Gas Well Deliquification Workshop

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Plunger Velocity Detection, Tracking, and Optimization

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Overview

- Fast plungers are the #1 issue in plunger lift
- Desire to detect fast plungers
- Use information to provide safety shut in
- Tracking plunger behavior
- Optimize off of plunger velocity
  - Enhanced safe operation
  - Maximize production

Issues with Fast Plungers

Safety Issues

- Possibly serious injury
- Damaged equipment

Environmental Issues

- Potential for spills

Production

- Lost Production on Failure
- Non-Optimal Production (Safety Factor)

Average Plunger Velocity

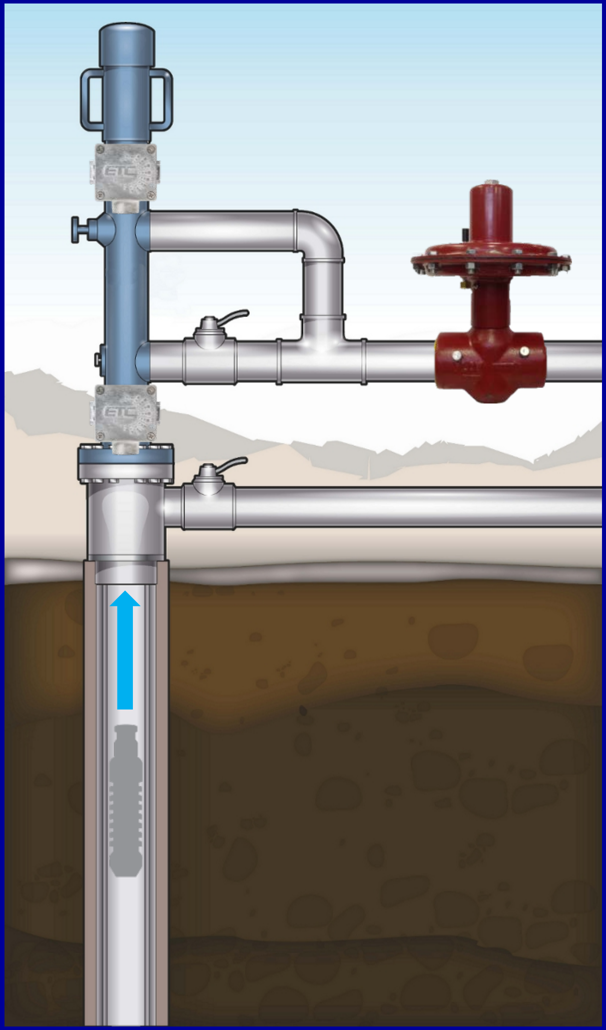
- **Most systems still rely on average plunger velocity**
- **Simply use the well depth and arrival time**
- **v = d/t**
- **System Parameters Depend on Plunger Type and Lubricator**
  - **Target of 750 ft/min**
  - **Fast Trip of 1000 ft/min**
  - **Dangerous Trip of 2000 ft/min**

Average Velocity Issues

- The plunger is not entering the lubricator at the velocity you think it is
- Assumes that the plunger was at bottom
- Ignores acceleration and deceleration
- Non-Optimal Operation
- Potential damage to plunger, lubricator, and spring without knowing it

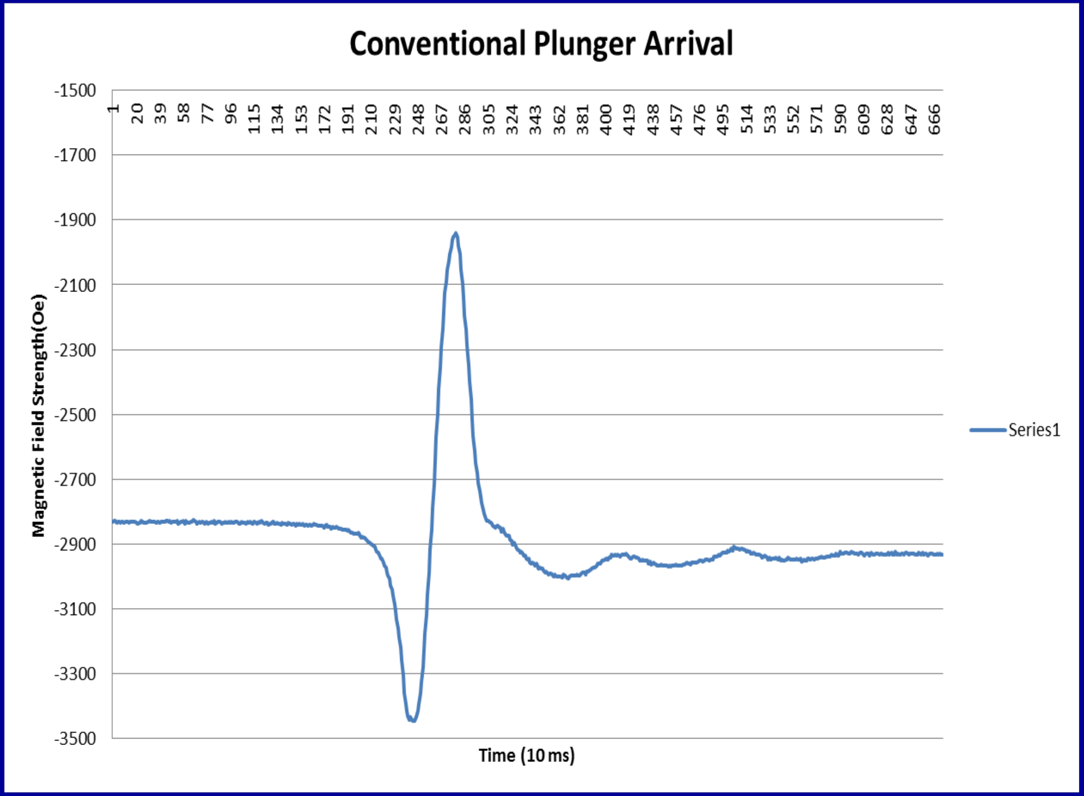
Use 2 Sensors?

- Too Much Error
  - Different Sensitivity per Sensor
  - Error in Clocks
  - Error in Position
  - Additional Hardware and Programming
- Have to space out 10s – 100s of Meters
  - Underground Installation
  - Long Cable Runs
  - Not Practical



Modern Plunger Detection

- New wave of digital plunger arrival sensors
- Magnetic sensor instead of a coil
- More accurate and reliable arrival detection
- Programmable software



Detecting Velocity – Single Point

Method

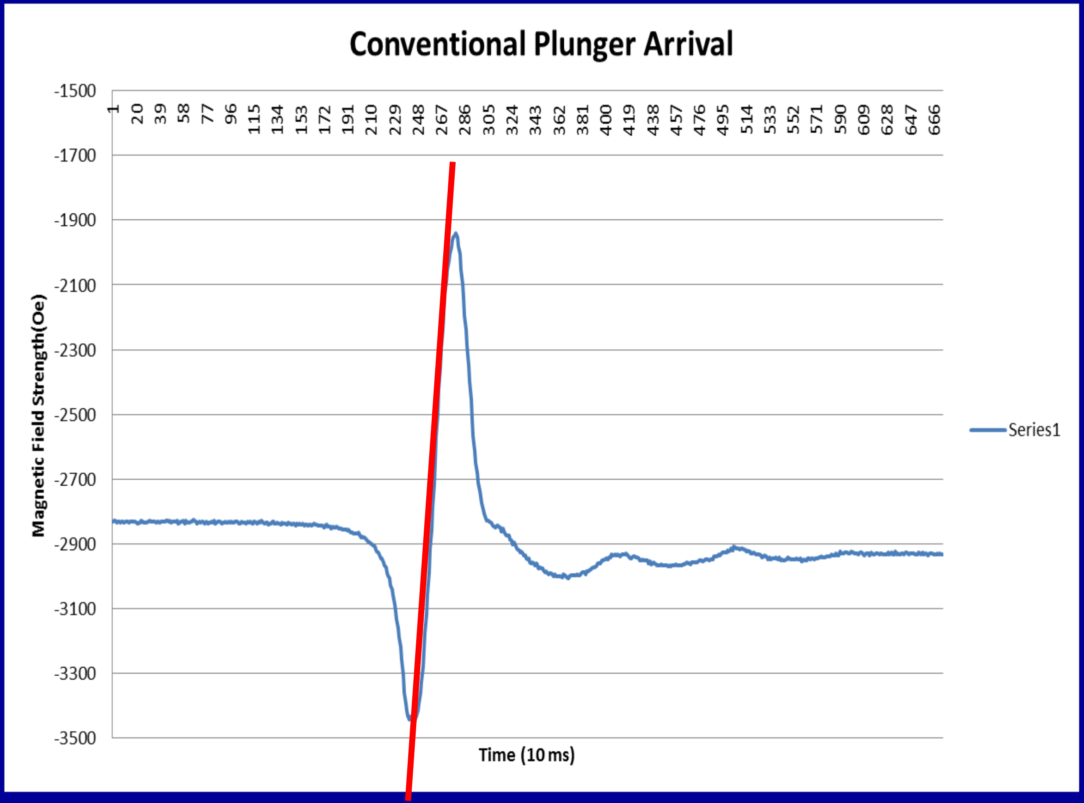
- Watch slope of the magnetic waveform
- Compensate for plunger material and length.

Benefits

- Inexpensive
- Simpler Hardware

Drawbacks

- Requires calibration
- Must input plunger information
- Plunger must pass sensor



Detecting Velocity – Multi Point

Method

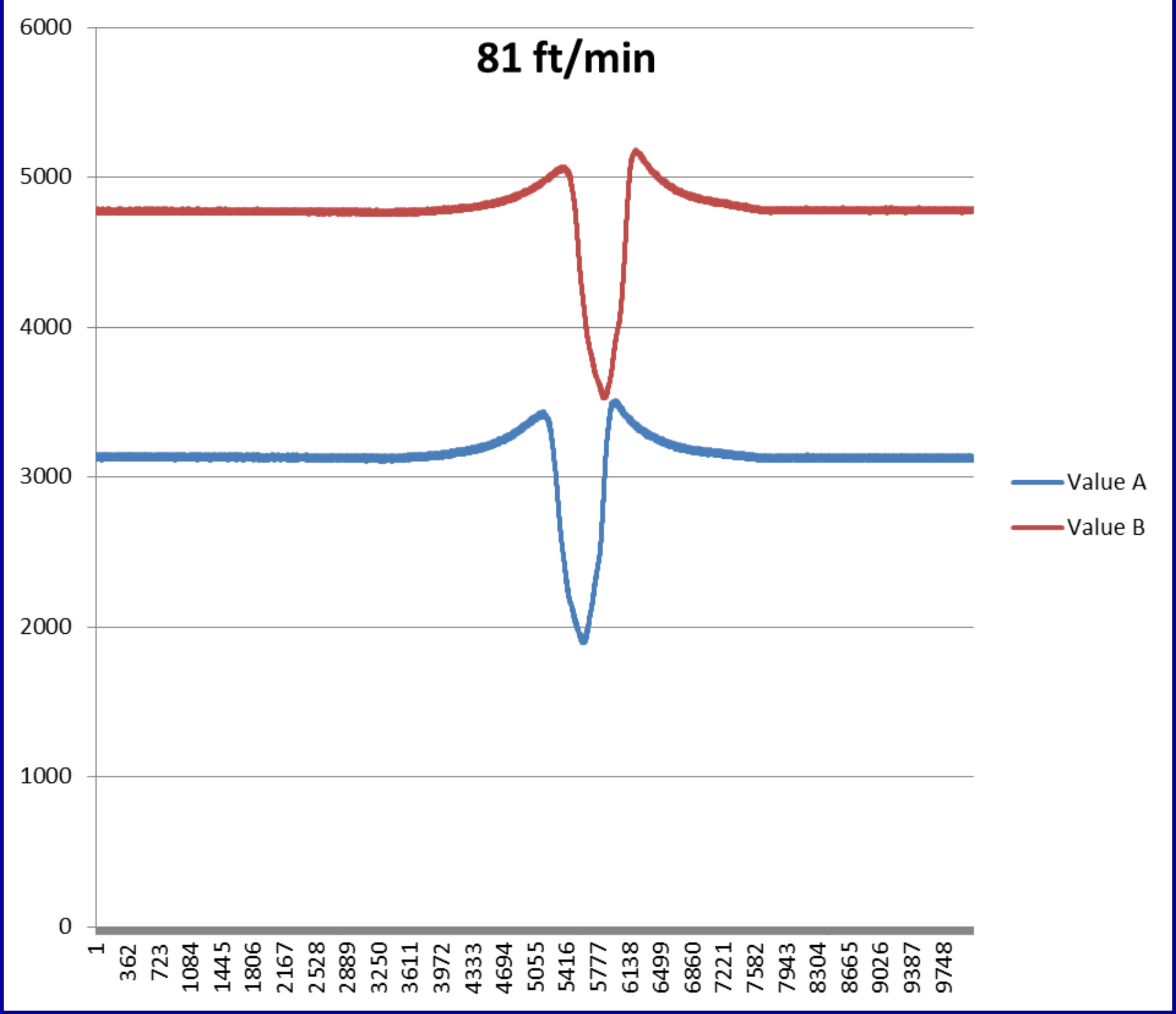
- Multi sensor array on the same board
- High speed synchronous clock
- Multi Point Correlation

Benefits

- Plunger independent
- More accurate (+/- 8%)

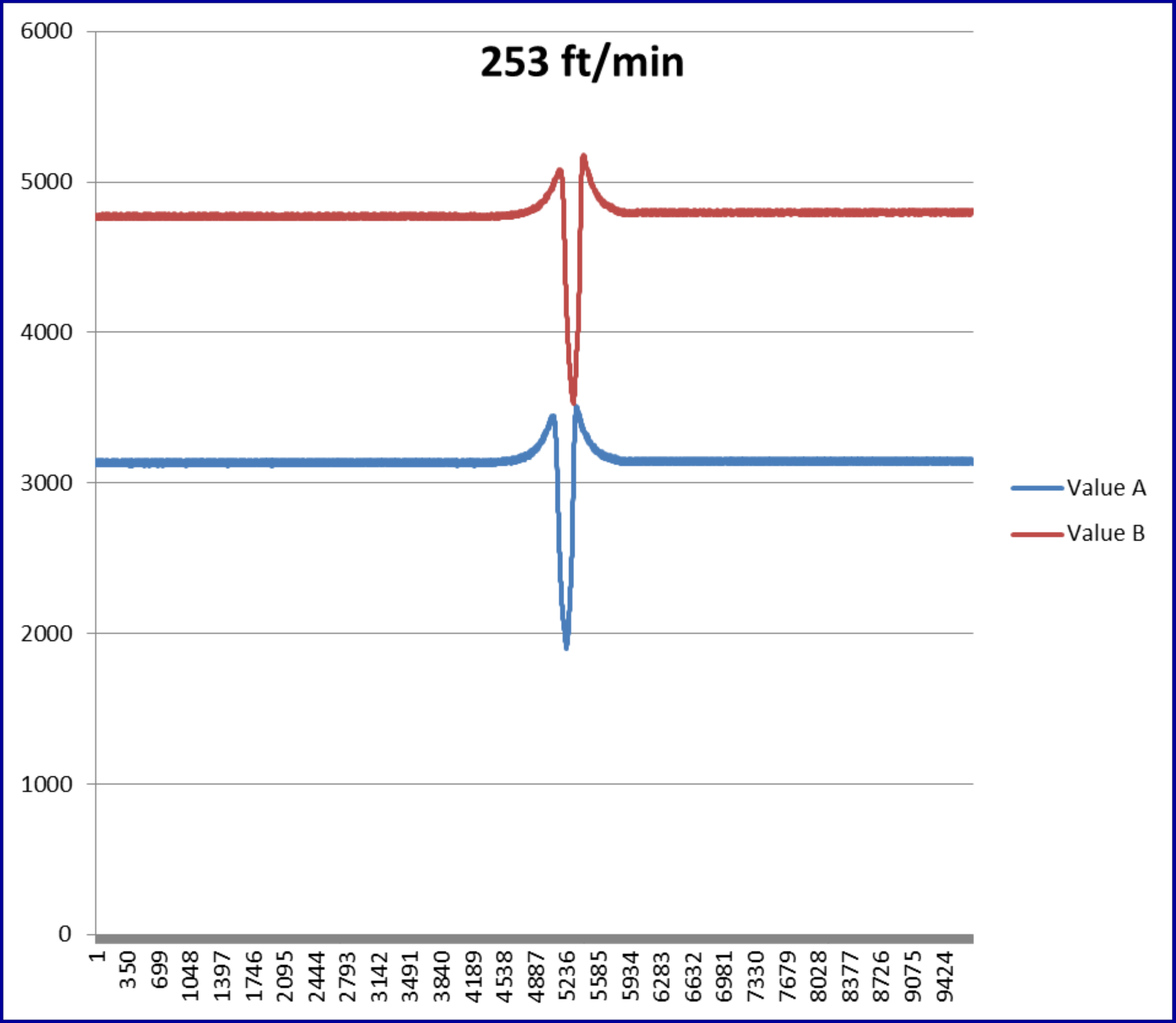
Drawbacks

- Less compact



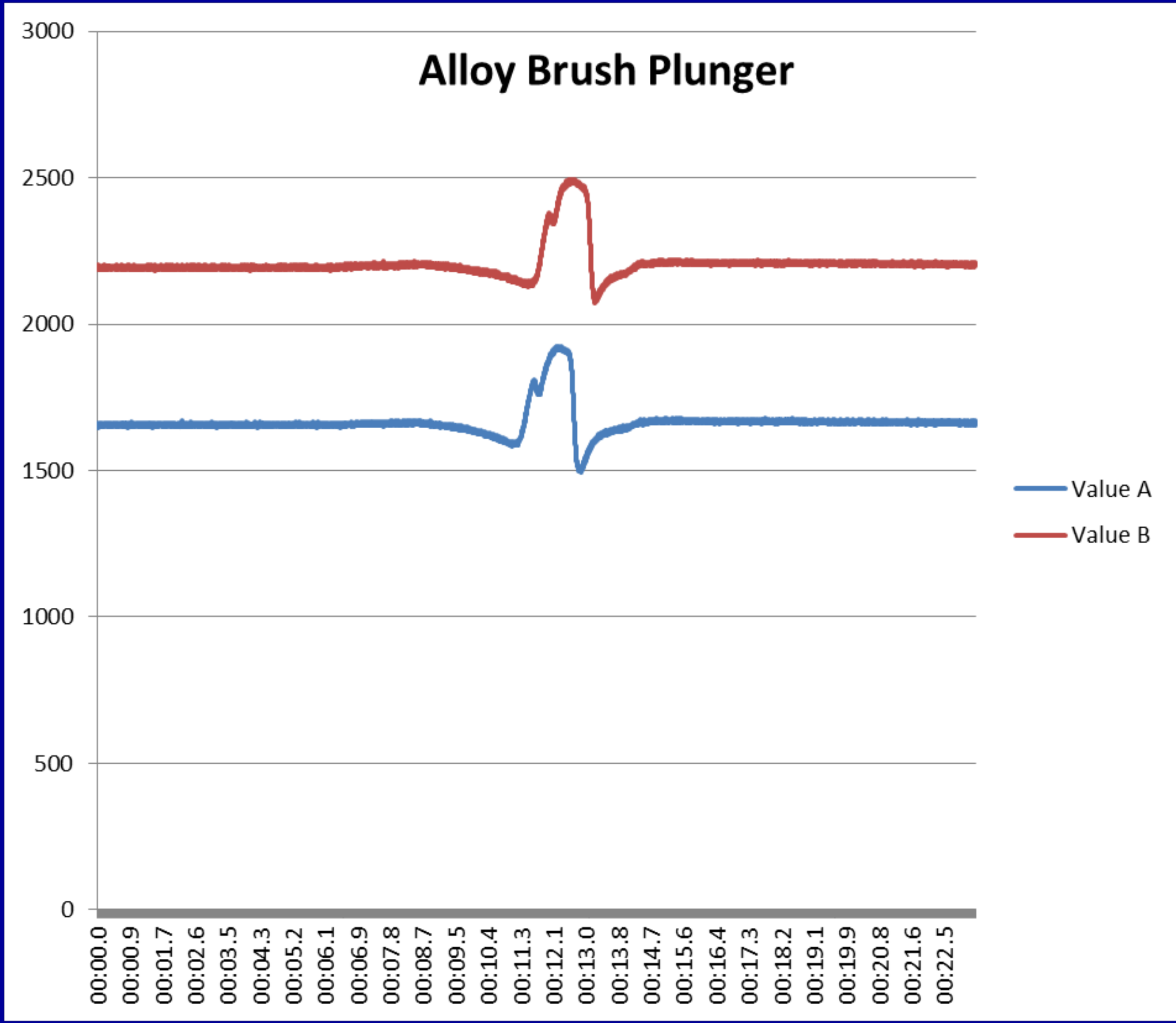
Increasing Velocity

- **Slope increases**
- **Peak narrows**
- **Time difference between key waveform points reduces**
- **Waveform shape is maintained**
- **Each plunger has a unique waveform**



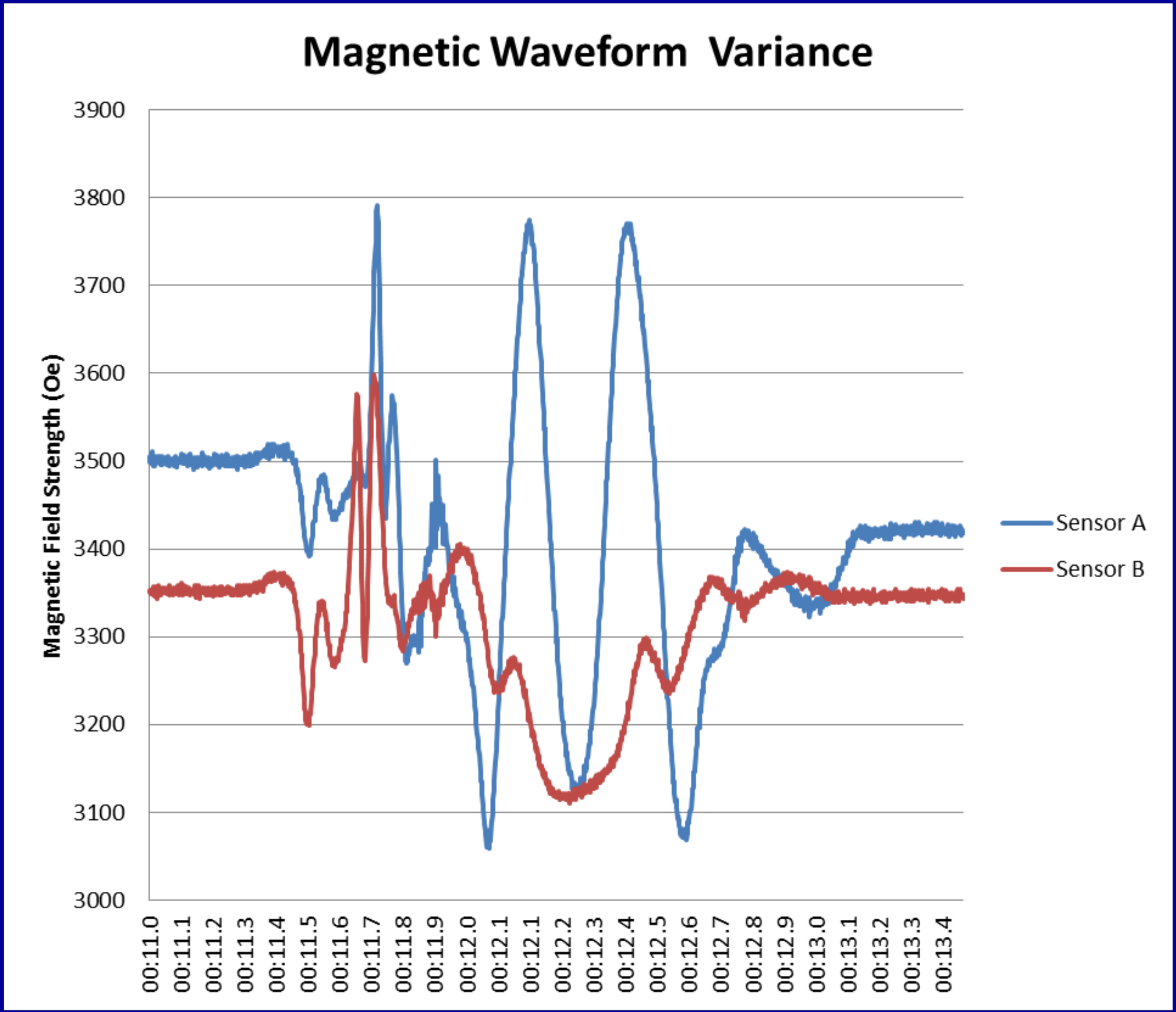
Different Material and Geometry

- Alloy brush plunger
- Different waveform shape
- Same principles apply
- Each plunger type has a signature



Other Waveforms

- **Dual padded plunger**
- **Multiple peaks**
- **More complex overall**
- **Acceleration skews the waveforms**

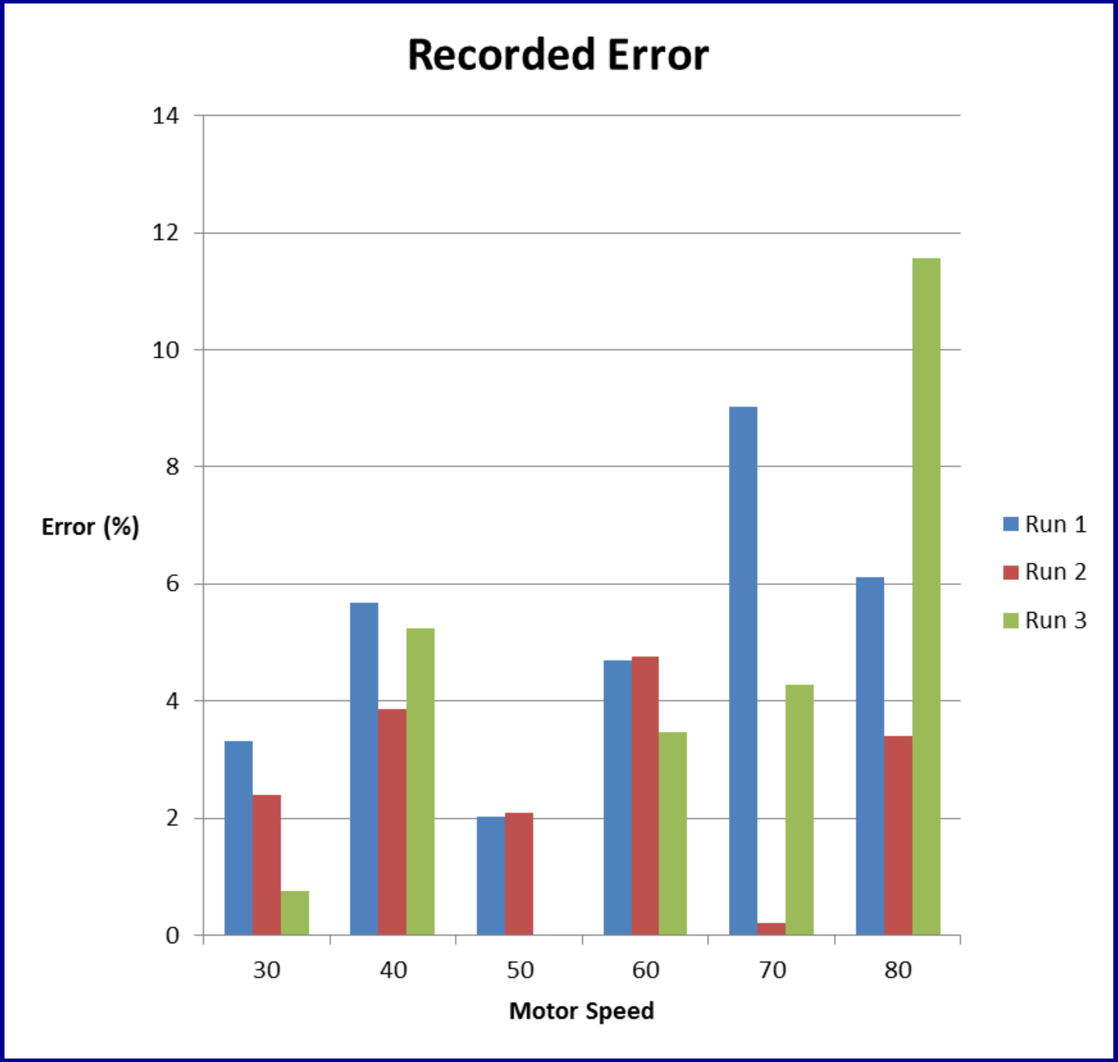


Validation

- Motor with a pulley and a piece of tubing
- Motor speed is varied
- Velocity is independently recorded with photo sensors
- Velocity from sensor is compared to photo sensor velocity

Error Rates

- Compared photo sensor velocity to velocity from waveforms
- Found higher errors at the higher velocities
- Some error due to the fact that the motor is not at a stable speed yet



Further Testing Required

- Building a larger scale test setup
  - Longer run of tubing with higher velocities
  - Put the lubricator back in the equation
  - Add plunger acceleration back in
- Need more runs with different types of plungers
- Move towards field trial
  - Documentation is available
  - Several producers are integrating with their controls
  - Targeting a broad range of well types and plunger types

Safer Operation

- More plunger intelligence
  - Know velocity of each plunger run
  - Trend velocity over time
  - Monitor during afterflow (sales)
- Use velocity for safety features
  - Shut in multiple fast trips (>1000 ft/min)
  - Shut in on single dangerous trip (2000 ft/min)
  - Adjust system parameters to slow future runs

Optimization Algorithm

- Safety factor can be reduced to increase production
- Proportionally adjust afterflow and close times based on velocity
- ETC has patent pending based on our previous time based optimization
- Makes small corrections on each run instead of trying to stop a dangerously fast plunger

$$\Delta AfterflowTime = \frac{ActualVelocity - TargetVelocity}{TargetVelocity} X\ ScalingFator\ X\ AfterflowTime$$

What's Next

- What else can velocity tell us?
- Can we use the difference between average velocity and actual velocity?
- Can we catch other situations where a fast plunger is ignored?
- Do lubricator and spring designs change now that we know the velocity?
- There is certainly a lot more possibilities now that we know actual plunger velocity.

Questions?

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