Subsea Integrity: From thoughts to actions

Subsea Europe 2009

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**Subsea Assets** What are we talking about?

**SURF** Subsea equipment, Umbilical, Risers, Flowlines

- **Subsea to beach**
- Work Over
- **Subsea Drilling Systems**
- Satellite Subsea Trees
- Smart Well Control Systems
- **Subsea Manifold w/trees**
- X-mas Trees
- Subsea Processing
- Non class Floaters
- Risers Umbilicals
- Flowlines
What is Integrity Management?

What’s the difference between a maintenance program and integrity management?
What is Integrity Management?

IM : Integrity Management

Integrity of an Asset or System:

- The asset/system fulfil the design requirements throughout its whole lifecycle
- Ensure fitness for purpose of assets with optimal use of effort whilst complying with company policies and regulatory requirements
- A continuous process of Knowledge and Experience Management applied throughout the lifecycle to assure that the asset/system is managed cost effectively and safely and remains reliable and available, with due focus on personnel, assets, operations and environment

IM activities:

The activities to control and document the integrity for the whole operational life

IM aims to ensure the integrity of an asset/system within a set of specified operational limitations throughout the lifecycle
What should we focus on?

- Avoid (major) accidents
- Comply with regulations and authority requirements
- Comply with codes and standards, e.g. DNV Codes, API standards, Company standards, etc. (acceptance criteria, requirements, PIM system etc.)
- Protect reputation
- Meet production targets / minimum downtime (economy)
- Low maintenance costs
 Integrity Management: System vs. Process

INTEGRITY MANAGEMENT SYSTEM

Core process

- Management of Change
- Contingency Plans
- Audit and Review
- Information Management

INTEGRITY MANAGEMENT PROCESS

- Company Policy
- Organisation and Personnel
- Reporting and Communication
- Operational Controls and Procedures
- Risk Assessment and IM Planning
- Mitigation, Intervention & Repair
- Inspection, Monitoring & Testing
- Integrity Assessment
The Integrity Management System; in a life cycle perspective

**INTEGRITY MANAGEMENT SYSTEM**

- **Company Policy**
- **Organisation and Personnel**
- **Reporting and Communication**
- **Operational Controls and Procedures**

**INTEGRITY MANAGEMENT PROCESS**

**Establish integrity stage**
- Concept, design and construction

**Maintain integrity stage**
- Operation and maintenance

<table>
<thead>
<tr>
<th>System risk review and strategy development</th>
<th>Inspection, monitoring and testing</th>
<th>Integrity Assessment</th>
<th>Mitigation, intervention and repair</th>
<th>Abandonment</th>
</tr>
</thead>
</table>

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IM in a life cycle perspective

Phases:

![Life Cycle Diagram]

Time scale:

- Establish integrity
- Maintain integrity
- Transfer Integrity
- Ownership transfer
- Operation

Examples:
- e.g. pipeline

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The Integrity Management Process: Key Elements

The Deming Wheel Model:

- Design requirements
- Authority Requirements
- Company requirements
- HAZOP etc

System Risk Review & Strategy Development

Inspection

Repair

Intervention

Mitigation

Integrity assessment

Monitoring

Testing

PLAN

DO

ACT

CHECK
The Integrity Management Process

**Keys steps**

- Developing the Integrity Management Plan
- Hazard evaluation and Risk assessment
- Learning and Improvement
- Implement the Integrity Management Plan

- Hazard evaluation & assessment methods are the basis for planning and execution of IM activities
- DNV approach for Integrity Management: *Risk Based Inspection & Maintenance Planning*
Risk Based Approach IM Strategy

- System breakdown
- Assessment of individual risks
- The level of inspection, monitoring or maintenance should be related to the level of risk identified.
Other tools for IM

- RCM: Reliability Centered Maintenance
- RBM: Risk Based Maintenance (RBI + RCM)
- SIL: Safety Integrity Level
- RAM: Reliability, Availability and Maintenability
- Fitness for Purpose
- Technical Assessment (fatigue, pressure containment, etc.)
- Flow Assurance
- CFD: Computational Fluid Dynamics
- Modeling (corrosion, flow, spills, etc.)
Market needs and challenges

- Integrity assessment
- Lifetime extension
- Flow assurance
- Failure investigation

- corrosion
- dents and cracks
- free spans
- buckles
- etc.
Integrity assessment

From diagnosis to solution...

- Results from inspections
- Design data and operational data
- Acceptance criteria
- Integrity evaluation
  - Failure modes
  - Loads and capacity
- Conclusions
- Recommendations
  - Inspections and analyses
  - Mitigation actions
  - Interventions and repairs
Integrity Management

Requirements and Guidelines

- Authority requirements
- Company requirements
- Standards e.g. ISO, NORSOK and DNV-OS-F101
  - Safety philosophy
  - Requirements to Integrity Management System
- Guidelines, e.g. DNV Recommended Practices
  - DNV-RP-F206 (Riser system)
  - DNV-RP-F116 (Pipeline system) ï upcoming 2009
  - Technical RP’s
    - Corrosion, erosion, free span, stability, bucklingé

Development and Implementation

- Integrity Management System
  - Technology, work processes, people and organisation
  - Integrity Management software and databases
DNV services following the field life cycle

Design and Construction

- Establish Asset Integrity Management systems Subsea/Pipelines & Structures
- Verification, technology qualification and technical advisor
- Establish HSE and Emergency Preparedness system
- Establish Production and Maintenance system

Operation and Production

- Installation ready for production
- Complete construction and commissioning
- Prepare for operation, e.g., Work procedures, Management systems and Administrative systems
- Technical issues: Corrosion, Flow assurance, Sand management, Specific system solutions and threats

- Safety and reliable performance
- Smooth handover from project to operational org.
- Smooth transition from design to operation
- Follow-up HSE and Emergency Preparedness performance
- Follow-up Improvement of production and maintenance performance

Technical issues: from thoughts to actions

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Operations Phase Services

- Development and implementation of Integrity Management system
- Condition assessment (fit for service)
- Lifetime extension and re-qualification
- Planning of inspections, maintenance and testing
- Technical assistance (in connection with repairs, mitigations, interventions, selection of inspection tools, decommissioning etc.)
- Failure investigation and laboratory testing
- Flow assurance and sand management
- Risk assessment (eg. HAZID and QRA)
- Availability and reliability evaluations
- Regulatory compliance services
- Data management and software systems
- Training and courses
Laboratory Services

DNV capabilities:
- Failure investigations
- Small and large scale testing
- Qualification management and testing
- Purpose made testing rigs according to client specifications
- Flow testing

Full scale bend testing of clad pipe

TTRD - Wear testing with mud
Tool joint wear on tubing hanger seal area
Shell: Ormen Lange - Subsea Integrity Management

Develop a Subsea Integrity Management System

- Critical Issue
  - Handover from Norsk Hydro
  - Safeguard integrity of subsea system

- Solution
  - Early preparation; DNV engaged 2 years prior to handover
  - Develop a Subsea Integrity Management System (SIMS) defining the organisation, work processes and resources
  - Assist Shell in implementation and auditing of SIMS

- Value delivered
  - Extensive expertise and knowledge from DNV on the system from concept, design, fabrication and installation
  - Technical assistance: Pipeline condition, corrosion and erosion assessment...
Petrobras Subsea Integrity Management

Develop a Risk Based Integrity Management System for subsea flow systems from Petrobras/UN-RIO

- **Critical Issue:**
  Develop a new approach on Integrity management of components with complex design, including those installed in deepwaters

- **Solution:**
  Multidisciplinary competencies, use of international networks in DNV, development of innovative solutions

- **Key Deliverables:**
  Best Practices reports, IM database, Risk Based IM Process, RAM analysis

- **Value Delivered:**
  State of the art IM System implemented, safety improvement, cost savings
Greater Plutonio FPSO

FPSO Integrity Management

- **Critical Issue:**
  Develop one integrity management program for all systems at the FPSO in a unified manner

- **Solution:**
  Cross disciplinary and cross regional cooperation to deliver the required equipment and system competence

- **Deliverables:**
  Integrity management program for all systems on the FPSO including hull, mooring, lifting equipment
  Manage the IM program during operation

- **Value delivered:**
  High quality integrity management program and engineering competence from one single service provider
StatoilHydro - Integrity assessment of HP/HT flowlines

Evaluate and document the integrity of the HP/HT flowlines

▪ Critical Issue:
  - Evaluate and document the integrity of the high pressure / high temperature (HP/HT) flowlines.
  - Propose and document effect of maintenance measures.
  - Kristin field (8 lines) and Åsgard field (26 lines). Currently extending to Mikkel and Urd fields.

▪ Solution:
  - Establish a risk based methodology for integrity assessment of HP/HT flowlines.
  - Develop effective FE analysis tools, databases and visualization tools.

Shut down

Normal operation
StatoilHydro Oseberg Øst: Well Risk Management

Develop a Well Risk Management System

- Critical Issues
  - Old installation has shut down wells due to leak caused by barrier degradation

- Solution:
  - Preparing a reliability analysis for each well including flow analysis and evaluation of fire and explosion potential.
  - Evaluating the effect of degraded compared to intact well in production with and without gas lift as well as in shut-in condition.
  - Prepared a method for analysis which can be updated when the operational conditions change.
  - Acceptance criteria based on fire and explosion risk or environmental risk.

- Value Delivered:
  - Providing risk based acceptance criteria’s for evaluation of degraded well barriers.
  - Presenting the total leak risk from all platform wells
  - Extensive expertise and knowledge from DNV on the system from well design, technical safety and reliability analysis.
ConocoPhillips Life Extension of Ekofisk Risers

- **Critical Issue**
  - Expected subsidence by year 2028 is as much as 12m at the centre of the Ekofisk complex giving large wave loads on risers just underneath the deck structure.
  - New extreme design waves.
  - Corrosion. Some risers are from the 1970s.

- **Scope**
  - All critical risers are to be verified with respect to prolonged service life.

- **Solution**
  - Non-linear time domain FE analyses of risers. CFD analyses of wave loads.
StatoilHydro: Statfjord A ï Pipelines Life Extension

- **Critical Issue:**
  - Field developed through 70’s and further installed from 1979
  - Field to be extended in operation additional 20 years from present
  - Future operation of risers, infield pipelines including relevant components

- **Solution:**
  - Assess degradation mechanisms from start-up to present; and toward future
  - Investigate operational condition vs. design requirements
  - Assess condition with respect to External and Internal threats of pipeline and components.

- **Value to be delivered:**
  - Current condition with recommendations for enhanced condition status
  - Recommendations toward future operation
Integrity Management — DNV References

**DNV Rules and RPs**

- OS-F101/2007 - Submarine Pipeline Systems (IM concepts for all phases of pipeline life cycle, from design to abandonment).

- RP-F206 — Riser Integrity Management:

- RP-H101 - Risk Management Subsea

- RP-F101 — Corroded Pipelines

- RP-F107 - Risk Assessment of Pipeline Protection

- RP-G101 - RBI Offshore

- RP-F116 - Submarine Pipeline Systems Integrity Management — To Be Issued
Wrapping up

- Offshore Assets: huge investments
- Integrity Management: cost effective compared to investments
- One solution doesn’t fit all
- IMPORTANT: start during conception phase
- Risk Based Inspection and Management Planning: core of IM process
- DNV: Recommended Practices and Softwares for IM, RBI and RCM + hands on experience
- DNV experience with IM for offshore assets:
  - Platforms (structures and topside plants)
  - Pipelines
  - Subsea installations and wells
  - Mooring Systems
Safeguarding life, property and the environment

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