STRUCTURAL INTEGRITY MANAGEMENT OF AGEING OFFSHORE INSTALLATIONS

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PRESENTATION OUTLINE

- **Background information**
  - Ageing
  - SIM
  - Regulations, standards & guidance

- **HSE / OSD SI activities on SIM of ageing installations**
  - Interventions
  - S&T
AGEING: Structural Integrity

No of Installations by Year

Year


No of Installations
Bathtub Curve

- Early life failures
- Steady failure rate
- Wear-out phase

Time
PERFORMANCE INTO LIFE EXTENSION

Original level

Acceptable level

(a) No loss of performance with time

(b) Fabrication problems corrected by remedial repairs/strengthening

(c) Loss of performance but acceptable into life extension phase

(d) Loss of performance acceptable at design life but not into life extension

Performance

Time

Design Life

Life extension
LOSS OF INTEGRITY

- **Ageing**: Potential for accumulating and/or accelerating damage and subsequent loss of integrity

- Need to focus on asset integrity management (AIM) of ageing (hazard identification, organisational issues, inspection, technology)

- **Need**:
  - good data on current condition
  - understanding of degradation processes & response
  - use of best technology / latest assessment methods (e.g. system strength) to determine safety margins
  - development of new techniques (e.g. online monitoring)
  - implementation strategy (incl. remedial and mitigation measures, update of SI management plan)
AGEING SCENARIOS

● Time-dependent mechanisms
  - Fatigue (welded connections, piles, supports)
  - Corrosion
  - Creep (non-metallic components)

● Damage or deterioration over time
  - Accidental damage (ship impact, dropped objects – cumulative effects)
  - Environmental overload
  - Geological & geotechnical (subsidence, scour, pile failure)

● External changes with time
  - Modifications / change of use
  - New technologies / understanding
  - More stringent standards
  - Failure to adapt to change
  - Obsolescence
  - Loss of knowledge base
MAINTENANCE STRATEGY

Data Update

Data → Evaluation → Inspection Strategy → Inspection Programme
INTEGRITY MANAGEMENT

LEADERSHIP
- Policy

PLAN
- Risk Assessment
- Regulations
- Objectives
- Action Plans

CHECK/CORRECT
- Roles and Responsibility
- Training
- Communication
- Operational Control
- Management of Change
- Emergency Preparedness
- Contractors & Suppliers
- Documentation and Records

REVIEW
- Management Review
- Monitoring and Measurement
- Accidents and Incidents
INFLUENCES ON SIM PRACTICE

(1) Regulatory regime (goal setting)
   (a) SCR 2005: 5-yearly thorough review / revised SC for extension of use of the installation beyond its original design life
   (b) DCR (Reg. 4, 5.2, 8): maintenance of integrity at all times; suitable arrangements for periodic assessment of integrity & remedial work on damage / deterioration affecting integrity

(2) Industry standards:
   (a) ISO 19900: 'assessments' required for all structures at end of design life
   (b) ISO 19902 (fixed structures), Section 25: detailed requirements for assessment (end of design life is a trigger)
   (c) ISO 19904 (semi-subs): need to ensure continuing compliance with regulations and standards – corrective action where required
   (d) ISO 19905 (jack-ups)

(3) HSE documentation:
   (b) GASCET (Chapter 3: G5, G17 – 21)
   (c) OSD technical policy on SI deterioration and repairs
   (d) Internal guidance on ageing
   (e) HSE Information Sheet OIS 4/2009 on Thorough Review guidance

API RP2SIM

HSE OIS 5/2007

Design & Construction Regs, 1996

Safety Case Regs (rev), 2005

Safety Case Regs, 1992

4th Edn Guidance Notes, 1990

ISO 19902, 2007

ISO 13822, 2001

ISO 2394, 1996

PSA regs, 2001

DNV OSS 101, 2003

NORSOK N-004, 2004

etc.
THE THOROUGH REVIEW

● A requirement to:
  - include advances in science and technology
  - take account changes in legislation
  - include learning from past incidents
  - review ALARP judgments

● An opportunity to:
  - think about future life and what changes could and should be made
  - include the workforce
  - review how things could be done better

“Its purpose is to confirm that the safety case as a whole continues to be fundamentally sound.”

Reg 13.
HSE GUIDANCE ON THOROUGH REVIEWS - OIS 4/2009

- Thorough review of the safety case
  - Thorough review summary
  - Asset life extension

- Management of ageing
  - Fire and explosion risk assessment
    - Risk assessment
    - Options for addressing ageing
  - Structural integrity
    - Structural integrity management
    - Life extension
  - Performance indicators
  - Organisational issues

- Issues with ageing
OSD SIM ACTIVITIES

- Technical policy and strategy (HSE website)
- Thorough Reviews & Safety Cases
- Inspection
  - SIMIP
  - Inspection programme on Ageing & Life Extension: 2010 - 2013
- S&T
  - Technology projects:
  - Standards and guidance, incl. HSE Information Sheet 4/2009 on Thorough Review guidance
- Stakeholder engagement
  - Dissemination (e.g. OMAE, PSA, IMechE, IChemE, HSE website)
  - Ongoing collaboration with PSA, Norway
  - Ageing Network (2010 / 11)
## INSPECTION FINDINGS

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- **Serious deficiencies requiring immediate attention**
- **Matters raised formally linked to ongoing work or change**
- **No matters needing formal raising with the DH**
AGEING & LIFE EXTENSION INSPECTION PROGRAMME

● Pilot study on ageing installations: 2009
  – 3 duty holders
  – Generic management, Structural integrity, Fire & explosion, Corrosion, Pressure systems integrity
  – SI: focus on
    • Duty holder structural integrity management practices for ageing
    • awareness / consideration of current technology (analysis tools, inspection techniques, etc.)
  – Set of standard questions for each topic area – ‘templates’

● Ageing & LE Inspection Programme: 2010 - 2013
  – Full programme for 2010 – 2013
  – SIM a major aspect
OSD SIM ACTIVITIES

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- S&T
  - Technology projects
  - Standards and guidance, incl. HSE Information Sheet 4/2009 on Thorough Review guidance
- Stakeholder engagement
  - Dissemination (e.g. OMAE, PSA, IMechE, IChemE, HSE website)
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AGEING SIM S&T: 2008 - 2011

- Framework for the Structural Integrity Management of Fixed Installations
- Framework for the Structural Integrity Management of Mobile Installations
- Evaluation of Worldwide Practices on the Structural Integrity Management and Regulation of Ageing Installations
- Overview of the UK’s Ageing Offshore Infrastructure
- Review of Classification Society Rules for Floating Installations on the UKCS
- Techniques and Technologies for Ageing Jacket Integrity
- Review and Appraisal of Current Structural Integrity Monitoring Technologies for Offshore Applications
- Review and Assessment of Material Property Requirements for Mobile Installations
- Further Study of Fatigue Damage to Girth Welds From Low Stresses in the Loading Spectrum (JIP)
- Investigation of Residual Stresses in Welded Joints (JIP)
LIFE EXTENSION – OTHER INDUSTRIES

- **UK Nuclear power stations**
  - Requirements for long term safety review to NII. Basis for extending life. Generic issues identified. Periodic safety reviews also introduced.

- **Civil aviation**
  - Well developed requirements for ageing aircraft. Ageing aircraft Task Group set up. Supplemental structural inspection programmes implemented. Concern about Widespread Fatigue Damage.

- **Power & process plant**
  - written scheme of examination for each pressure system
  - best practice in the management of ageing pressure systems and related plant not widespread across industry – HSE study underway

- **Ships**
  - No formal procedures for life extension of ships other than part of the regular survey procedures, based on Classification Society rules

- **Bridges**
  - Reassessment regime being developed and formalised
OVERVIEW OF THE UK'S AGEING OFFSHORE INFRASTRUCTURE

Need to prioritise inspection of installations / issues to optimise the targeting of resources.

Information required on

- structural performance, to enable the categorisation of installations according to relative criticality;
- anticipated oil and gas production to enable assessment of future use of individual installations.
UKCS DECOMMISSIONING
Aim
To identify the extent to which class rules for mobile offshore installations satisfy the structural integrity management aspects of UK regulations and to identify any limitations or gaps.

Scope
Classification Society Rules: DnV, ABS, LR
REVIEW OF CLASSIFICATION SOCIETY RULES FOR FLOATING INSTALLATIONS ON THE UKCS

● Differences in class rules, e.g.
  – Treatment of ageing units
  – Strength safety factors on moorings
  – Forepeak strength requirements and associated plating thicknesses
  – Design fatigue factors
  – Hydrogen induced cracking / cathodic protection limits

● Changes in Class Rules not retrospective: no requirement for a re-assessment if there is a rule change:
  – ISO 19900 Section 10.1 requires a re-assessment “when the original design criteria are now longer valid”, e.g. when the design code used originally has been superseded by a more onerous one.
REVIEW OF CLASSIFICATION SOCIETY RULES FOR FLOATING INSTALLATIONS ON THE UKCS

- For conventional ship or mobile drilling units, which can be readily dry-docked, standardised system of SIM evolved by Classification Societies, involving several grades of survey (special survey, intermediate surveys, and periodical surveys) at prescribed intervals.

- **IACS**: Unified Standard for Survey and Certification (IACS, 2009), which all Classification Societies must follow.

- Different for oil production vessels:
  - Not mobile, cannot readily be dry-docked. Need to rely on in-situ inspection and repair techniques.
  - No IACS unified standard for SIM.
  - Reported that hull surveys postponed, moorings have remained uninspected ……
Classification alone does not appear to meet the HSE regulatory requirements, which place responsibility for SIM on the duty holder. The experience to date of floating production installations is limited.

Integrity management is a safety case requirement but is not addressed adequately in class rules alone.
TECHNIQUES AND TECHNOLOGIES FOR AGEING JACKET INTEGRITY

Considerable amount of technical information requiring exploitation:

• Development of OSD's technical policy on structural integrity management
• Development of guidance, standards and good practice
• OSD's enforcement activities (safety case assessment / thorough review process / inspection)
• Particularly important for ageing installations
TECHNIQUES AND TECHNOLOGIES FOR AGEING JACKET INTEGRITY

● Inspection techniques and planning
  – FMD, online monitoring, POD

● Structural analysis
  – Fatigue, reserve / system strength analyses, progressive collapse, failure mode interaction

● Materials issues
  – High strength steels, ship steels, composites

● Metocean conditions
  – Air gap / green water, steep waves, changes in significant wave height, current & wind data

● Degradation assessments
  – Design fatigue factors, high and low cycle fatigue, single-sided welds, fatigue of stiffened joints, fatigue of cast joints, SCFs for unusual geometries, corrosion / hydrogen assisted cracking in high strength steels

● Foundation performance
  – Settlement, scour, behaviour of piles, pile driving damage, reservoir compaction, seismicity of North Sea

● Accidental damage
  – Boat impact, dropped objects

● Repairs
  – Grouted and mechanical strengthening and repair
TECHNIQUES & TECHNOLOGIES

- Better understanding of loading & resistance, e.g.:
  - Extreme weather forecasting
  - Ultimate capacity of components
  - Structural system strength – testing & analysis
TECHNOLOGY BENCHMARK

- Blind pre-test analytical predictions
- Comparison with test measurements
TECHNIQUES & TECHNOLOGIES

- Structural integrity monitoring
- Techniques for strengthening & repair
TOPICS FOR FURTHER WORK

- Organisational challenges (knowledge & competence)
- Barriers of control (i.e. gap between not meeting standards requirements and structural failure)
- Damage data
- Cumulative damage
- Inspection strategies (especially non-intrusive inspection)
- Repair techniques – review / dissemination
- Post-assessment of decommissioned structures (PSA)
- Issues for mobile installations
PRESENTATION OUTLINE

- Background information
  - Ageing
  - SIM
  - Regulations, standards & guidance

- HSE / OSD SI activities on SIM of ageing installations
  - Interventions
  - S&T
CONCLUSIONS

- Life extension & SIM of ageing is an ongoing requirement
- Need better understanding of the performance of offshore structures
- UK industry practice under review
- Findings to date suggest lack of full recognition of significance of ageing processes in connection with life extension beyond original design life
- Identification of:
  - (a) deficiencies in current approaches, and
  - (b) needs for the development of risk-based best practice for safe operation offshore
- Need for development of guidance & procedures for management of ageing & life extension (including performance standards for safety critical elements)
- Ongoing collaboration with UK industry & PSA