Primary funding is provided by

THE SPE FOUNDATION THROUGH MEMBER DONATIONS AND A CONTRIBUTION FROM OFFSHORE EUROPE

The Society is grateful to those companies that allow their professionals to serve as lecturers

Additional support provided by AIME
Well Integrity in the Operate Phase – past, present and future. The tools of a crime scene detective

Simon J Sparke
## Jargon Buster

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
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<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
<td>MAASP</td>
<td>Maximum allowable annulus surface pressure</td>
</tr>
<tr>
<td>BOEMRE</td>
<td>USA offshore regulator</td>
<td>MoC</td>
<td>Management of change</td>
</tr>
<tr>
<td>DCR</td>
<td>Design &amp; Construction Regs (UK)</td>
<td>SCF/min</td>
<td>Standard cubic feet per minute</td>
</tr>
<tr>
<td>IOGP</td>
<td>International Oil &amp; Gas Producers</td>
<td>SCSSSV</td>
<td>Surface controlled sub surface safety valve</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organisation</td>
<td>WIMS</td>
<td>Well integrity management system</td>
</tr>
<tr>
<td>IWCF</td>
<td>International Well Control Forum</td>
<td>GVI</td>
<td>General visual inspection</td>
</tr>
</tbody>
</table>
What is Well Integrity?

The job discipline is very much like modern day forensic science – Crime Scene Investigators
Well Integrity is a lifecycle event

Elements common to all phases
- Well integrity
- Well integrity management
- Well integrity policy
- Risk assessment
- Organisational structure
- Well barriers
- Performance standards
- Well barrier verification
- Reporting & documentation
- Management of change
- Continuous improvement
- Auditing

Well integrity life cycle phases
- Basis of design phase
- Design phase
- Construction phase
- Operational phase
- Intervention phase
- Abandonment phase
- Lessons learned
- Optional workflow

After ISO 16530, 2017
What is a Barrier?

There are four type of barriers, and these consist of the following:

1. **Hardware** barriers (equipment which is designed, installed and verified)

2. **Operational** barriers (monitoring equipment, practices and procedures)

3. **Human** barriers (competencies and training)

4. **Administrative** barriers (assignment of roles, resource provision and procedures)
Two Barrier Principle - Operate phase

1, Blue = primary barrier (always sees the pressure)
2, Red = secondary barrier (last line of defence)

“hat over hat”
Two barrier principle in the Operate Phase

Norsok principle: Hat-over-hat envelope philosophy
Colour coding explanation

- Standard or recommended practice published
- Significant technical advancement
- Data sharing
- Industry failure
A History of Well Integrity

- 1969 Santa Barbara
- 1977 Ekofisk
- 1988 Ocean Odyssey
- 1988 Piper Alpha
- 2009 Montara
- 2010 Deepwater Horizon
- 2012 Elgin
- 2015 Aliso Canyon
Spindletop, Texas

1901

2013
Acceptable leak rates

Source of 15 SCF/Min where does the leak rate come from?
A History of Well Integrity – The past

- **1963**: VAM thread = Vallourec & Alexandre Madrelle
- **1969**: Santa Barbara
- **1972**: SCSSV patented
- **1973**
  - API 14A
  - API 14B
  - First extensive CRA trial of 13% Chrome
- **1974**
  - IOGP
  - API 14C
- **1975**: NACE MR0175 published
- **1977**: Ekofisk
- **1978**: Sintef equipment reliability data base
- **1979**: NORSOK D-010
- **1982**: SCSSV published
- **1986**: NORSOK D-010
- **1988**
  - API 14B
  - API 14C
  - Ocean Odyssey
  - Piper Alpha
- **1990**
  - DCR-96
  - IWCF Pressure Control started
- **1992**: IWCF Established
- **1996**: DCR-96
- **1998**: IWCF Pressure Control started
- **1999**: DCR-96
- **2000**
  - IWCF Pressure Control started
  - DCR-96
- **2009**: Montara
- **2010**: Deepwater Horizon
- **2012**: Elgin
- **2015 (Oct)**: Aliso Canyon
- **2019**
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- **1988** Ocean Odyssey
- **1992** IWCF Established
- **1996** DCR-96
- **1998** IWCF Pressure Control started
- **1997** - WIMS software established
- **1998** IWCF Pressure Control started
- **1999** DCR-99
- **2000** SPE established
- **2002** SPE established
- **2005** The Hague SPE
- **2006** Abu Dhabi SPE
- **2008** Abu Dhabi SPE
- **2009** UK SPE
- **2010** Deepwater Horizon
- **2012** Elgin
- **2015** (Oct) Aliso Canyon
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A History of Well Integrity – The present

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1994 API 14C
1994 IOGP
1994 API 14D
2006 The Hague SPE
2005 First extensive CRA trial of 13% Chrome
2008 Abu Dhabi SPE
2007 Perth SPE
2008 Abu Dhabi SPE
2007 SPE 142449, 7 Pillars of Well Integrity
2008 SPE 142449, 7 Pillars of Well Integrity
2009 UK SPE
2008 SPE 142449, 7 Pillars of Well Integrity
2009 Abu Dhabi SPE
2008 SPE 142449, 7 Pillars of Well Integrity
2009 Montara
2009 Abu Dhabi SPE
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2010 BOEMRE
2009 US SPE
2009 Abu Dhabi SPE
2009 SPE 142449, 7 Pillars of Well Integrity
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2010 BOEMRE
2010 Abu Dhabi SPE
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2010 BOEMRE
2011 NOPSEEMA
2011 SPE 142449, 7 Pillars of Well Integrity
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2012 Mexico & Abu Dhabi SPE
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2012 Mexico & Abu Dhabi SPE
2015 API 1170 & 1171
2017 ISO Full well lifecycle
2019 O&GUK Well lifecycle, Norsok D-010 + API 6A
2021 API 65-3 Recommended practice for P & A.
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A History of Well Integrity – The future

- 2010 ISO Production Well Integrity started
- 2010 BOEMRE
- 2011 NOPSEEMA
  - 2011 SPE 142449, 7 Pillars of Well Integrity
  - 2012 Mexico & Abu Dhabi SPE
  - 2015 API 1170 & 1171
  - 2017 ISO Full well lifecycle
  - 2019 O&GUK Well lifecycle, Norsok D-010 + API 6A
  - 2021 API 65-3 Recommended practice for P & A.
  - Standards – ISO, O&GUK, Norsok, Nopsema updated periodically
  - API recommended practices to be updated
  - New regulations to allow for Bismuth, resins ...
  - Tougher regulations on ALL emissions
  - Geothermal

- 2011 SPE 142449, 7 Pillars of Well Integrity
- 2012 Elgin
- 2015 Aliso Canyon
- 2019 O&GUK Well lifecycle, Norsok D-010 + API 6A
- 2021 API 65-3 Recommended practice for P & A.

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- 2021 API 65-3 Recommended practice for P & A.

- Re-purposing wells – failure due to age
- Cyber attack
- Co2 sequestration well failure
- Post abandonment leaks
- Knowledge loss due to retirement, cut-backs, oil price etc
A quick review of Geology

The world as nature created
The world Big Oil designed
The world Big Oil constructed
The world as Big Oil had to manage

After Ken Feather
Well Integrity Management Systems (WIMS) – what is the range?

From the mule shoe/perforations

To the Production wing valve or associated flange
Well Data Management – Ideal System

WIMS data system
Well construction data
- Casing & Completion
- Wellhead & Tree
- Valves

Well Operations data
- MAASP & Well Envelope
- Well integrity tests
- Certification
- Well Barriers
- Well Interventions
- Risk Assesments

Well data to Offices
Maximo  Auto
PI  Auto
SAP  Auto
Unity  Manual
GVI  Video
Well Interventions  Manual
MoC  Auto
Well Data Management - Ideal System

Data Sources
- Headquarters
- Wellsite(s)
- Intervention site

WIMS data system
- Well construction data
  - Casing & Completion
  - Wellhead & Tree
  - Valves
- Well Operations data
  - MAASP & Well Envelope
  - Well integrity tests
  - Certification
  - Well Barriers
  - Well Interventions

Data Sources

Well data to Offices
- Maximo: Auto
- PI: Auto
- SAP: Auto
- Unity: Manual
- GVI: Video
- Well Interventions: Manual
- MoC: Auto
Typical Data Path

WIMS Manager

Wells Register
- Subsea
- Platform
- Onshore
- Non-operated

WIMS Data repository
- Well construction data
  - Casing
  - Completion
  - Wellhead & Tree
  - Valves
  - Etc

Well handover
- MAASP
- Well operating envelope
- Well integrity tests
- Certification
- Well Barriers
- Well Interventions
- Risk Assessments

WIMS Users

Partners

Stakeholders

Reports

Well Examination + Regulator

Company standards,
- ISO-16530
- O&GUK
- DCR-96
- NORSOK
- API

24
Three Key Features to the WIMS

• Legislative – what do I have to do

• Responsibilities – how will I do it
  – Well examination scheme
  – Wells register
  – Well integrity policy
  – Well handover process

• Data management – how do I collect/present my data, and provide status report(s)
Example Regulatory Documents

INTERNATIONAL STANDARD
ISO 16530-1

Petrophysics and natural gas industries — Well integrity —
Part 1: Life cycle governance
Pétrole et industries du gaz naturel — Intégrité du puits —
Partie 1: Gestion du cycle de vie

Guidelines for the Abandonment of Wells
Issue 5
July 2015

OIL & GAS UK

NORSOK D-010:2021
Published: 2021-03-11
Language: English

Well integrity in drilling and well operations
Brannintegritet i boring og brannoperasjoner

Oil and Gas and Sulphur Operations on the Outer Continental Shelf—Oil and Gas Production Safety Systems

Bradenhead Pressure Management
Example Supporting Documents

Annular Casing Pressure Management for Offshore Wells

API RECOMMENDED PRACTICE 90
FIRST EDITION, AUGUST 2006
REAFFIRMED, JANUARY 2012

Specification for Wellhead and Tree Equipment

API SPECIFICATION 6A
TWENTY-FIRST EDITION, NOVEMBER 2018
API MONOGRAM PROGRAM EFFECTIVE DATE: JANUARY 2021

ERRATA 1, APRIL 2019
ERRATA 2, JUNE 2020
ERRATA 3, SEPTEMBER 2020
ADDENDUM 1, JULY 2020

API 6ACRA : 2015
AGE-HARDENED NICKEL-BASED ALLOYS FOR OIL AND GAS
DRILLING AND PRODUCTION EQUIPMENT
American Petroleum Institute

API Recommended Practice 14B
Design, Installation, Operation, Test, and Redress of Subsurface Safety Valve Systems

SKYTH EDITION | SEPTEMBER 2015 | 37 PAGES | $128.00 | PRODUCT NO. G14808

This document establishes requirements and provides guidelines for subsurface safety valve (SSSV) system equipment. This includes requirements for SSSV system design, installation, operation, testing, redress, support activities, documentation, and failure reporting. SSSV system equipment addressed by this document includes control systems, control lines, SSSVs, and secondary tools as defined herein. SSSV types including surface controlled (SCSSV), sub-surface controlled (SSCSV), and sub-surface.
Well Integrity Toolkit

- Anomaly management
- Risk Assessment
- Well Operating Envelope
- Well Handover
- MAASP
- Well construction data
- WIMS software
How does this all fit together?

- Valve testing
- Annulus monitoring
- Tree maintenance
- Wellhead and tree inspections
- Annulus blow down
- Valve failure matrix
Abandonment Considerations
Abandonment Considerations

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