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Pitfalls to Avoid in Assessing Artificial Lift Run-Life Performance

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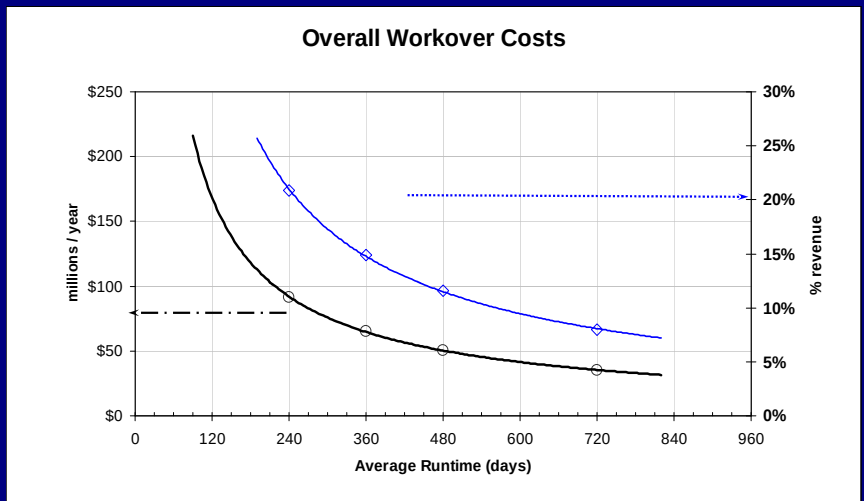
Impact on Economics

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

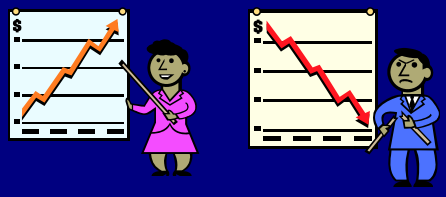
Impact of ESP Run-Life

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

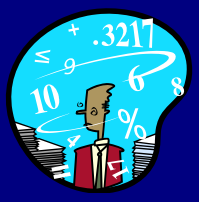
- All these averages can be calculated based on different exposure times
  - Time-in-Hole, Total Runtime, Actual Runtime
- Over different (calendar) periods of time
  - Last two years, last five years, etc.

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:

$$\langle MTTF \rangle = \frac{\sum T_{pulled} + \sum T_{running}}{\#\ failed}$$

What is a Failure?

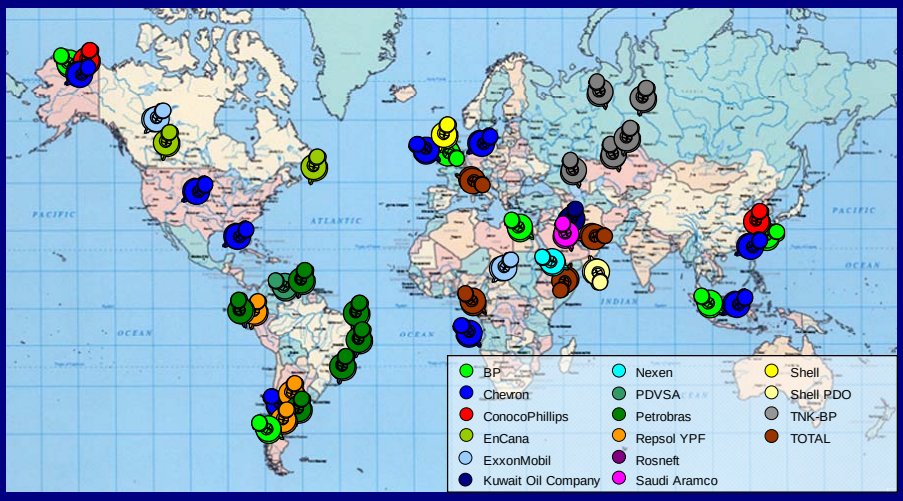
- Failure:
  - The termination of the ability of an item to perform its required functions

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



ESP-RIFTS: ESP Reliability and Failure Tracking System

Common Pitfalls

- Early Failures versus Frequent Failures
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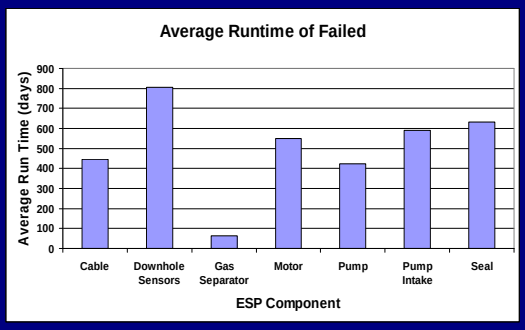
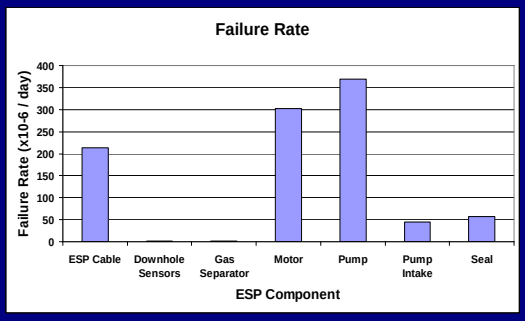
What is the least reliable component?
Is it the gas separator?



Which is more reliable?
The motor or the cable?



Common Pitfalls

- Early Failures versus Frequent Failures
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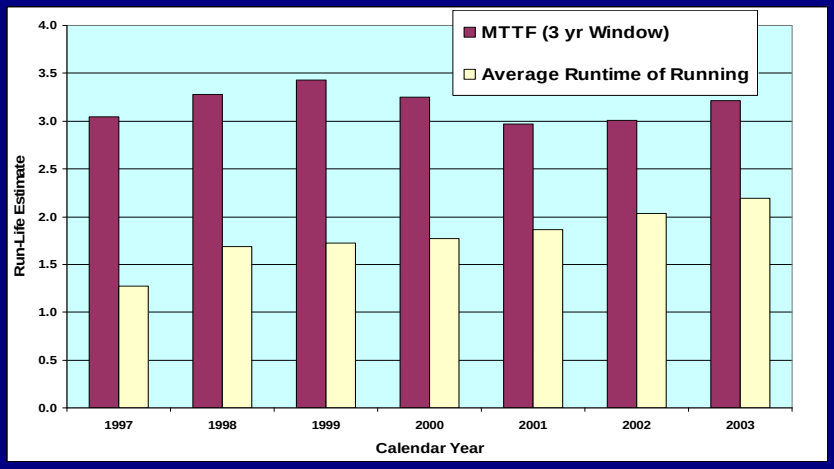
Is the system reliability improving?
Or are the systems just aging?



Common Pitfalls

- Early Failures versus Frequent Failures
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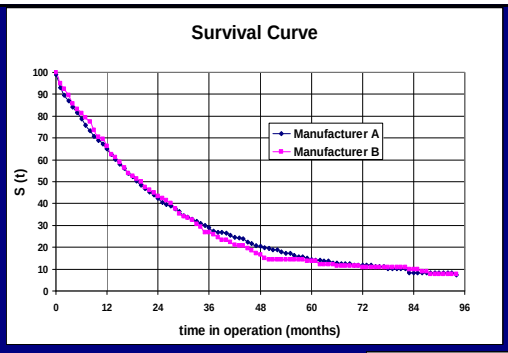
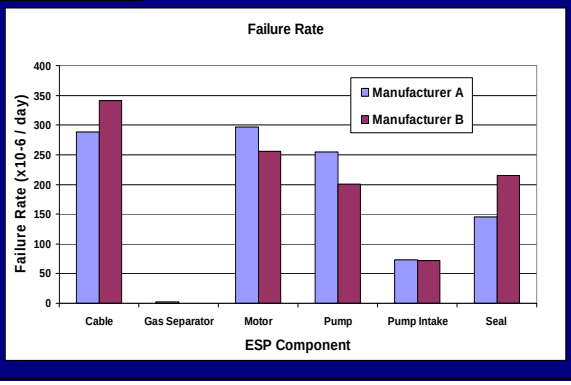


Is the equipment from both manufacturers equally reliable?



Common Pitfalls

- Early Failures versus Frequent Failures
- Improvement versus Aging
- Component Reliability and System RL
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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

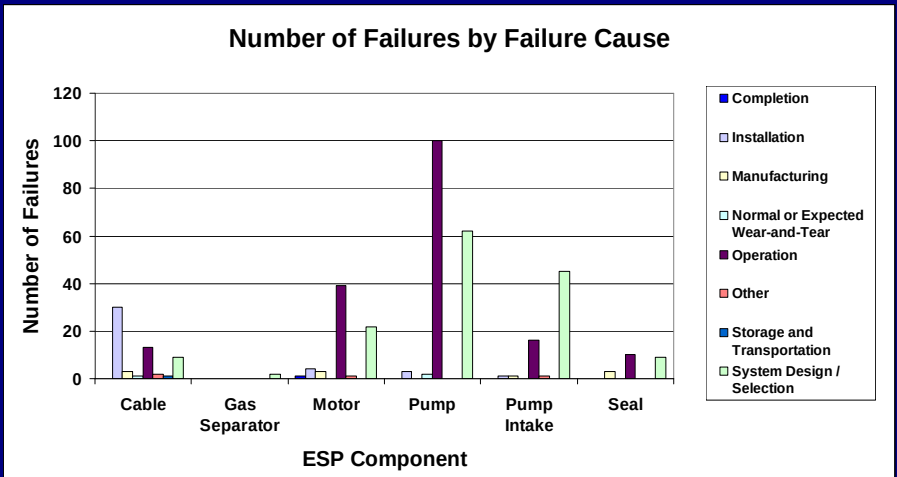
System Failure
- Reason for Pull defined:
e.g., No flow to surface

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?



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 !

Acknowledgement

- ESP-RIFTS JIP Participants:
  - BP
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  - Repsol-YPF
  - Rosneft
  - Shell
  - StatoilHydro
  - TNK-BP
  - Total