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Pitfalls to Avoid in Assessing Artificial Lift Run-Life Performance

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Impact on Economics

• Artificial Lift Run-Life Performance directly affects:
  – Work over frequency
  – Work over costs
  – Production losses

Impact of ESP Run-Life

<table>
<thead>
<tr>
<th>Overall Workover Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Runtime (days)</td>
</tr>
<tr>
<td>$0 120 240 360 480 600 720 840 960</td>
</tr>
<tr>
<td>$0 50 100 150 200 250 300 350 400</td>
</tr>
<tr>
<td>% revenue</td>
</tr>
<tr>
<td>0% 5% 10% 15% 20% 25% 30%</td>
</tr>
</tbody>
</table>

- 20 Wells
- Average oil production per well: 1,000 bpd
- Average intervention cost: 150 k US$
- Average workover & waiting time: 60 days
- Oil price: US$60/bbl
AL Run-Life Performance is important

• Key Performance Indicator (KPI)
  – effects of changes in operational conditions, equipment selection and operational practices
  – used in many alliance contracts between operators and vendors

Assessing AL RL Performance

• Not as simple as it may sound
  – Several measures used throughout the industry
  – Trends are often misleading

• Issues must be understood, so that
  – Pitfalls can be avoided
  – Proper RL measures can be selected
Run-Life and Runtime

• For many installations, Run-Life is not known, only Runtime
  – Systems that are still running
  – Systems that were pulled for other reasons than system failure

Censoring

• The data is said to be “censored”
• One can only hope to obtain estimates of average Run-Life
• Based on all the systems Runtime
Run-Life Estimates

- Average Runtime can be calculated for:
  - All systems (pulled or still running)
  - Running systems only
  - Pulled systems only
  - Pulled and Failed systems only

- All these averages can be calculated based on different exposure times
  - Time-in-Hole, Total Runtime, Actual Runtime

- Over different (calendar) periods of time
  - Last two years, last five years, etc.

Run-Life Estimates

- Average Runtime of pulled systems:
  - Includes failure of other “systems”: tubing, sand control, etc.
  - It is a reasonable indicator of the overall production system reliability
  - But not of the AL system reliability

- Average Runtime of failed systems:
  - Also affected by failures of other “systems”
  - Not a good indicator of the AL system reliability either
Run-Life Estimates

• At a certain point of time, all you can have is a statistical “best estimate”, or “expected value” of average Run-Life or Mean Time to Failure (MTTF)

Run-Life Estimates

• Average Failure Rate:
  – Number of failures per well over a period of time
• MTTF estimate:
  – the inverse of the average failure rate
  – ratio of the total time in operation (for all systems, pulled or still running) to the number of failures:

\[
\langle MTTF \rangle = \frac{\sum T_{\text{pulled}} + \sum T_{\text{running}}}{\# \text{failed}}
\]
What is a Failure?

• Failure:
  – The termination of the ability of an item to perform its required functions

ISO 14224: Petroleum and Natural Gas Industries: Collection and Exchange of Reliability and Maintenance Data for Equipment

Common Pitfalls

• Early Failures versus Frequent Failures
• Improvement versus Aging
• Component Reliability and System RL
• Failure Mechanism versus Failure Cause
ESP-RIFTS Data
Locations of Fields

Common Pitfalls

• Early Failures versus Frequent Failures
• Improvement versus Aging
• Component Reliability and System RL
• Failure Mechanism versus Failure Cause
What is the least reliable component? Is it the gas separator?

Which is more reliable? The motor or the cable?

Common Pitfalls

- Early Failures versus Frequent Failures
- Improvement versus Aging
- Component Reliability and System RL
- Failure Mechanism versus Failure Cause
Is the system reliability improving?  
Or are the systems just aging?

Common Pitfalls

- Early Failures versus Frequent Failures
- Improvement versus Aging
- Component Reliability and System RL
- Failure Mechanism versus Failure Cause
Is the equipment from both manufacturers equally reliable?

Common Pitfalls

- Early Failures versus Frequent Failures
- Improvement versus Aging
- Component Reliability and System RL
- Failure Mechanism versus Failure Cause
Failure Classifications

• **Reason for Pull**
  – Suspected system failure or any other reason
  – e.g.: stimulation, re-completion

• **Primary Failed Item and Descriptor**
  – Component (or part) in which the failure likely initiated, and likely mechanism
  – Based on observations during pull or teardown
  – e.g. motor burn

• **Failure Cause:**
  – The circumstances during design, manufacture or use which have led to a failure
  – e.g. improper assembly during installation

Failure Analysis Process

**System Failure**
- Reason for Pull defined: e.g., No flow to surface

**System Pull and Teardown**
- Items and Descriptors defined: e.g., Shorted MLE

**Failure Investigation**
- Cause defined: e.g., Installation; Improper Assembly
Do I have a manufacturing (QC) problem?  
Or do I have an operational problem?

![Number of Failures by Failure Cause]

Conclusions

- There are several measures used throughout the industry
- One needs to understand their meaning to properly interpret the trends
- Best picture of the situation likely requires looking at several measures
- Improvement requires thorough investigation of the failure causes
- Be aware of the pitfalls!
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  – KOC - TNK-BP
  – Nexen - Total