Well Integrity Management and failure case Studies

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Majority of Oil & Gas Production is from Offshore fields
Definition of Well Integrity

Application of technical, operational and organizational solutions to reduce risk of uncontrolled release of formation fluids throughout the life cycle of a well (NORSOK D-010)
Well Integrity Life Cycle

- **Design & Construct**
  - Design → Drill → Complete

- **Operate**
  - Produce

- **Maintain**
  - Repair → Work over + Side-track → Produce

- **Abandon**
  - Temporary / Permanent

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Well Integrity Management System

- Accountability & Responsibility
- Well Operations
- Well Interventions
- Tubing / Annulus Program
- Wellhead / Tree Maintenance
- Safety Valve Program

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Well Integrity Management System

- **Accountability**: Accountable, responsible and Team Approach

- **Well Operations**: Well operation & Handover, Personnel Competence
  Procedures: Startup, operating, shutdown, Corrosion & Erosion Management

- **Well Interventions**: Well ownership & Handover, Personnel Competency
  Procedure, Records, Document well service event

- **Tubing / Annulus Program**: Assigned operating pressure limit
  Report anomalies, Respond to anomaly reports

- **Wellhead / Tree Maintenance**: Tree & Well head valves serviced twice per year
  Wellhead team to handle wellhead leaks

- **Safety Valve Program**: SSV on all producers
  Downhole safety valve on gas injectors & offshore wells and Tested every 6 months
Well Integrity Management system

Barrier Diagram for Avoidance and Mitigation of HC leaks, Fire and Explosion

**Ageing Process**

- Corrosion, Erosion, Fatigue, Vibration, Degradation of Material, Blockage of Hydrocarbon System

**Hydrocarbon Leak**

**Ignition Source, Fire & explosion**

**Damage to Equipment, Escape, Evacuation & Rescue**

**Injury to Personnel**

**Barrier System**

- Historic
- Subject to Ageing Process

1. Good Material Choice
2. Proper design for corrosion protection
3. Good fatigue design
4. Inspection & Maintenance
5. Gas Detection system
6. Emergency Shut Down System
7. Fire & smoke detection
8. Active fire protection
10. Blast Walls
11. EER Facility

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## Age Statistics of Jackets and Wells WO

<table>
<thead>
<tr>
<th>Sl</th>
<th>Age Group</th>
<th>No Of Jackets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Up to 15 Years</td>
<td>88</td>
</tr>
<tr>
<td>2</td>
<td>Between 15-20 Year</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Between 20-25 Year</td>
<td>51</td>
</tr>
<tr>
<td>4</td>
<td>Between 25-30 Year</td>
<td>63</td>
</tr>
<tr>
<td>5</td>
<td>Between 30-35 Year</td>
<td>39</td>
</tr>
<tr>
<td>6</td>
<td>Above 35 Year</td>
<td>7</td>
</tr>
</tbody>
</table>

Wells are also of above age group

- **Design life of all platform is 25 years except**
  - Design life of Platform NG(F0, NA,ND,NC,NE,NF,NB,NK,NI) is 20 YEARS.
    - All these Jackets were commissioned before 1980
  - Design life of B-173A is 10 years

- Platform Installed in mid seventies and most are still in place.

- More than 40% of platforms have exceeded initial design life.
  - Design Life: The assumed period for which a structure is to be used for its intended purpose with anticipated maintenance but without substantial repair from ageing processes being necessary.
  - Life Extension: Continued operation of an installation beyond the design life assumed at the time of design or revised following a reassessment with reference to a new base line to reflect changes through prior service.

- IMR group/ IOT/Engg Services is doing recertification of Jackets for Life Extension
Loss of well integrity & ONGC’s Concern for mitigation

A high level committee after analyzing well integrity related issues have prepared a detail report with suggestions for improving well integrity:

- To implement solutions for sustained casing pressure in the wells.
- Improve historic barrier in new wells.
- Managing SCP in accordance with API-RP-90.
- Modalities to be adopted in future wells.
- Measures to Prevent SCP in existing wells & New Wells.

Leaks in Casing hanger seals
Leaks caused by erosion / corrosion / fatigue / vibration
Leaks caused by burst/collapsed casings
Leaks caused by degraded cement quality
Leaks caused by failing valve / packer
Case History-I Well Integrity Failure

Well Drilled: 28.03.1997
Drilled Depth: 1055 mtrs

- 2.7/8" tubing
- 13 5/8" C/S @ 255.32 M
- Cement Rise 7" @ 793 mtrs
- Packer @ 883.5 Mtrs
- Perforation 915.5-920 Mtrs (Khuila Sand)
- 7" Bridge plug @ 923.6 Mtrs
- 7" C/S @ 982.6 M

Well details
Case History – II Well Integrity Failure

- **5-1/2” 3149m Tubing 3139m**
  - Drilled Depth 3241 m
  - SOURCE zone (2413-2403m)

- **13-3/8” 598 m**
  - Tubing 3270m

- **9-5/8” 1900 m**

- **KOP 657 m**

- **5.5M**

- **KHAS**

- **KHAZ**

- **13-3/8” 600 m**

- **9-5/8” 1850 m**

- **KOP 1897 m**

- **Tubing 3139m**

- **5-1/2” 3149m**

- **Drilled Depth 3241 m**

- **Source zone (2413-2403m)**

- **Tubing 3270m**

- **5-1/2” 3288m**

- **Drilled Depth 3288 m**
Case History – III Well Integrity Failure
Gas Leakage from surface casing # NSBX

- Observed activity of Gas flow from 30’x20” Annulus and Gas was gushing Horizontally from outside of 30” casing at well NSBX.
- On closely observing of leakage point it revealed that 20”casing has hole 2m below well head deck. Gas is gushing out from 20” and coming out from 30”casing horizontally,
- “A” section flowing pressure was 290psi
Case History – III Well Integrity Failure
Gas **Leakage** from surface casing
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Reason for Gas leakage

HT of well NS#2Y was leaking and had shallow ST

- HT was leaking
- Dropped Standing valve in Tubing
- Bull headed 144 bbl 10 ppg mud in C section
- R/O 10 ppg mud through CV @ 6 spm with pumping pressure 850 psi and no loss during R/O
- "C" section pressure comes back to 55 kg even after having 10 ppg mud above hang tag
- Off bottom kill
- Indicates gas migration at depth 502 m (window in 9 5/8" csg) and may be migrating to shallow depth.
Case –IV Integrity Failure In EOR-Air Injector Well BALOL#45

- Balol#45 (BL#45) Was a air injector well
- Plan was to abandonment and drill a substitute vertical well just 11 meter away
- Well could not be subdued with CTU. Felt obstruction from 300-525m
- Tubing punctured at 273 with firing gun
- Observed activities in 3 nearby tube-wells within 300m radius on 23/11/2007

Tuing Punctured at 273m
Csg Damaged at 346m

BALOL # 45
Case –IV Integrity Failure In EOR-Air Injector Well BALOL#45
Case – IV Integrity Failure In EOR-Air Injector Well BALOL#45

TW#3 : 27/11/07 14:28
TW#5: 30/11/07
TW#3 30/11/07
TW#1: 01/12/07
Cave Creation, Algeria

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Indonesia Mud Volcano

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Remedial Measure - Detection of SCP VSEB#5H

- C-section pressure was bled off from 1200 to 160psi. B-sec Pressure remained constant at 850psi. Further B and C-sec pressure build up to 1200 & 1250psi respectively was observed.

- B-sec was bled off to 0psi.

- Annulus pressure build-up was again observed (B-sec=1200psi & C-sec=1250psi). Pressures were again bled off.

- A, B & C section well head seals were tested at 500psi, 2000psi & 3500psi, respectively and found OK.

- Again annulus pressure build-up was observed (B-sec=1200psi & C-sec=1250psi).
Remedial Measure - Detection of SCP VSEB#5H
Detection for Cause of SCP

1. B section Bled off 1150 psi to 0 within 5 minutes. kept open and observed feeble gas.
2. C section Bled off from 1200 psi to minimum (700 psi). Pressures build up observed in B section during bleeding off of C section and STHP remain unchanged.
3. Flow the well with 1 inch bean size FTHP 450 - 600 psi.
4. After 48 hrs of flow of well with 1” bean size,
   a. A section pressure - 0
   b. B section pressure - 1050 psi
   c. C section pressure - 1125 psi
   d. FTHP -575 psi (with 1 inch bean)
5. Well was shut again and following pressures are recorded:
   a. A section pressure - 0
   b. B section pressure - 1200 psi
   c. C section pressure - 1200 psi
   d. STHP - 1050 psi
Remedial Measure- Detection of SCP VSEB#5H Analysis of BOBU for Cause of SCP

1. B & C section Pressure were higher than FTHP No Communication from tubing & packer.

2. Two possibilities
   a. Formation pressure migrating upward due to poor cementation behind 7” liner and further in to “C” section via 7” hanger. (i.e. 7” hanger is leaking).
   b. Formation pressure migrating upward due to poor cementation behind 7” liner and further upward in to 13 3/8”/ 12 ¾” OH x 95/8” annulus and entering “C” section from the compromised 95/8” casing joint.

2. “B” section bleeds off very quickly and suggest liquid level is maintained in “B” section annulus. After bleeding pressure raises in “C” section first then in ”B” section.
Remedial Measure- Detection of SCP VSEB#5H
ALFA Log for Cause of SCP

1. Perform ALFA( Acoustic leak Flow Analyzer) log in static and dynamic condition( i.e. keeping all TH,C,B closed and while keeping TH pressure in closed condition and bleeding “C” section pressure and similarly keeping TH & “C” section closed and “B” section bleeding/open) to determine exact point of leakage.

1. Based on diagnosis by ALFA tool work over plan shall be made accordingly
Remedial Measure- Detection of SCP VSEB#5H
ALFA Log for Cause of SCP

APPLICATIONS
- Leak Detection (tubing/casing/packer leaks)
- Diagnosis of Sustained Casing Pressure
- Location of open perforations
- Identification of flow zones & channeling behind pipe

FEATURES
- Ability to detect flows through multiple tubular.
- Ability to distinguish flow behind pipe from flow inside pipe.
- Combinability with other logging tools to provide a complete well evaluation in a single run
- Slim tool design allowing safe and easy deployment through the smallest completion tubing and restrictions

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VSEB#5H Annulus Pressure Communication Path Detection

The Result

Surface Noise
Possible SSV Leak

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VSEB#5H Annulus Pressure Communication Path Detection

**The Result**

- **Surface Noise**
- **Possible SSV Leak**
- **High Frq noise of 26 kHz across the entire surveyed interval**
  - Associated by micro annulus channeling
- **Intense noise in the frequency range of 0-24 kHz and temp perturbation indicating**
  - 13 3/8" csg shoe leak at the depth of 1015 m TH
- **High Amplitude noise recorded in the entire frequency range**
  - Indicating 7" liner hanger leak

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Corrective Measure: Replace aged casing above boat landing Deck
Corrective Measure: Replace aged casing in badly corroded casings

Slot recovery using Deflecting Conductor Sleeve

Slot recovery by Milling 20” Casing
Why Well Integrity is Important

- Injury
- Environment
- Cost
- Liability
- Future generations
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Thank You