Workshop on Reliability & Risk Management of SSSVs for UGS Applications

Battelle/Sandia National Laboratories

Denver, CO; March 4-5, 2020

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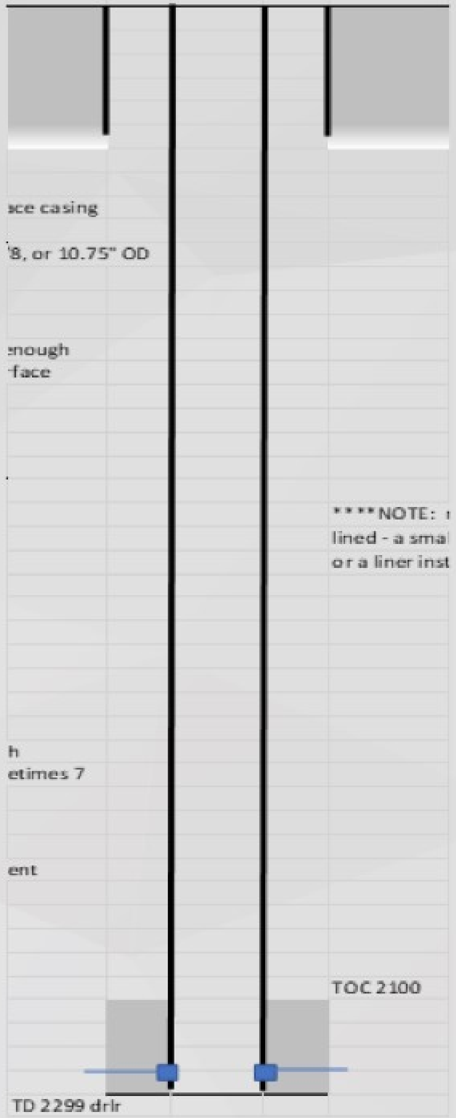
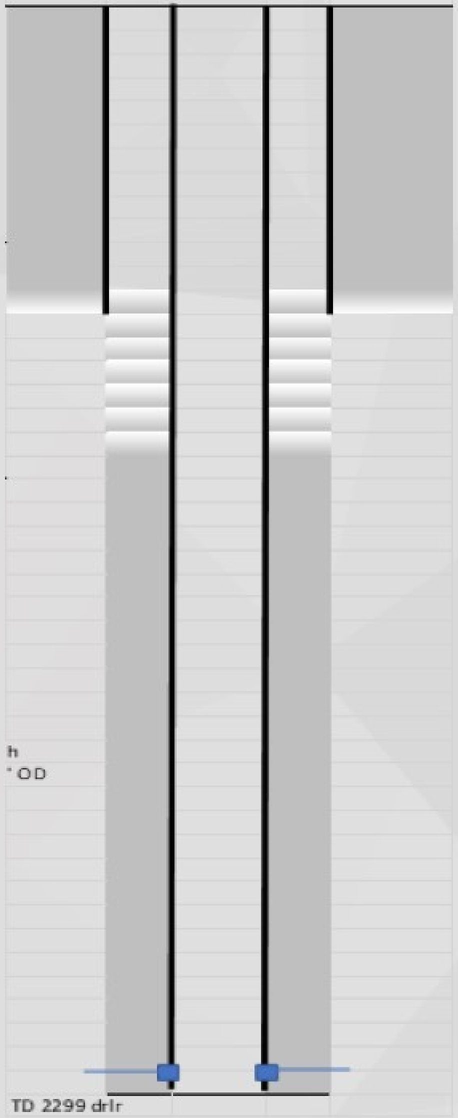
Test Case Creation: Well Construction Types: 4 Cases (Plus WC and Ideal)

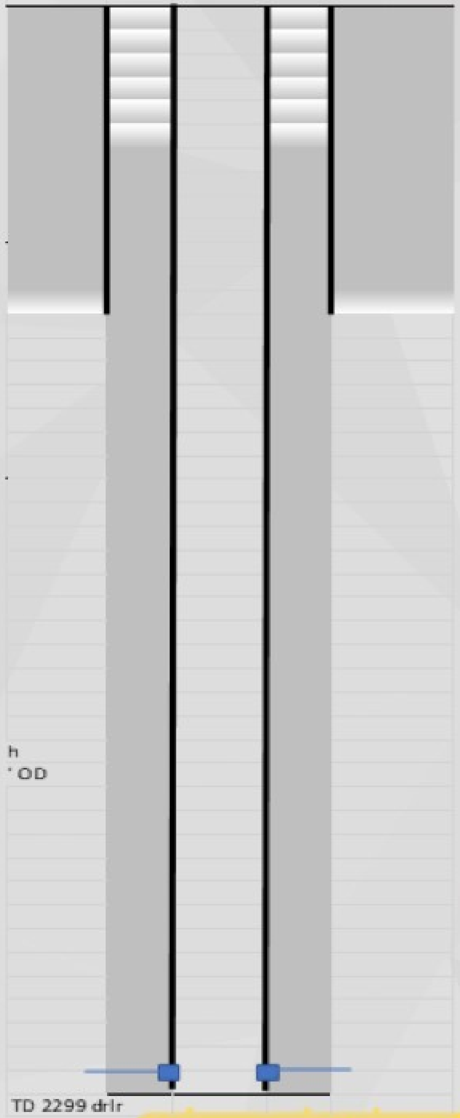
Age >70 yr; API WH/valve?



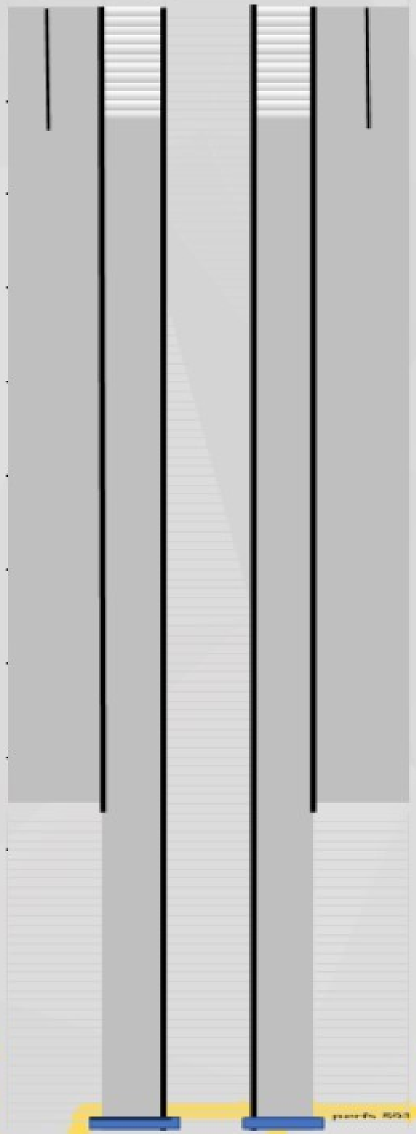
Age ~70 yr; API WH/valve



Age ~50 yr; API WH/valve



Age <25 yr; API WH/valve



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LOFI and COFI Ranges

Likelihood Cases Range over 5 orders of magnitude (failure/well-yr)

Excluding “problem” well at/near failure and an “ideal” well,

- Type 1: 1x10-1 to 1x10-2
- Type 2: 1x10-2 to 1x10-3
- Type 3: 1x10-3 to 1x10-4
- Type 4: 1x10-4 to 1x10-5

Consequence Cases Range over 5 orders of magnitude (USD)

Inputs

- Population density range over 5 orders of magnitude (1000s to <1)
- Flow potential range over 4 orders of magnitude (100s to <1)
- Feed volume range over 4 orders of magnitude (Bcfs to <Mcf)

Workover-Re-entry LOFI and COFI Ranges

Likelihood of Events Range over 5 orders of magnitude

Consequence of Events Range over 2 orders of magnitude (USD)

Concentrated on Maximum Cases

Could Increase Due to Human Factors

Notable for dominance of safety consequences in all cases

Summary – Percent of Cases Showing Potential Efficacy of SV

Type 1		Type 2		Type 3		Type 4	
shallow	deep	shallow	deep	shallow	deep	shallow	deep
60-90%	50-90%	25-55%	20-50%	5-40%	5-25%	0-15%	0-3%
Most often in Hi Cons		only in Hi Cons		only Hi-Cons		only Very Hi Cons	
Often in Mid Cons		Sometimes in Mid-Cons		Seldom in Mid-Cons		Never in Mid Cons	
Seldom in Lo Cons		Never in Low Cons		Never in Low Cons		Never in Low Cons	
All Cases Subject to Actual Site-Specific Condition Analysis!!!							
Alternatives?		*Alternatives?*		*Alternatives?*		*Alternatives?*	

SV Issue #1 - RELIABILITY

What is "Failure"?

Failure to Close on Demand or within acceptable time

Leaking above acceptable rate

Lack of control line communication and functional control

Causal Dependencies

SV placement (shallow, deep)

Mechanical components

Flow stream composition

Control System

Maintenance Complexity (Human Factors)

Range	shallow-set R	deep-set R
v. low	.60	.36
low	.80	.67
mid	.905	.84
high	.985	.94

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SV Issue #2 – SERVICE IMPACTS

Deliverability:

Reliability of Well Flow

Decrease in Well Potential

Secondary or Cascading Effects on Other Wells in System

Causal Dependencies

False Closures ("Safe Failures")

Pre-installation Well Potential

Pre-installation Well Flow Reliability

Installation Depth and Tubing Diameter

Need for Deliverability/Reliability

SV Issue #3 – WELL RE-ENTRY RISK

Inputs:

Reliability-driven re-entries

General increase in re-entry due to regulations

Job Complexity

Human Factors

World Data – Re-entry/Drilling LOC rates

Areas for Improvement

LOC Data: include "near miss" (trouble but not LOC)

LOC not reported or under-reported

Secondary or Cascading Impacts (chance of tools stuck/lost)

SV Issue #3 – WELL RE-ENTRY RISK

$$LOFI_{workover} = Frequency_{workover} \times FailureRate_{workover} \times Credit_2$$

Range of Re-entry Frequency (Re-entries per year)?

"Trouble" and Loss of Control Frequency – (Events per entry)?

Management of Human Factors – ("credit" or "demerit")

Life-Cycle Costs (Install and Maintain)

Added or Residual Cost for Deliverability/Reliability Make-up

Data Collection and Sharing with UGS Industry Discussion Review

- Need for standardization of data collection/reporting methods
- Need to come to a consensus on the definition of "failure," then segregate into "critical" vs "safe"
- What data can operators share that will benefit the industry as a whole?
- To determine what data to collect we should ask: what controls equipment reliability?
- If we have a secure, anonymous database managed by a third party, we could control who has access to what data
  - Need to work out the details/methods
- What would the data reporting form look like? Burden of completing? Concerns about funding

Data Collection and Sharing with UGS Industry Discussion Review

- Look at examples of other industries that share failure data voluntarily/without regulations as a guide
- Vendors collect failure information and run statistics that are available upon request
  - How can operators improve the frequency of feedback?
- With new safety valves being introduced, does the data on old valves have relevance?
- Do SVs introduce more risk through installation and maintenance that outweighs the benefits?
  - Are SVs the right way to ensure the integrity of a UGS well?

Data Collection and Sharing with UGS Industry Discussion Summary

Suggested data to collect (request for research team to create a strawman template):

- Number of failures during withdraw season
- Incidents when trying to pull equipment
  - Single vs double barrier
- Cost of maintenance
- Failure mode
- Operational history
  - How many times maintenance occurred and the results
  - How many times operated
  - Shut in duration

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Data Collection and Sharing with UGS Industry Discussion Summary

Suggested data to collect (request for research team to create a strawman template):

- How many times SVs worked as well as how many times they failed
- Set depth
- P-T
- Flow regime and composition
- Information on control system
- Tabulate workover events

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Risk Models in Industry Discussion Summary

- Need to consider routine exposure to SSSV beyond workover
- Need to collect and add rate of near misses to risk models
  - Can operators provide this?
  - Need to standardize language/definitions around this for consistency in reporting
- Poll operators on reasons for removing SSSVs
  - INGAA and/or AGA could facilitate
- Need to balance safety and reliability vs affordability
- Concerns that model implies SSSV are highly reliable
- Add greenhouse gas emission impacts

Risk Models in Industry Discussion Summary

- Impacts of snubbing versus dead hole work
- Model account for shallow vs deep SSSV?

Inclusion of T&P in Risk Model Discussion

- Is there a case where SSSV is added to T&P?
- Create two models? One with T&P and one without?
- Operators, through INGAA, to provide failure statistics on T&P?
- Should reverse cycling be considered, fatigue?
- Once T&P is set, reliability is good.
  - Issues more likely wellhead sealing
- Are there differences in failure rate with environment?
- Some prefer cement liner to T&P, but can't inspect
- Erosion considered?
- Communication on deliverability data, tubing vs. none.

Inclusion of T&P in Risk Model Discussion

- T&P is not always a second barrier.
- Discussion about standard vs. premium threads.
- Does model consider the more “stuff” put in a hole the more damage induced?
  - Included in mechanical damage factor.

Could INGAA and AGA house data together with PHMSA?

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T&P Version of the Model

Slawek Winecki
Battelle

T&P model - Questions

Battelle/Sandia team questions for the audience:

- Should two models be developed?
  - One for currently tubing-less wells
  - One for wells with tubing/packer already
- Once a tubing/packer system is in place, how might Likelihood of Failure equations be adjusted?
- How might Consequence of Failure be affected by tubing/packer systems?
- Should a well with T&P be modeled as a two-barrier model?
- How to account for annular pressure monitoring practices in the model?
- What are concerns over T&P workovers? Should the general form of approach to workover risk be different for T&P vs. SSSV?
- What is a good approach to modeling workover risk? Should the approach taken to modeling workover risk in the SSSV question be modified for tubing/packer systems?
- Should cemented liners be modeled as an alternative to T&P? How might modeling approaches be different for cemented tubulars vs. tubulars on packers?

T&P model - Questions

Battelle/Sandia team questions for the audience:

- What components of tubing/packer systems should be of concern in reliability modeling?:
  - Tubing body
  - Tubing connections
  - Wellhead adapters, seals, valves
  - Packer elements – seals, seating nipples, other; differences by packer type (?)
  - Tubing/packer connections
  - Annulus fluid
  - Other components
- What information do you recommend for understanding total or component reliability of tubing/packer systems? What is your experience with reliability of tubing/packer systems?
- What, in your opinion, constitutes "failure" of a tubing/packer system? Is an EPA-UIC-type MIT failure a starting point?
- What other tests do you perform to define tubing/packer system element failure requiring repair or replacement? Do ISO 16530 tables for WBE failure modes help?
- What additional input and/or ideas do you have?