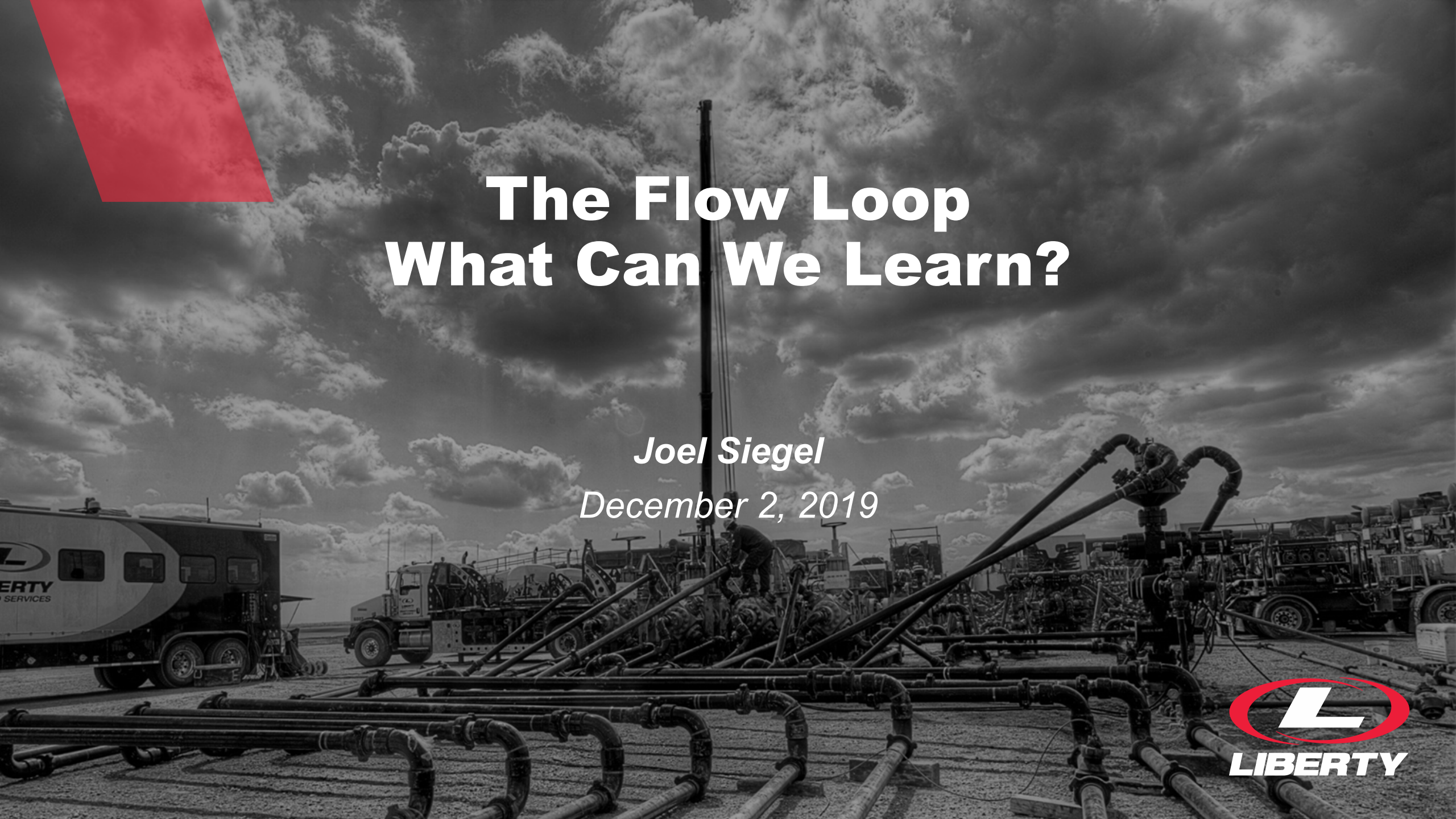

The Flow Loop
What Can We Learn?

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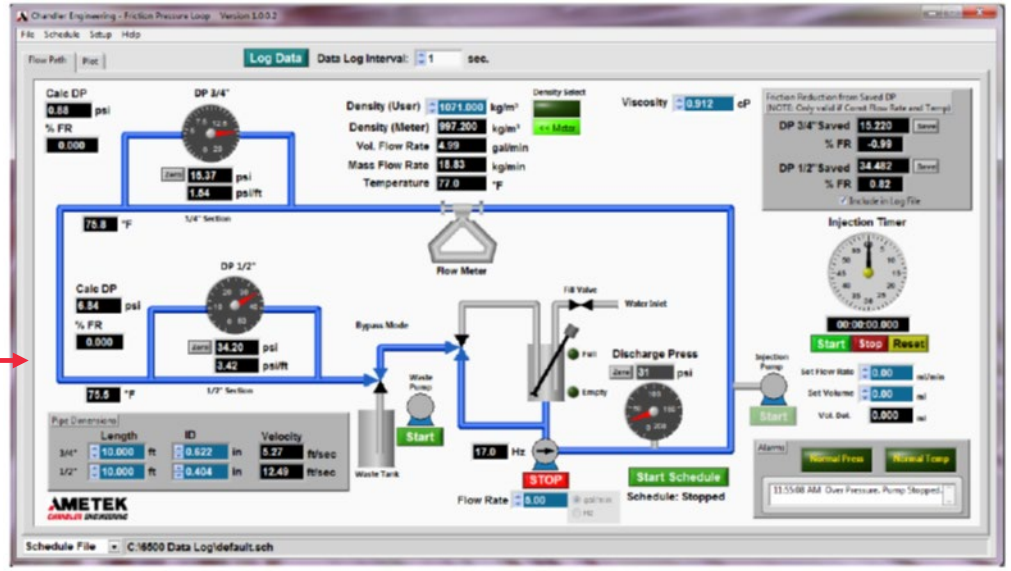
Outline

- Flow loop description
- Different ways that LOS utilizes flow loop data
- FR good vs FR bad example data
- QC process
- Conclusions

Flowloop – the ultimate wall space eater

- Circulates fluid through two 10 ft test sections of various diameter tubing.
- In the presence and in the absence of an FR in order to generate differential pressure versus flow rate data.
- The differential pressure data is used to calculate %friction reduction. ((DP base fluid – DP test) / DP base fluid) * 100
- The system incorporates a low shear, progressive cavity pump for injection of base fluids with the flow rate controlled by a Coriolis flow meter.
- Differential pressure transducers are provided on each tubing diameter for multiple data readings per test.
- Instrument control and data are fully automated to enable multiple tests to be run quickly in secession with minimal clean up time.



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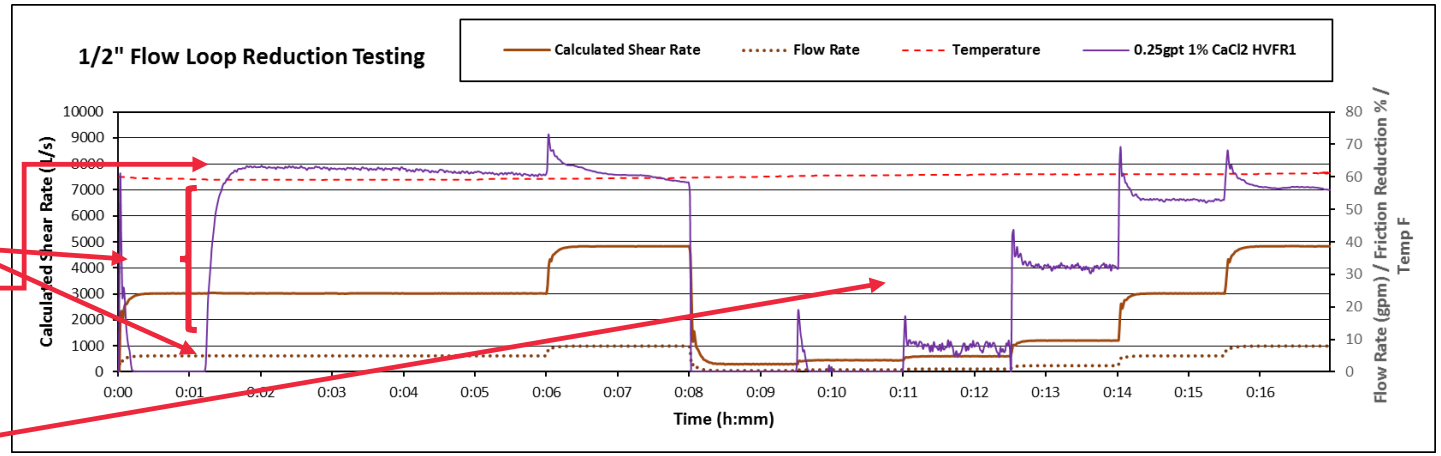
Utilization of the Flows Loops

- Product Differentiation
  - Selecting high performing FR's for our primary product line.
    - LOS understands the strengths and weaknesses of the majority of FRs available on the market.
  - Regularly evaluate the performance of the newest FR's on the market.
    - Whether they be in solid form, emulsion, slurry, dispersion or hybrid
- Comparing FRs from the same or different vendors
  - Is the lowest cost option good enough?
  - QAQC of vendor products
  - Optimize FR performance in different water matrices
  - Do you need an expensive high brine FR or will a mid-brine option work?
  - Can I change source water and still have confidence in my FR?
- Additive compatibles - evaluating the effect of other additives on FR performance
  - Due to ionic charges, many additives such as biocides are not compatible with friction reducers
  - Some additives such as FR boosters will enhance FR performance
- Maximizing the volume of produced water in produced water / fresh water blended fluids
  - You need to reuse a specific volume of produced water on location, but the majority of your job is fresh source water.
  - How much contamination can my FR handle? Can I add an FR booster?

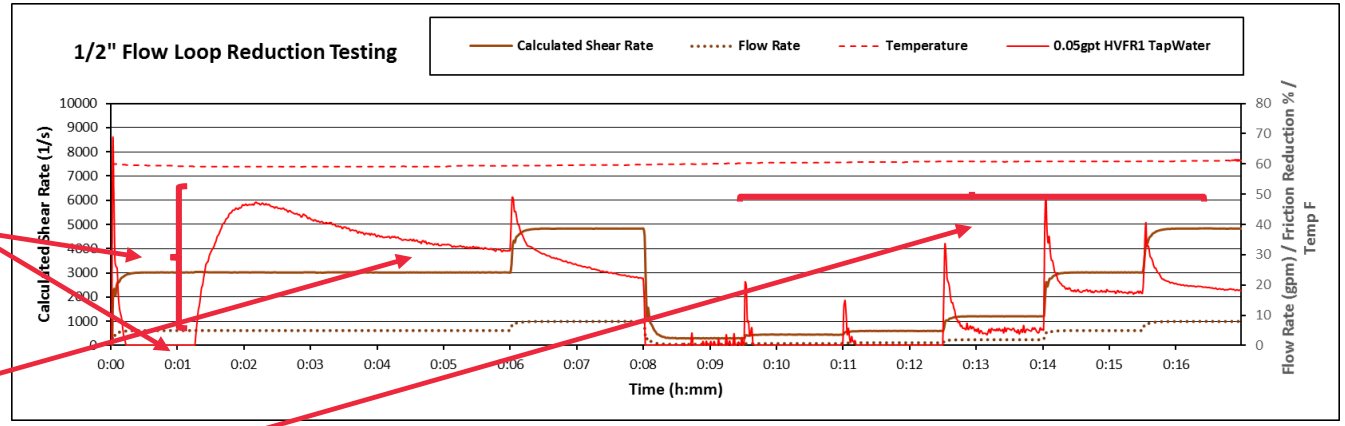
Anatomy of a Good FR - Example

- To the right is an example of a pretty good flow loop data.
- Why is it good?:
  - Sample injection is at just after 1min
  - The sample then inverts rapidly
  - And reaches max friction reduction that is high and stable
- Often times this first 5 min is the only flow loop data that labs present to customers.
- At LOS, we take it a bit farther and test the fluid at multiple shear rates to get as much data as possible.
  - You run the frac job at multiple rates, so it's good to know how the fluid performs at multiple shear rates – SPE 169497
- Any loss in FR performance can lead to tens of thousands in cost over runs.



Anatomy of a Bad FR - Example

- To the right is an example of what might be considered less than perfect flow loop data.
- Why is it not so good?:
  - Again, the sample is injected at just after 1min
  - The sample then inverts a little bit slower than the good example
  - And reaches max friction reduction that is lower and less stable than the good example
  - During the multi-shear steps the sample continues to shear down and has low performance.



Flow Loop QC and Conclusions

- As early as possible prior to job start date, LOS will request multiple 5 gal water samples to the lab.
  - How much we need generally depends on what is being planned so talk with your sales guy.
  - Synthetic water can also be utilized but is generally not preferred.
- These samples are used to select the best price to performance friction reducers for your job accounting for anticipated produced water blend ratios and any anticipate possible contaminants.
- A properly designed friction reducer system ensures optimum performance, particularly when using recycled produced water.
- The flow loop allows us to easily screen for the highest performing product.
- Any loss in FR performance can lead to tens of thousands in cost over runs.