OIL & GAS

Managing New Technology Risks – DNV GL Technology Qualification (TQ) Process

AIChE - Houston

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Meeting Agenda

1. Overview of DNV GL RP A-203 Technology Qualification Process
2. Benefits of Technology Qualification (TQ) Certificate
3. Other DNV GL service offerings
4. Discussion/Feedback
“It is likely that something unlikely will occur”

(Aristotles)

However

“Chance favors the prepared mind”

(Louis Pasteur)
What is Technology Qualification (TQ)

- Qualification is the process of *providing the evidence* that the technology will *function within specific limits* with an *acceptable level of confidence*

- Systematic risk-based approach that supports technology developers and operators to manage risks/uncertainties when bringing new technology to market.
Proven Technology

- C: Case is based on proven technologies
- C: Concept covered by standards
- C: Design complies with standards
- C: Produced according to specs

New Technology

- C: Business attractive if technology works
- C: Concept is technically feasible
- C: Design is fit for intended use
- C: Recipient ready to use new technology
- C: Basic principles validated
- C: Tech. uncertainties can be handled by normal design process
- C: Produced according to specs
Key Aspects of Technology Qualification

- Technology Qualification establishes:
  - What needs to be tested
  - How it should be tested (for example on a pilot well)?
  - In which scale tests or analyses should be performed (small scale, pilot test, onshore/offshore)?
  - What are the testing conditions, acceptance criteria?
  - What are documentation needs?

- Involvement:
  - On behalf of technology developer,
  - On behalf of end user
  - On behalf of independent party such as regulator
Overview of DNV GL RP A-203 Technology Qualification Process

**Qualification Work Process**

1. **Qualification Basis**
2. **Technology Assessment**
3. **Threat Assessment**
4. **Selection of Qualification Methods**
5. **Execute Qualification Plan**
6. **Performance Assessment**

**Concept Improvement**

- What is the technology and application to be qualified, how mature is it?
- What is new about it?
- What are the failure modes and associated risks?
- How can uncertainties and risks be reduced for each and every failure mode?
- Gather data and results and document all that is done
- Close out the gaps and make sure that the qualification expectations were met
- Uncertainties and risks are reduced while confidence has increased

**Planning**

- **Qualification Basis**
- **Technology Assessment**
- **Threat Assessment**
- **Selection of Qualification Methods**
- **Execute Qualification Plan**
- **Performance Assessment**

**Technology Deployment**

- Identify Threats
- Collect Evidence
- Install Confidence
Qualification Basis
Description of the technology, operating conditions, system performance requirements

Technical Workshops
SMEs from: equipment manufacturer, end user (such as operator) and DNV GL.
Facilitation: DNV GL

Qualification Plan
Qualification methods are specified to provide evidence for each identified failure mode

Technology Qualification Basis
Technology Assessment
Threat Assessment
Qualification Activities
## Technology Assessment

<table>
<thead>
<tr>
<th>Application</th>
<th>Technology Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - Proven</td>
</tr>
<tr>
<td>1 - Known</td>
<td>1</td>
</tr>
<tr>
<td>2 - Limited</td>
<td>2</td>
</tr>
<tr>
<td>3 - New</td>
<td>3</td>
</tr>
</tbody>
</table>

Technology Assessment Novelty Scale:

1. No new technical uncertainties
2. New technical uncertainties
3. New technical challenges
4. Demanding new technical challenges
### Threat Assessment _ FMECA Methodology

<table>
<thead>
<tr>
<th>Component (Segment/Assembly Level)</th>
<th>Function</th>
<th>Failure modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the function of the given segment/assembly that is being analysed during operation?</td>
<td>How could the segment/assembly potentially fail to perform its functional requirement?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Local/system/global failure effects</th>
<th>Safeguards</th>
<th>Failure causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the potential local, system and global effect of the failure mode?</td>
<td>What mechanisms can cause each functional failure?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk ranking</th>
<th>Action items</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the likelihood and consequence of the failure mode (frequency x consequence)?</td>
<td>Should the failure mode be investigated further after the session?</td>
</tr>
</tbody>
</table>
Failure mode/mechanism hierarchy

Consequence of leakage from sealing

System level
(Pump system with lubrication system, instrumentation etc.)

Sub-system level
(Pump)

Component level
(Sealing)

Root Cause
- Poor lubrication
- Usage outside spec.
- Wrong material spec.
- etc.

Failure Mechanism
- Corrosion
- Wear / erosion
- Hardening
- etc.

Failure Mode
- Leakage from sealing
- Internal leakage in pump
- etc.

Cause
- Internal leakage in pump

Failure Mode
- Unable to shut down completely

Effects
- Intervention and repair or replacement

"Local effect"

"Global effect"
## Threat Assessment_Risk Matrix

<table>
<thead>
<tr>
<th>Consequence Likelihood</th>
<th>Safety &amp; Health</th>
<th>Impact</th>
<th>Increasing Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Injuries &amp; Community Health</td>
<td>Damage to industry reputation</td>
<td>Slight impact; customer awareness but resolution within Schlumberger</td>
<td>Rare or unheard of</td>
</tr>
<tr>
<td>1 - Incidental</td>
<td></td>
<td></td>
<td>Has occurred once or twice within industry</td>
</tr>
<tr>
<td>Workforce: Minor first-aid injury to a single person in the workforce. Treatment is minimal or not necessary. AND Public: No impact</td>
<td>Physical and Biological</td>
<td>Impact such as localized or short term effects on habitat, species, and environmental media.</td>
<td>Reasonable to expect that the event will not occur at this facility.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimal damage, negligible downtime or asset loss. Costs &lt; $30,000.</td>
<td>Has occurred several times in the industry. Exceptional condition may allow consequences to occur within the facility lifetime.</td>
</tr>
<tr>
<td>2 - Minor</td>
<td></td>
<td></td>
<td>Has occurred once or more at this facility. Condition may allow consequences to occur at the facility during its lifetime.</td>
</tr>
<tr>
<td>Workforce: One or more injuries, not severe. Full recovery with medical treatment. OR Public: One or more first-aid injury. Treatment is minimal or not necessary.</td>
<td>Limited impact; resolution involves active participation by technical personnel</td>
<td>Impact such as localized, long term degradation of sensitive habitat or widespread short term impacts to habitat, species or environmental media.</td>
<td></td>
</tr>
<tr>
<td>3 - Moderate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workforce: One or more injuries, not severe. Full recovery with medical treatment. OR Public: One or more injuries, not severe. Full recovery with medical treatment.</td>
<td>Considerable impact; negative involvement by asset and high level technical personnel</td>
<td>Impact such as localized but irreversible habitat loss or widespread, long-term effects on habitat, species or environmental media.</td>
<td></td>
</tr>
<tr>
<td>4 - Major</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workforce: Fatalities (1-4) OR Public: One or more severe injuries. Full recovery with extensive medical treatment.</td>
<td>Extensive negative attention with specific customer; high level Schlumberger and customer awareness and involvement</td>
<td>Impact such as significant widespread and persistent changes in habitat, species or environmental media. (e.g widespread habitat degradation)</td>
<td></td>
</tr>
<tr>
<td>5 - Severe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workforce: Multiple fatalities (5-10) OR Public: Multiple fatalities (1-10)</td>
<td>Extensive negative attention in the industry</td>
<td>Impact such as persistent reduction in ecosystem function on a landscape scale or significant disruption of a sensitive species.</td>
<td></td>
</tr>
</tbody>
</table>

**Impact Levels**: 1 - Incidental, 2 - Minor, 3 - Moderate, 4 - Major, 5 - Severe

**Increasing Likelihood**: 1 - Rare, 2 - Remote, 3 - Unlikely, 4 - Seldom, 5 - Occasional
# Qualification Activities Example for High/Medium Risk Items

<table>
<thead>
<tr>
<th>Component</th>
<th>Failure Modes</th>
<th>Actions/Safeguards</th>
</tr>
</thead>
</table>
| Component #1    |                                                    | • Independent verification  
|                 |                                                    | • FEA Analysis  
|                 |                                                    | • Historic reference review                                                      |
| Component #2    |                                                    | • Isolated full-scale nozzle test using LNG                                         |
| Component #3    |                                                    | • Design alternatives to eliminate the actuated plugs                              |
| Component #4    |                                                    | • Usage of bearings under similar applications  
|                 |                                                    | • Rotor stress/deflection calculations  
|                 |                                                    | • Mechanical run tests.                                                           |
|                 |                                                    | • SIL certification for over-speed protection  
|                 |                                                    | Modal analysis of the turbine wheel  
|                 |                                                    | Performance test of scaled VPT unit.                                              |
Technology Qualification Phase II

Qualification Plan Execution
Carry out the Technology Qualification Plan in order to substantiate the performance margins for the failure modes of concern

Qualification Activities

Performance Assessment
Review available qualification documentation against the technology qualification basis and the acceptance criteria in the Technology qualification plan

Review Qualification Results, establish qualification Management Table
Collect Qualification Evidence

Technology Qualification Certificate
Conclude the technology has been qualified and is ready to deployment

Issue TQ certificate
DNV GL TQ Process (DNV RP A-203) Deliverables

1. Qualification Basis
   Set the performance targets

2. Technology Assessment
   Analyse how to assure the functions

3. Threat Assessment
   Identify the failure modes and risks

4. Qualification Plan
   Plan the provision of evidence

5. Qualification Execution
   Provision of the evidence

6. Performance Assessment
   Compare with the performance targets

Targets met?

No

Yes

When requirements met

Technology Qualified

When no prohibitive obstacles

Statement of Feasibility

When technically executable

Endorsement of Qualification Plan

1. When no prohibitive obstacles

2. When technically executable

3. When requirements met
Benefits of DNV GL TQ Certificate

▪ DNV GL TQ Process: systematic risk-based process of providing evidence that a technology will function within specific limits with an acceptable level of confidence;

▪ For Equipment Manufacturer (Technology Owner):
  ✓ Incorporate regulatory requirement or other compliance requirement early on in the design phase and reduce the rework risk;
  ✓ Opportunity to improve system design at early stage;
  ✓ Leverage industry experience as we have completed many TQ projects for various companies;
  ✓ Marketing competitive advantage: DNV-RP-A203 widely accepted and recognized in the industry for Technology Qualification;
Benefits of DNV GL TQ Certificate (Cont’d)

- For Equipment End User:
  - Minimize the uncertainty/risk associated with deploying the new technology;
  - Reduce development cycle time by using “qualified technology”;
  - Common criteria when selecting different vendors;
  - Enhance confidence on the operation where there is no proven experience in the application
When would you do Technology Qualification projects?

- Lack of confidence on the technology, not sure how it will behave as expected
- Not knowing what they do not know, need an expert source of knowledge
- Need to comply with internal company requirements for new technology use
- Market Competitive Advantage
- Operator / End Customer Requirement
- Technology Selection for increased reliability
What do you think would be areas/technology in downstream that are applicable to the Technology Qualification project criteria?
Examples of technologies we are qualifying

Platform Concepts – **Interface with Offshore Class**

- Aker Dry Tree
- HOE Dry Tree
- Compliant Vertical Risers
- Composite Risers
- Flexible Risers
- Pipe-in-pipe solutions
- Enhanced collapse properties
- Bi-directional piggable wye

Oxy-Fuel Generator

**CH₄, CO, H₂, etc.**
## DNV GL TQ Project Reference

<table>
<thead>
<tr>
<th>Customer</th>
<th>Technology Qualification Project Name</th>
<th>Project Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGS</td>
<td>Subsea Fiber Optics monitoring system 1.0</td>
<td>2010</td>
</tr>
<tr>
<td>Fluor Corporation</td>
<td>Subsea LNG cryogenic Pipeline</td>
<td>2010</td>
</tr>
<tr>
<td>Chevron</td>
<td>CIMV TQ</td>
<td>2010</td>
</tr>
<tr>
<td>Chevron</td>
<td>Tahiti 2 water Injection Pumps</td>
<td>2010</td>
</tr>
<tr>
<td>Chevron</td>
<td>JSM TQ support</td>
<td>2010</td>
</tr>
<tr>
<td>Enbridge Offshore Facilities</td>
<td>QCS’ Dual Director Wye™</td>
<td>2011</td>
</tr>
<tr>
<td>Chevron</td>
<td>Direct Electric Heating System</td>
<td>2011</td>
</tr>
<tr>
<td>FloaTEC, LLC</td>
<td>Extendable Draft Semi-Submersible Grouted Connector</td>
<td>2011</td>
</tr>
<tr>
<td>Roxar</td>
<td>Roxar’s Subsea Multiphase Flow Meter</td>
<td>2012</td>
</tr>
<tr>
<td>Chevron</td>
<td>Blind Faith Artificial Lift</td>
<td>2012</td>
</tr>
<tr>
<td>Parker Hannifin Corporation</td>
<td>Phastite Pipe Fitting</td>
<td>2013</td>
</tr>
<tr>
<td>Voith Composites GmbH &amp; Co. KG</td>
<td>Carbon Fiber Reinforced Polymer (CFRP) Drill Pipe</td>
<td>2013</td>
</tr>
<tr>
<td>Trendsetter Engineering Inc. (TEI)</td>
<td>10K and 15K Capping Stack</td>
<td>2014</td>
</tr>
<tr>
<td>BP</td>
<td>Bonded Composite Pipe for Subsea Spools</td>
<td>2014</td>
</tr>
<tr>
<td>Shell</td>
<td>Low Salinity Water Flood System</td>
<td>2014</td>
</tr>
<tr>
<td>Chevron</td>
<td>Lianzi TQ support (Subsea sampling system, DEH, MPFM)</td>
<td>2015</td>
</tr>
<tr>
<td>Techlam</td>
<td>TLP Tendon Connector</td>
<td>2015</td>
</tr>
<tr>
<td>Aker Solutions</td>
<td>5&quot; - 15k/10K Vertical Christmas Tree on Tubing Head Spool (VXT on THS)</td>
<td>2015</td>
</tr>
<tr>
<td>ConocoPhillips Company Inc. (COP)</td>
<td>Flashing Liquid Expander Technology Qualification</td>
<td>2015</td>
</tr>
<tr>
<td>Chevron</td>
<td>Intelligent well completions</td>
<td>2015</td>
</tr>
<tr>
<td>Chevron</td>
<td>Lufkin PRC Regen well manager system</td>
<td>2015</td>
</tr>
<tr>
<td>Cameron</td>
<td>CDX system TRL Assessment</td>
<td>2016</td>
</tr>
<tr>
<td>PGS</td>
<td>Subsea Fiber Optics monitoring system 2.0</td>
<td>2016</td>
</tr>
<tr>
<td>SOFEC</td>
<td>Internal Turret System</td>
<td>2017</td>
</tr>
<tr>
<td>MWCC</td>
<td>20K Capping Stack</td>
<td>Ongoing</td>
</tr>
<tr>
<td>View into the Blue</td>
<td>Underwater camera</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Schlumberger</td>
<td>Managed Pressured Drilling System</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Steelhead</td>
<td>Compositie accumulator</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Transocean/Shell</td>
<td>BOP control system (ZED)</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Halliburton</td>
<td>3’ subsea tree EH control system</td>
<td>Ongoing</td>
</tr>
</tbody>
</table>

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**Customer Technology Qualification Project Name**

- PGS Subsea Fiber Optics monitoring system 1.0
- Fluor Corporation Subsea LNG cryogenic Pipeline
- Chevron CIMV TQ
- Chevron Tahiti 2 water Injection Pumps
- Chevron JSM TQ support
- Enbridge Offshore Facilities QCS’ Dual Director Wye™
- Chevron Direct Electric Heating System
- FloaTEC, LLC Extendable Draft Semi-Submersible Grouted Connector
- Roxar Roxar’s Subsea Multiphase Flow Meter
- Chevron Blind Faith Artificial Lift
- Parker Hannifin Corporation Phastite Pipe Fitting
- Voith Composites GmbH & Co. KG Carbon Fiber Reinforced Polymer (CFRP) Drill Pipe
- Trendsetter Engineering Inc. (TEI) 10K and 15K Capping Stack
- BP Bonded Composite Pipe for Subsea Spools
- Shell Low Salinity Water Flood System
- Chevron Lianzi TQ support (Subsea sampling system, DEH, MPFM)
- Techlam TLP Tendon Connector
- Aker Solutions 5" - 15k/10K Vertical Christmas Tree on Tubing Head Spool (VXT on THS)
- ConocoPhillips Company Inc. (COP) Flashing Liquid Expander Technology Qualification
- Chevron Intelligent well completions
- Chevron Lufkin PRC Regen well manager system
- Cameron CDX system TRL Assessment
- PGS Subsea Fiber Optics monitoring system 2.0
- SOFEC Internal Turret System
- MWCC 20K Capping Stack
- View into the Blue Underwater camera
- Schlumberger Managed Pressured Drilling System
- Steelhead Compositie accumulator
- Transocean/Shell BOP control system (ZED)
- Halliburton 3’ subsea tree EH control system

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**Project Completion**

- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- Ongoing
Public Service Announcement!

- DNV GL RP- A203 is a publicly available document.

Our services span through the asset life

TECHNOLOGY QUALIFICATION

VERIFICATION/ CERTIFICATION

INTEGRITY MANAGEMENT

INDEPENDENT ANALYSIS
Verification Service

“The confirmation through the provision of objective evidence that specified requirements have been fulfilled.”
Certification Services & Differentiation of Services

- Type Examination Certification
  - “Certification” to Recognized Industry Standards (i.e. API/ ISO/ EN/ AUS/NZ)

- Product Certification
  - “Certification” to DNV GL SE-0045/ ST-0035

Certification Notes

- *Certification is a conformity assessment requiring both design and manufacturing verification activities to be performed.*
- *Certification is typically performed on a scope of work dictated by the DNV GL or the publically available scheme.*

- Compared to Verification?
  - *Verification is typically performed on a scope of work dictated by the client.*
Late-Life Assessment

- Late-life Assessment services
  - Verify that structure, systems and components is in compliance with today's standards and legislation
  - Ensure technical, operational and organisational integrity
  - Assess sufficient integrity to continue safe operations throughout lifetime
  - Late-life costs and planning
  - **Goal**: Comply with NORSOK U-009 Life Extension for Subsea Production Systems
## Risk Management Advisory Services

Risk Management Advisory offers a portfolio of capabilities that cover a full range of services in the area of risk assessments and mitigation techniques. Our services can categorized as:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SAFETY RISK MANAGEMENT</strong></td>
<td>Comprises services which help our customers manage their activities’ risk to humans. These services focus on risk prevention and mitigation, as well as investigating why things go wrong. These services are also inputs to asset, environmental and enterprise risk.</td>
</tr>
<tr>
<td><strong>ASSET RISK MANAGEMENT</strong></td>
<td>Comprises services taking care of our customers’ activities’ risk to their own assets. The services concentrate on risk prevention, looking at the systems and plans as well as the activities and the physical assets themselves.</td>
</tr>
<tr>
<td><strong>ENVIRONMENTAL RISK MANAGEMENT</strong></td>
<td>Comprises services regarding risk to the external environment. The services focus on risk prevention and mitigation and include detailed environmental analysis of an area’s vulnerability.</td>
</tr>
<tr>
<td><strong>ENTERPRISE RISK MANAGEMENT</strong></td>
<td>Comprises services taking care of our customers’ business, albeit always with a technical perspective. The services concentrate on risk identification, control and prevention, looking at the systems and plans as well as the overall activities in their projects or organization.</td>
</tr>
</tbody>
</table>
Service Areas

- Quantitative Risk Assessment (QRA)
- Fire and Explosion Analysis (CFD or Phast)
- Smoke and Gas Dispersion Analysis (CFD or Phast)
- Turbine Exhaust Assessment
- Emergency Systems Survivability Assessment
- Emergency Escape, Evacuation and Rescue Analysis
- Dropped Objects Analysis
- Structural Integrity Analysis
- Fire & Gas Mapping Study
- Process Hazard Analysis (PHA) – HAZOP / HAZID
- FMECA / FMEA
- Reliability, Availability and Maintainability (RAM) Analysis
- Functional Safety (SIL / LOPA)
- Fault Tree Analysis
- Noise and Vibration Study
- Bowtie Analysis / Barrier Management
- Incident Investigation
- Safety Critical Elements Identification / Assessment and Performance Standards
- Human Factors Analysis
- ALARP Study
- Readiness Reviews
- Safety Culture Diagnostic and Implementation of Improvement Measures
- Safety Case Development
- Compliance support with permits, licenses and consents
- Management System Related Gap Analysis
- Illumination Study
Some Value Adding Services / Differentiators

- **Advanced 3D visuals or short animations** of a release event, which offer a powerful method of risk communication.

- **Visualization of QRA** risk results in Google Earth

- **Streamlined PHA** significantly reduces costs for facilities with requirements to conduct periodical PHA reviews (e.g. once every five years or annually).

- **PHA with Analytics** helps companies prioritize the implementation of safeguards and recommendations within their facilities through improved analysis of their PHA data.

- **BSCAT for Incident Investigation** Barrier-based Systematic Cause Analysis Technique (BSCAT) approach more clearly identifies safeguards and controls that failed or were degraded in operation, and also makes more transparent why a recommendation might be generated.
What we do

We build trust and confidence
Discussion and Feedback
Thank You!

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SAFER, SMARTER, GREENER