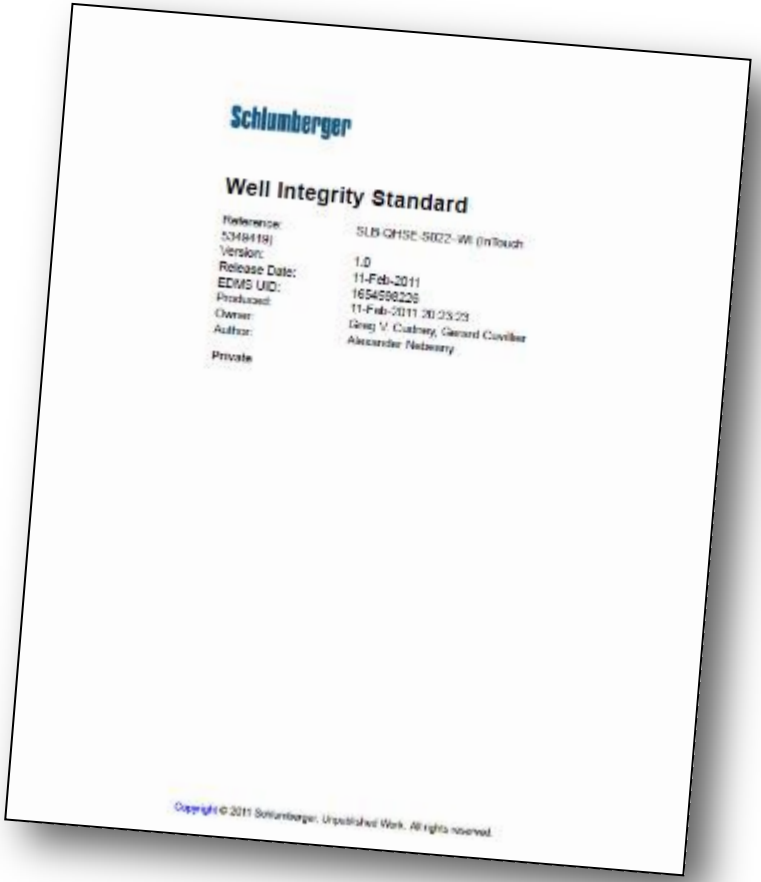
# Schlumberger Well Integrity Standard - Update

- SLB QHSE Standard 22 – Well Integrity Standard
- Released: February 11, 2011

- Well barrier philosophy and definitions

Built using established industry standards and practices:

ISO, API and Norsok used where relevant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Well Integrity Standard

| | |
|---|---|
| Reference: | SLB-QHSE-S022-WI (InTouch |
| 5348418) | |
| Version: | 1.0 |
| Release Date: | 11-Feb-2011 |
| EDMS UID: | 1654598226 |
| Produced: | 11-Feb-2011 20:23:23 |
| Owner: | Greg V. Cudney, Gerard Cuvillier |
| Author: | Alexander Nebesny |

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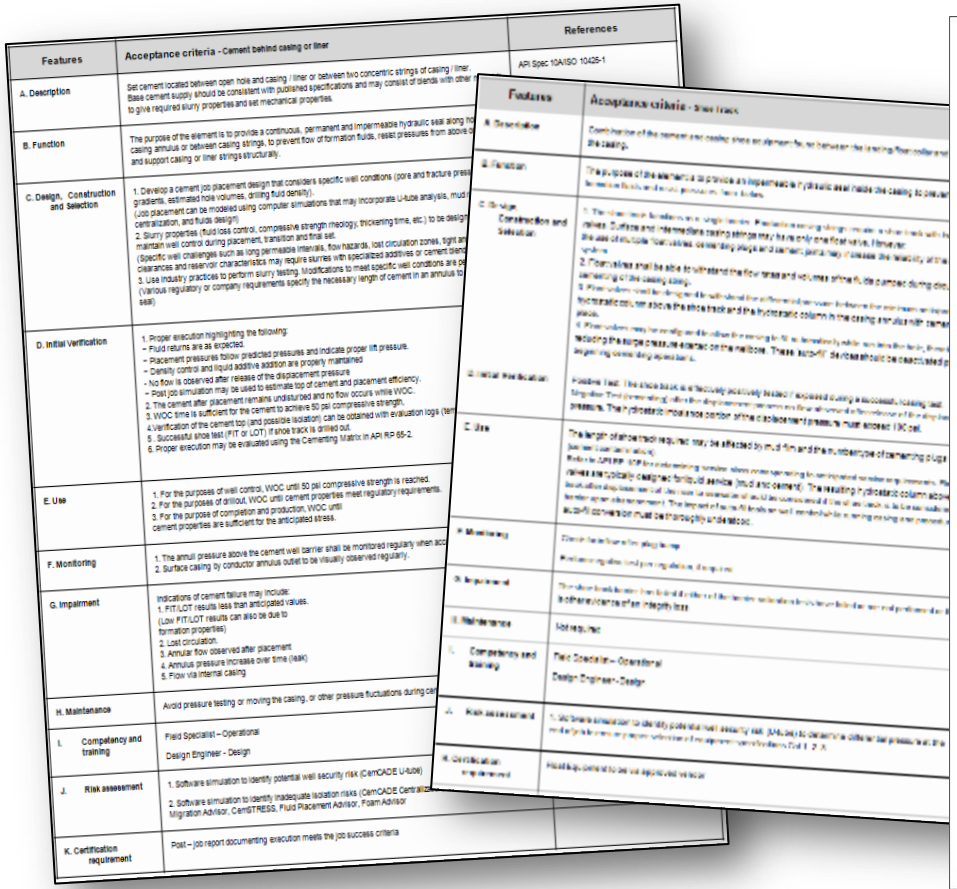
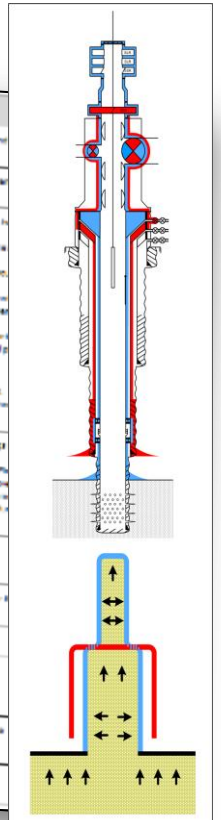
# Well Barrier Acceptance Criteria



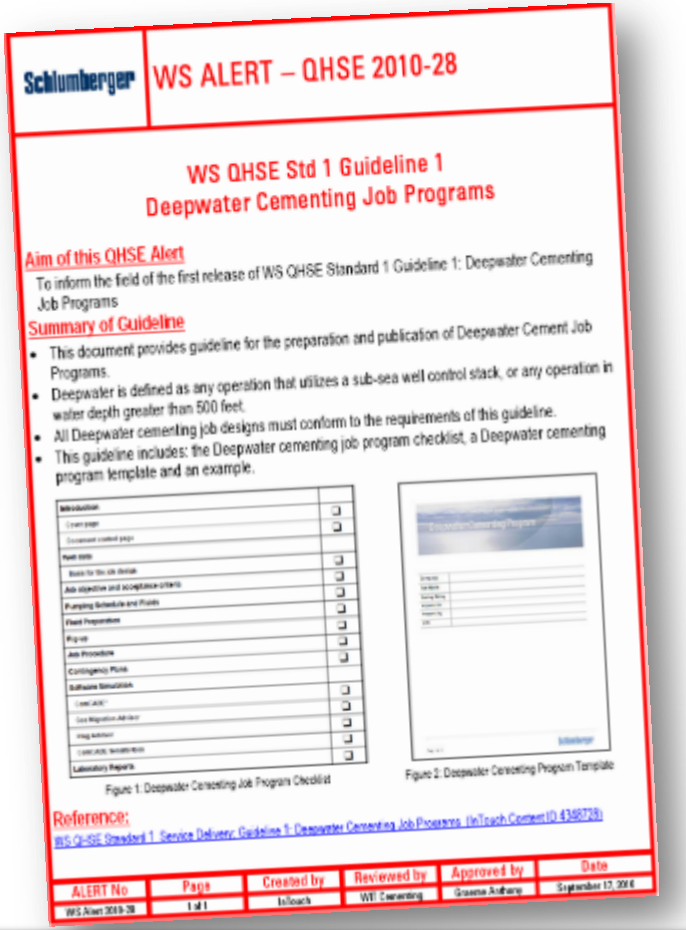
| Features | Acceptance criteria - Cement behind casing or liner | References |
|---|---|---|
| A. Description | Set cement located between open hole and casing / liner or between two concentric strings of casing / liner. Base cement supply should be consistent with published specifications and may consist of blends with other to give required slurry properties and set mechanical properties. | API Spec 10A/ISO 10425-1 |
| B. Function | The purpose of the element is to provide a continuous, permanent and impermeable hydraulic seal along ho casing annulus or between casing strings, to prevent flow of formation fluids, resist pressures from above o and support casing or liner strings structurally. | |
| C. Design, Construction and Selection | 1. Develop a cement job placement design that considers specific well conditions (pore and fracture pressi gradients, estimated hole volumes, drilling fluid density). (Job placement can be modeled using computer simulations that may incorporate U-tube analysis, mud centralization, and fluids design) 2. Slurry properties (fluid loss control, compressive strength rheology, thickening time, etc.) to be design maintain well control during placement, transition and final set. (Specific well challenges such as long permeable intervals, flow hazards, lost circulation zones, tight an clearances and reservoir characteristics may require slurries with specialized additives or cement blend 3. Use industry practices to perform slurry testing. Modifications to meet specific well conditions are pe (Various regulatory or company requirements specify the necessary length of cement in an annulus to seal) | |
| D. Initial Verification | 1. Proper execution highlighting the following: – Fluid returns are as expected. – Placement pressures follow predicted pressures and indicate proper lift pressure. – Density control and liquid additive addition are properly maintained - No flow is observed after release of the displacement pressure – Post job simulation may be used to estimate top of cement and placement efficiency. 2. The cement after placement remains undisturbed and no flow occurs while WOC. 3. WOC time is sufficient for the cement to achieve 50 psi compressive strength. 4. Verification of the cement top (and possible isolation) can be obtained with evaluation logs (tem 5. Successful shoe test (FIT or LOT) if shoe track is drilled out. 6. Proper execution may be evaluated using the Cementing Matrix in API RP 65-2. | |
| E. Use | 1. For the purposes of well control, WOC until 50 psi compressive strength is reached. 2. For the purposes of drillout, WOC until cement properties meet regulatory requirements. 3. For the purpose of completion and production, WOC until cement properties are sufficient for the anticipated stress. | |
| F. Monitoring | 1. The annuli pressure above the cement well barrier shall be monitored regularly when acc 2. Surface casing by conductor annulus outlet to be visually observed regularly. | |
| G. Impairment | Indications of cement failure may include: 1. FIT/LOT results less than anticipated values. (Low FIT/LOT results can also be due to formation properties) 2. Lost circulation. 3. Annular flow observed after placement 4. Annulus pressure increase over time (leak) 5. Flow via internal casing | |
| H. Maintenance | Avoid pressure testing or moving the casing, or other pressure fluctuations during ce | |
| I. Competency and training | Field Specialist – Operational<br>Design Engineer - Design | |
| J. Risk assessment | 1. Software simulation to identify potential well security risk (CemCADE U-tube)<br>2. Software simulation to identify inadequate isolation risks (CemCADE Centrali Migration Advisor, CemSTRESS, Fluid Placement Advisor, Foam Advisor | |
| K. Certification requirement | Post – job report documenting execution meets the job success criteria | |



Penetrated cap rock replaced by redundant barriers typical for live operations w/common element

- Fluid in the Well
- Cement Behind Casing or Liner
- Cement Plugs
- Shoe Track
- Well Suspension Packer & Storm Valve
- Mechanical Tubing Plug

# Deepwater Cementing Service Standard 1



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WS ALERT – QHSE 2010-28

WS QHSE Std 1 Guideline 1
Deepwater Cementing Job Programs

Aim of this QHSE Alert

To inform the field of the first release of WS QHSE Standard 1 Guideline 1: Deepwater Cementing Job Programs

Summary of Guideline

- This document provides guideline for the preparation and publication of Deepwater Cement Job Programs.
- Deepwater is defined as any operation that utilizes a sub-sea well control stack, or any operation in water depth greater than 500 feet.
- All Deepwater cementing job designs must conform to the requirements of this guideline.
- This guideline includes: the Deepwater cementing job program checklist, a Deepwater cementing program template and an example.

Figure 1: Deepwater Cementing Job Program Checklist

Figure 2: Deepwater Cementing Program Template

Reference:

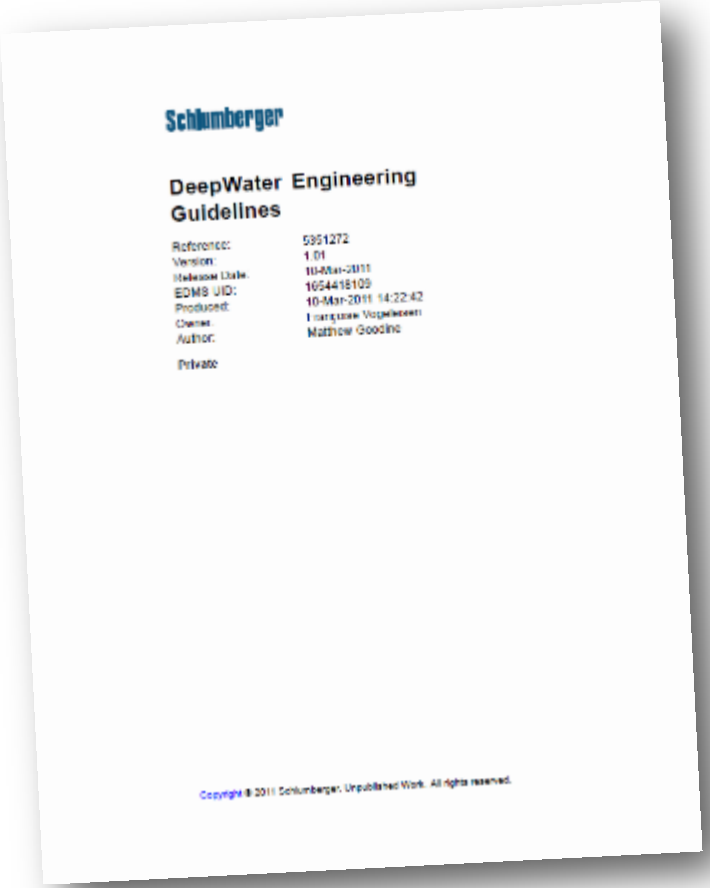
WS QHSE Standard 1, Service Delivery: Guideline 1: Deepwater Cementing Job Programs (InTouch Content ID 4398728)

| ALERT No | Page | Created by | Reviewed by | Approved by | Date |
|---|---|---|---|---|---|
| WS Alert 2010-28 | 1 of 1 | Intouch | WE Cementing | Graeme Anthony | September 13, 2010 |

- This document provides guidelines for the preparation and publication of Deepwater Cement Job Programs following API RP 65-2

- Deepwater section for Cement Engineering Manual
- Deepwater Program review
- Deepwater Certification
  - Field Specialist /Field Engineer / Design Engineer
- Software Enhancements for Deepwater cementing simulation
- Equipment Improvments

# Deepwater Engineering Guideline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DeepWater Engineering Guidelines

| | |
|---|---|
| Reference: | 5951272 |
| Version: | 1.01 |
| Release Date: | 10-Mar-2011 |
| EDMS UID: | 1654418109 |
| Produced: | 10-Mar-2011 14:22:42 |
| Owner: | Hanquan Vogelaeen |
| Author: | Matthew Goodine |

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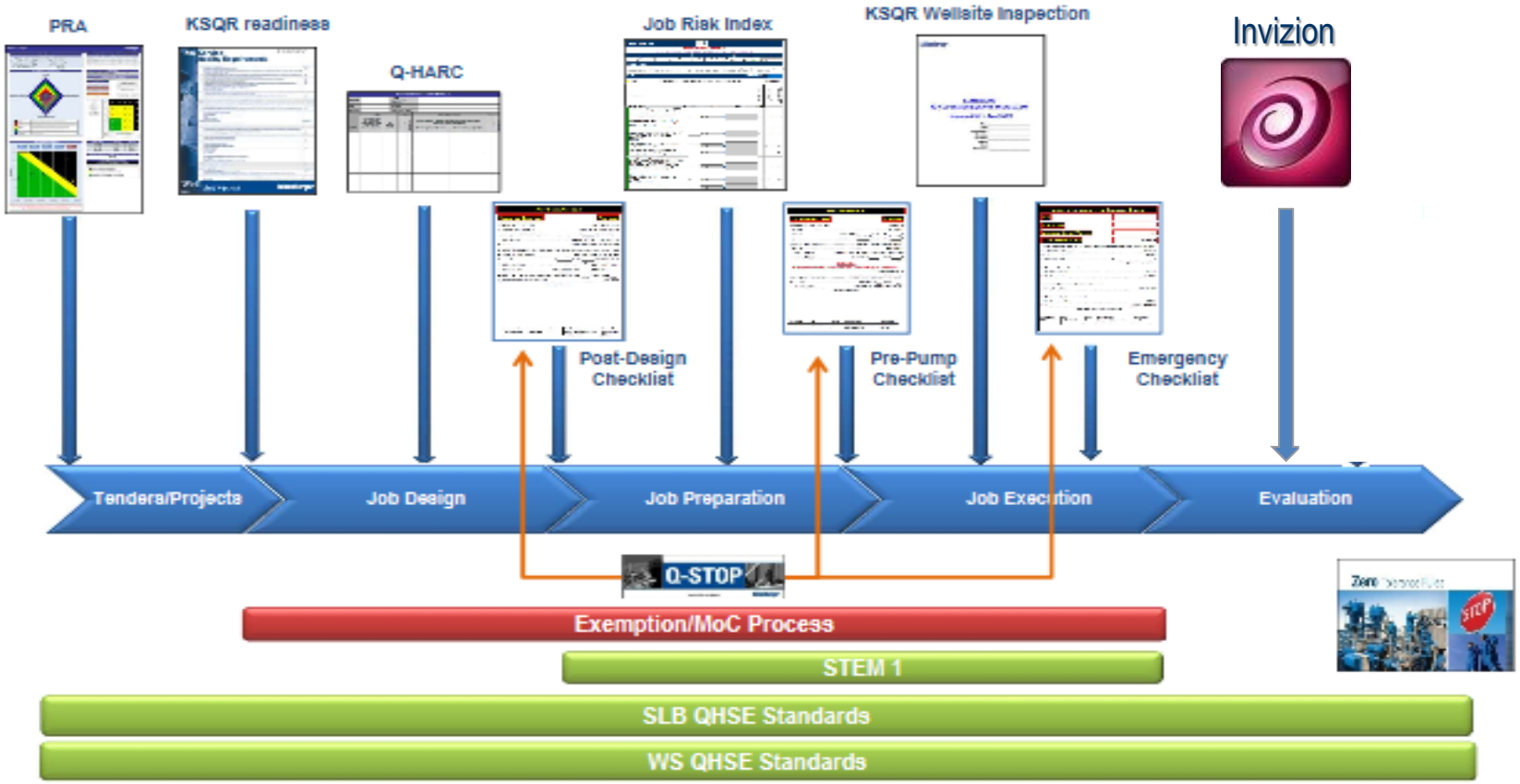
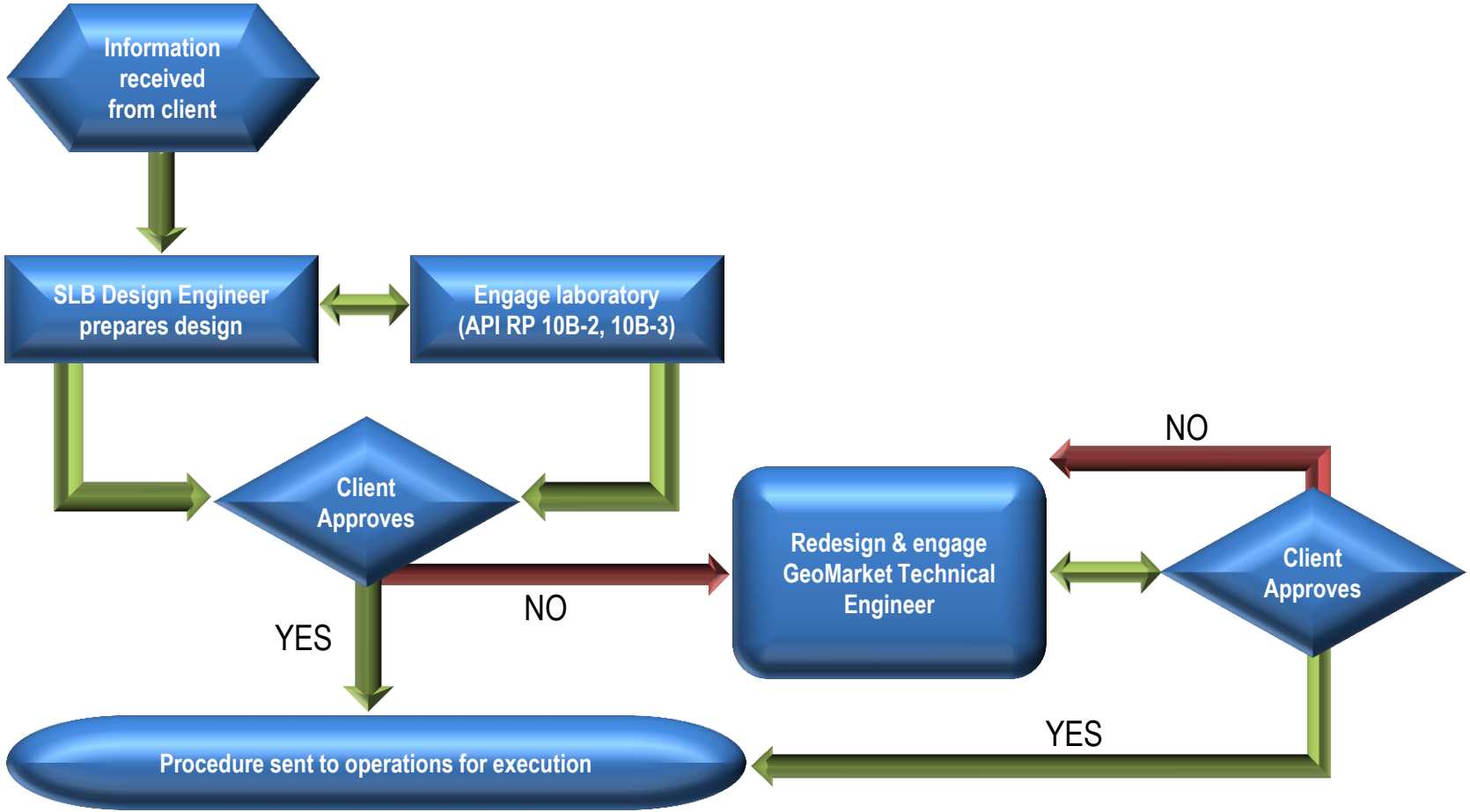
- Cement Engineering Manual
  - Section 5.10 Deepwater Engineering Guidelines
    - Published March 10, 2011

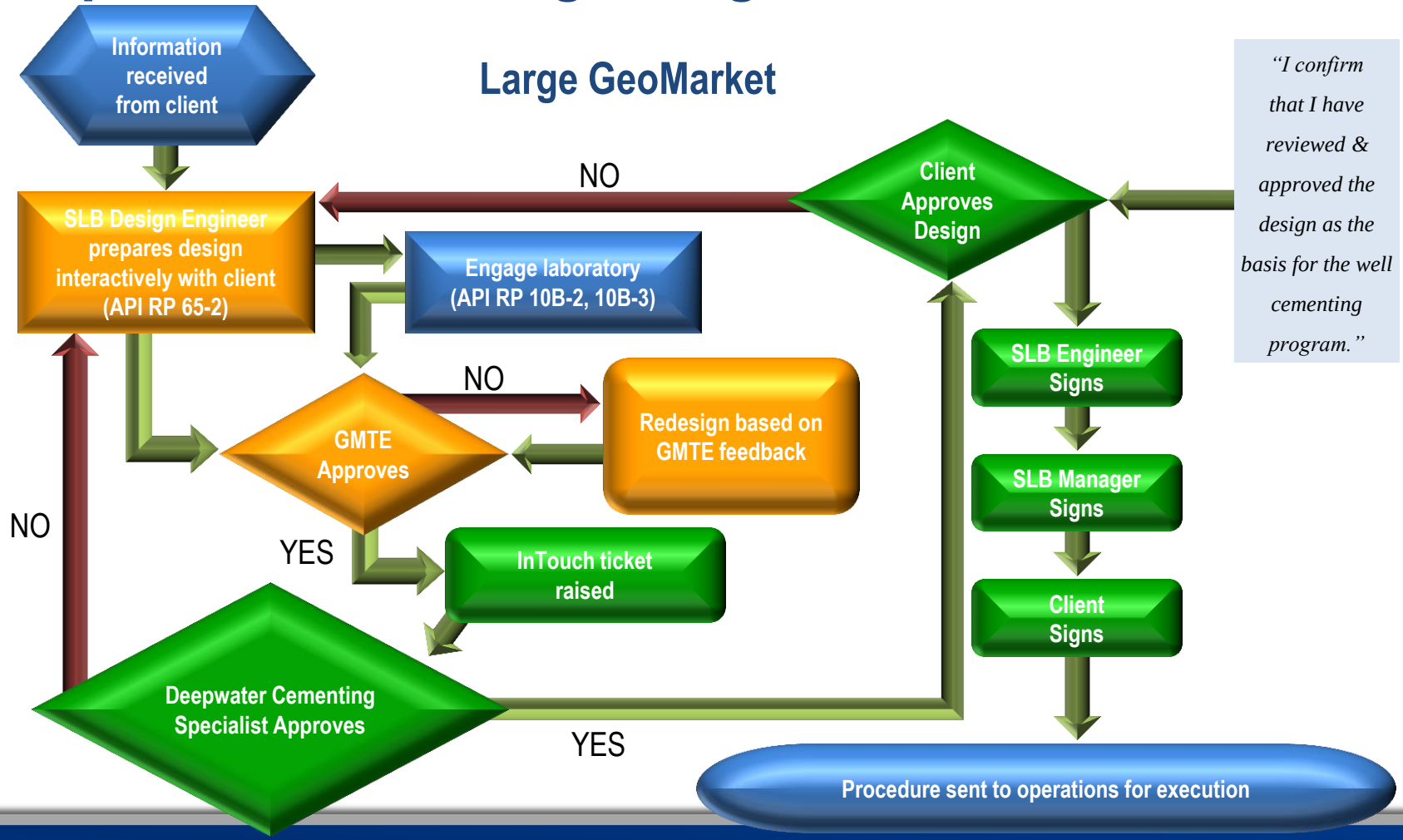
# Operational Risk Tools



# Deepwater Cementing Design Process – Pre Macondo

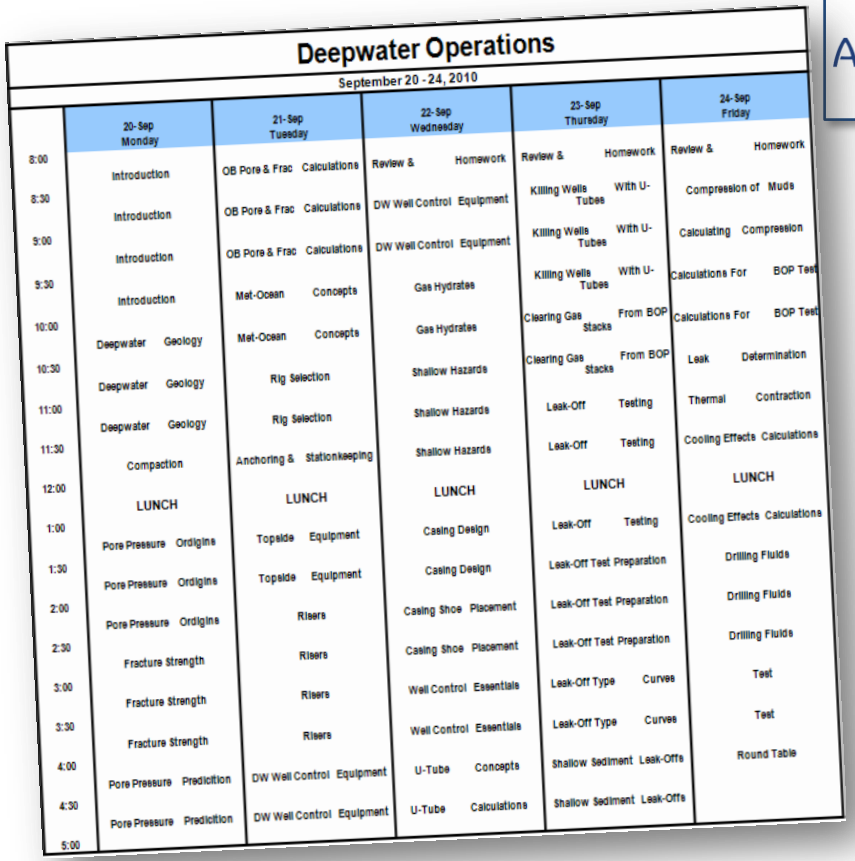


# Deepwater Cementing Design Process – Post Macondo




*"I confirm that I have reviewed & approved the design as the basis for the well cementing program."*

# Deepwater Field Specialist Training



**Deepwater Operations**

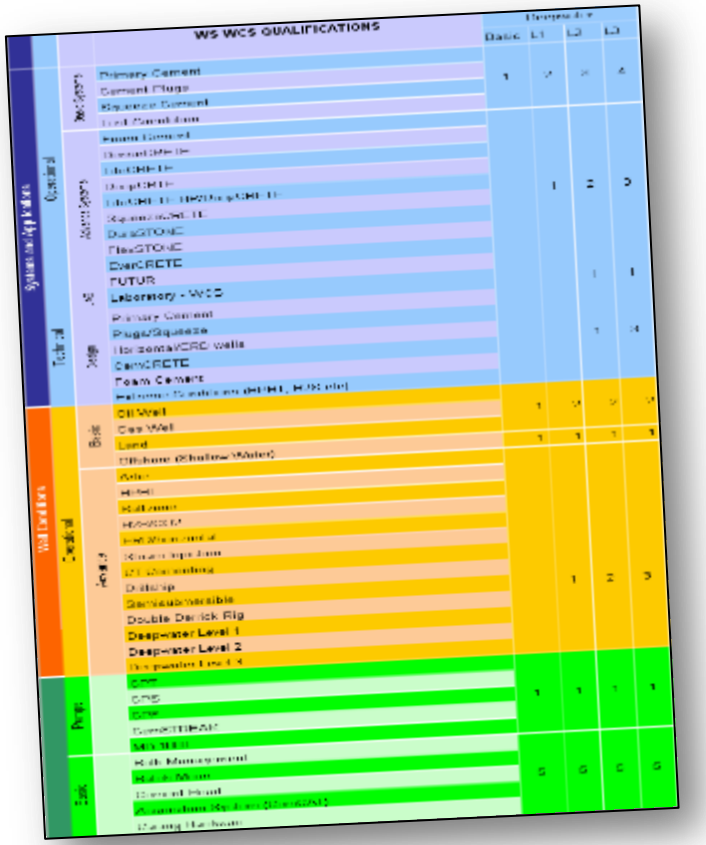
September 20 - 24, 2010

| | 20-Sep Monday | 21-Sep Tuesday | 22-Sep Wednesday | 23-Sep Thursday | 24-Sep Friday |
|---|---|---|---|---|---|
| 8:00 | Introduction | OB Pore & Frac Calculations | Review & Homework | Review & Homework | Review & Homework |
| 8:30 | Introduction | OB Pore & Frac Calculations | DW Well Control Equipment | Killing Wells With U-Tubes | Compression of Muds |
| 9:00 | Introduction | OB Pore & Frac Calculations | DW Well Control Equipment | Killing Wells With U-Tubes | Calculating Compression |
| 9:30 | Introduction | Met-Ocean Concepts | Gas Hydrates | Killing Wells With U-Tubes | Calculations For BOP Test |
| 10:00 | Deepwater Geology | Met-Ocean Concepts | Gas Hydrates | Clearing Gas From BOP Stacks | Calculations For BOP Test |
| 10:30 | Deepwater Geology | Rig Selection | Shallow Hazards | Clearing Gas From BOP Stacks | Leak Determination |
| 11:00 | Deepwater Geology | Rig Selection | Shallow Hazards | Leak-Off Testing | Thermal Contraction |
| 11:30 | Compaction | Anchoring & Stationkeeping | Shallow Hazards | Leak-Off Testing | Cooling Effects Calculations |
| 12:00 | LUNCH | LUNCH | LUNCH | LUNCH | LUNCH |
| 1:00 | Pore Pressure Ordigins | Topside Equipment | Casing Design | Leak-Off Testing | Cooling Effects Calculations |
| 1:30 | Pore Pressure Ordigins | Topside Equipment | Casing Design | Leak-Off Test Preparation | Drilling Fluids |
| 2:00 | Pore Pressure Ordigins | Risers | Casing Shoe Placement | Leak-Off Test Preparation | Drilling Fluids |
| 2:30 | Fracture Strength | Risers | Casing Shoe Placement | Leak-Off Test Preparation | Drilling Fluids |
| 3:00 | Fracture Strength | Risers | Well Control Essentials | Leak-Off Type Curves | Test |
| 3:30 | Fracture Strength | Risers | Well Control Essentials | Leak-Off Type Curves | Test |
| 4:00 | Pore Pressure Prediction | DW Well Control Equipment | U-Tube Concepts | Shallow Sediment Leak-Offs | Round Table |
| 4:30 | Pore Pressure Prediction | DW Well Control Equipment | U-Tube Calculations | Shallow Sediment Leak-Offs | |
| 5:00 | | | | | |

- To comply with the Deep water Certification Guideline, Well Services is providing technical training for all Deepwater Field Specialists

# Deepwater Certification

## Field Specialists Population Mapping




- 3 Deepwater certification levels, parallel but not linked to SCDP grade levels.
  - Deepwater Level 1: Deepwater Cementer
  - Deepwater Level 2: Deepwater Advanced
  - Deepwater Level 3: Deepwater Expert
- Certifications assessment through iLearn
- Deepwater specific training for Field engineers

# EQUIPMENT Cementing

| Cementing | Q3 2010 | Q4 2010 | Q1 2011 | Q2 2011 | H2 2011 |
|---|---|---|---|---|---|
| **Rationalize Casing Hardware Suppliers** | Involve supply chain & audit (API RP 10-F) | | Engage Smith | Audit to ensure compliance | |
| **Disposal of Non Compliant Casing Hardware** | | Write procedure | Publish & communicate | Disposal | Audit to ensure compliance |
| **Rationalize Well Suspension Packer Suppliers** | Involve supply chain & audit (API RP 11-D1) | | Limit SWPS | Disposal | |
| **Rationalize Service Packer Suppliers** | Involve supply chain & audit (API RP 11-D1) | | Limit SWPS | | Disposal |
| **Provide Support to the field** | | SRC Sustaining Engineer assigned | | On going support | |
| **Ensure Zoned Equipment has not been compromised** | | | Perform assessment | | |

# Casing Hardware supplier audits

Version 1.0, Sep 2010

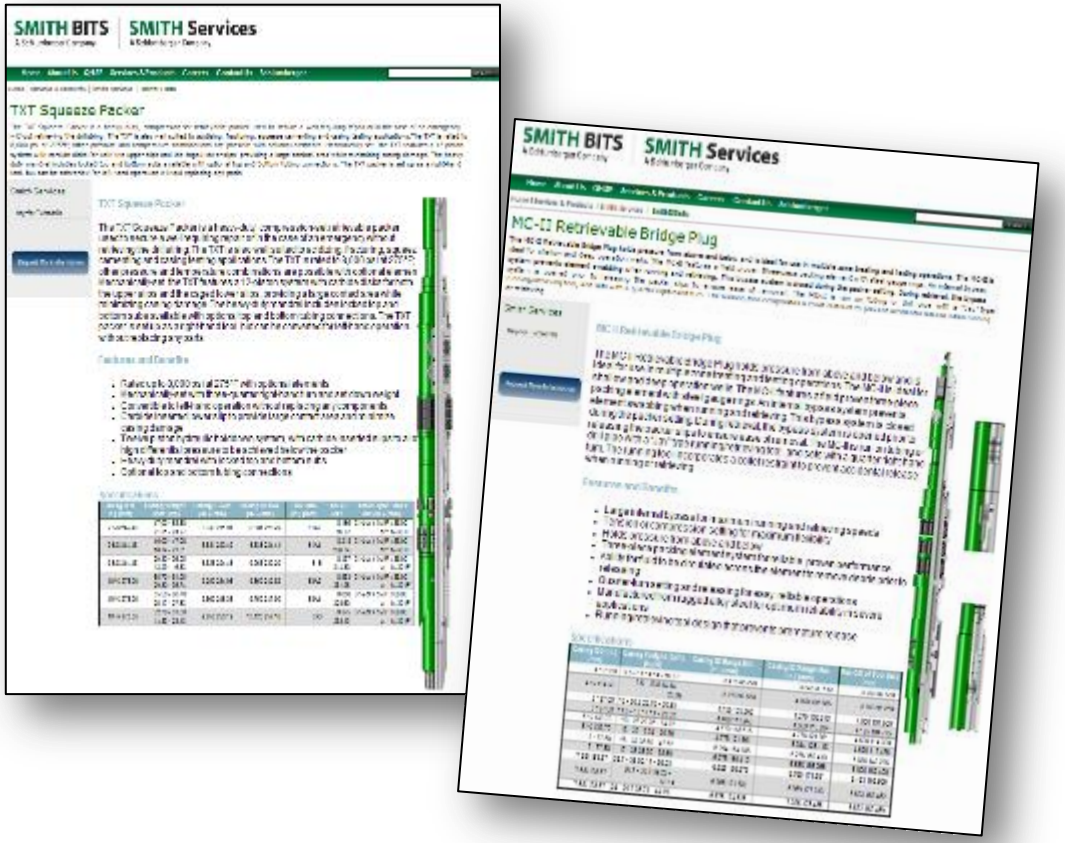
**Supplier Name:** P.T. Sagatrade Murni
**Supplier Address:** JL. Aditayawarman No. 51 Kebayoran Baru, Jakarta 12160 -
**Supplier Contact:** Egar Suharta Legawa, Marketing Mgr.
**Hardware Reviewed:** Centralizers, Float Collars, Float Shoes, Stop collars

**Plant Location:** JL. Lumba - Lumba, Log Pond Selili, Samarinda - K
**Audit Date:** Oct 7 & 8, 2010
**Auditor Name:** Walter Friedl
**Auditor Job Title:** Quality& Operations Support Mgr. WS ASA
**Supply Chain Representative:** Dyah Utami

| Stop Collars | | | | |
|---|---|---|---|---|
| Number | Questionnaires | Yes / No | Auditor Comments | Assessor Guidance |
| 1 | Does the supplier follow API RP 10D-2 / ISO 10427-2 for stop collar testing? | Yes | - Test on centralizers only done on request from customer or new design. No periodic testing to proof consist product performance over time.<br>- Test report does not make reference to a particular batch of production.<br>- Test report does not include measurements of scratch length, width or depth on the casing. | This is not mandatory but will demonstrate the supplier follows recommended industry practices |
| 2 | Do the records of the tests show that the design resistance exceeds the starting force of a given size of centralizer? | Yes | - Verified records for several sizes, including 4 1/2", 7", 9 5/8" 13 3/8" & 20" | Ask the supplier to produce records of the tests performed on current production run to ensure the design resistance exceeds the starting force of a given size of centralizer.<br>Example: For a 7" stop collar, the stop collar resistance should be greater than a 7" centralizer starting force of 1040 lbf plus a multiplier |
| 3 | Is the stop collar test stand adequate as per described in API 10D-2? | Yes | | View stop collar test stand to see if it is adequate as described in API 10D-2. |
| 4 | Are measuring devices rated to the proper accuracy? | Yes | 10,000 PSI Digital Gauge with 10 PSI resolution, 1.2% maximum error based on last calibration record<br>Potentiometer with 0.05" resolution to measure displacement readings | Check documentation of measuring devices to ensure they are rated to the proper accuracy |
| 5 | Are measuring devices calibrated annually? | Yes | Master Gauges calibrated and certified every 5 years by 3rd party. All records in place. Internal calibration program of measuring devices on test bench done every 6 month against Master Gauges | Check calibration records of measuring devices (annual calibration required) |
| 6 | Is the test stand functional and procedures followed? | Yes | | Observe a test, if possible, to determine the test stand is functional and procedures followed |
| 7 | Is there a system in place to report non conformance? Is there a process in place to close out the non conformance reports? | Yes | No NCR on record related to Stop collars | Ask to see Non Conformance Reports that have been created and ask how they are closed out<br>The supplier should have a process they follow. |
| 8 | Note any other concerns / discrepancies from the review or any positive observations. | | No acceptance criteria or QA/QC processes in place for set screws or pins. Set screws are procured in Singapore or Korea; pins are procured locally (nails) | |

- Casing Hardware suppliers are being limited to companies that comply with:
  - API Spec 10D
  - API RP 10F
- Davis Lynch
- Topco
- SagaTrade
  - Waiting on follow-up audit

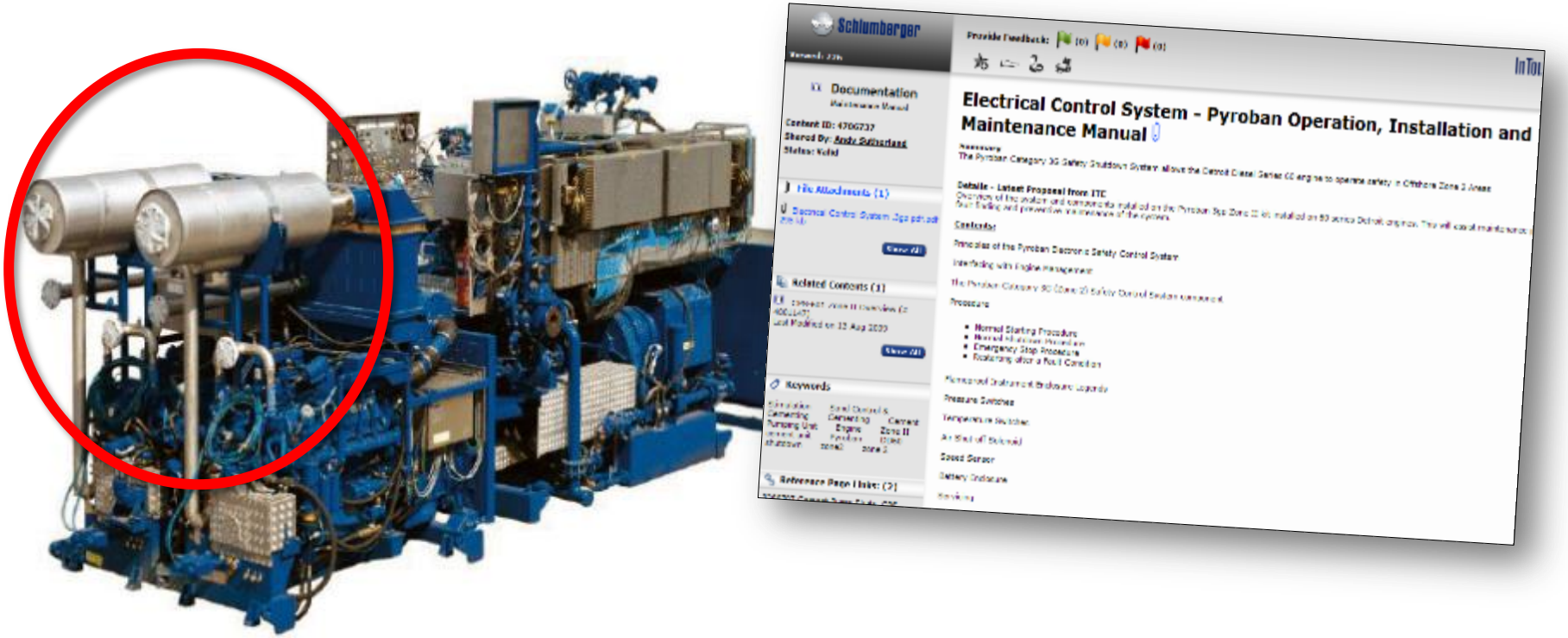
# Rationalization of Abandonment Packers




- Abandonment Packers have assessed as a gap in our integrity review
  - No direction provided in the past to the field as to the suppliers that meet API 11D1
- Approved Packer / RBP's
  - DLT Packer
  - Smith TXT and TXT-2 Packer
  - Smith MC-II RBP

# Zoned Equipment

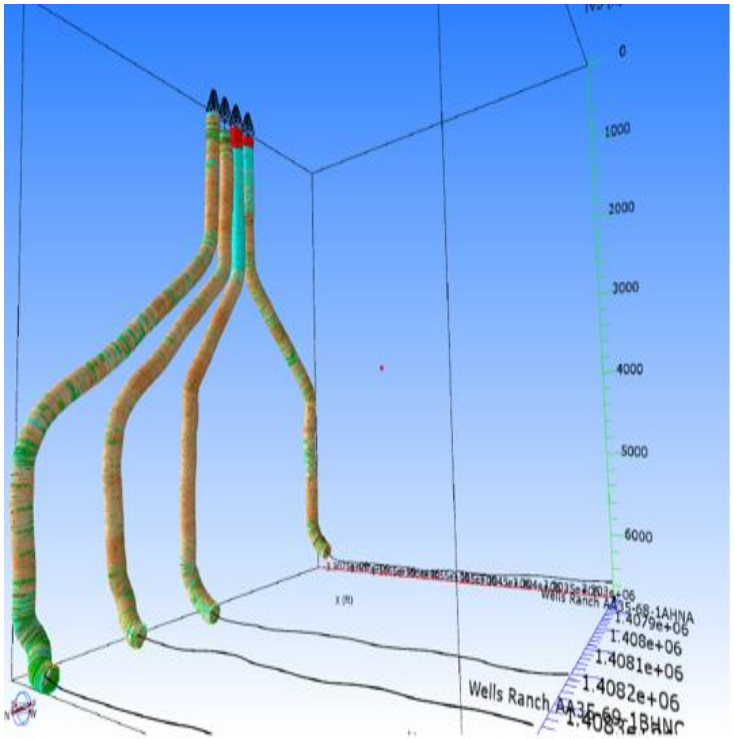
## Ensure Pyroban System Integrity



# Cementing software upgrade

- Automated Cement slurry Design Process
- API Std 65-2 & RP 96 compliant
- Friction pressure model incl fluids characteristics changes with T and P
- Temperature simulator validated with downhole measurements
- Realistic centralization model based on FE
- Mud displacement model with 3D aperture and azimuthal pressure gradient component
- Cement plug contamination model down pipe + up annulus
- Casing Rotation and Reciprocation effects

# Well Integrity Evaluation Workflow INVIZION




- **Analyze** open hole logs
- **Forecast** simulation of cementing placement
- **Measure** against actual acoustic logs

# Well integrity evaluation work flow