# Mud Pump Condition Monitoring and Pulsation Control Equipment Technology

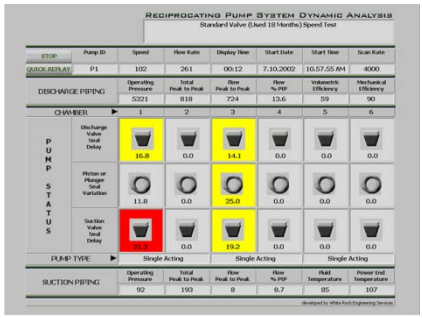
IADC Maintenance Committee Meeting

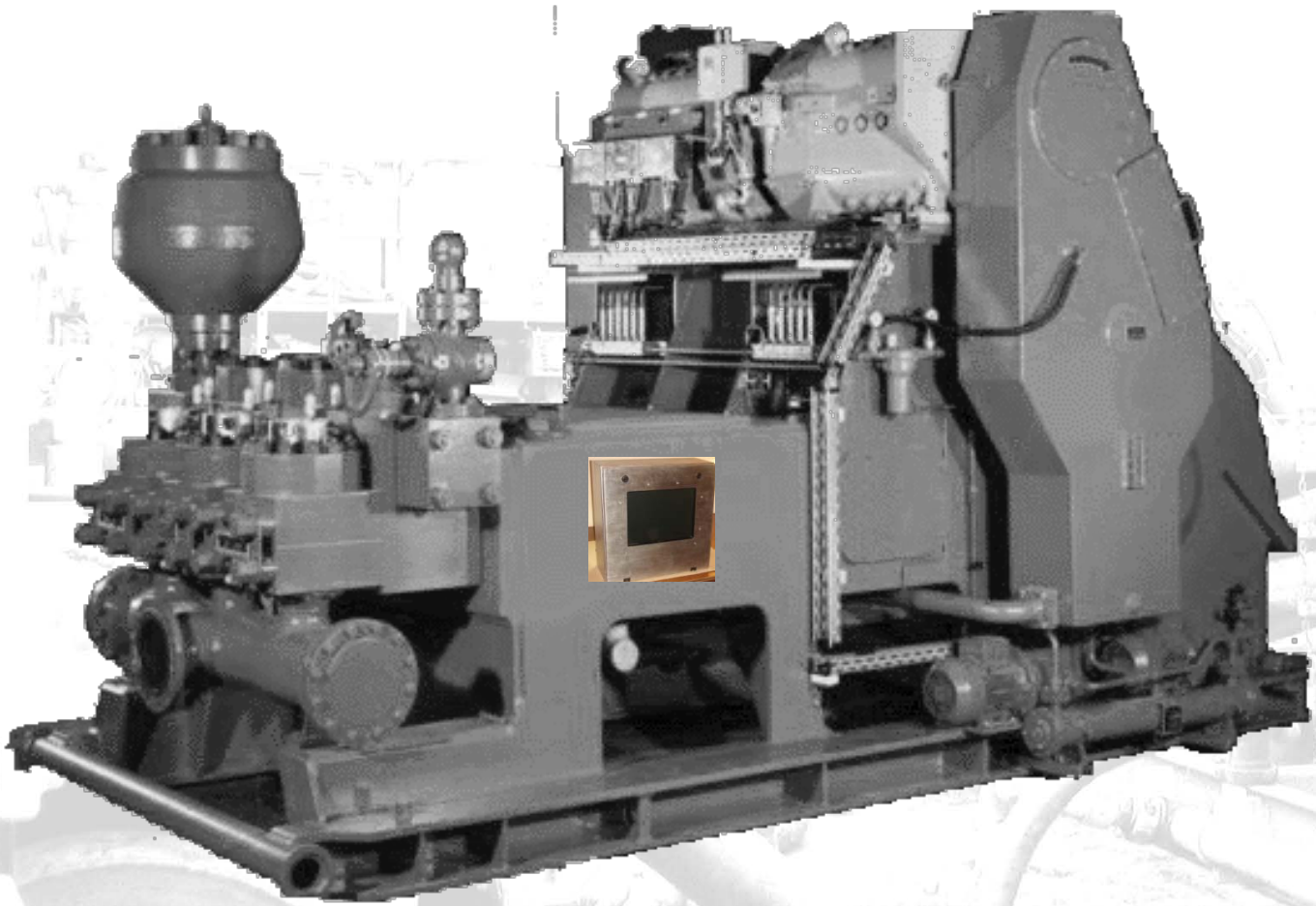
2008-10-08

# IADC Presentation

- Optimization of the mud pump system performance through pump condition monitoring and understanding of pump dynamics and pulsation control equipment

# Mud Pump System



# Overview

- Safety and Economic Benefits
- Mud Pump Condition Monitoring
- Pulsation Control Equipment Technology

# Economic and Safety Benefits

- Safety – Reduce stress related failures
- Improved MWD Signal Processing
- Elimination of premature relief valve activation
- Accuracy of down hole pill position
- Reduce potential for power-end failures
- Reduced expendable parts consumption

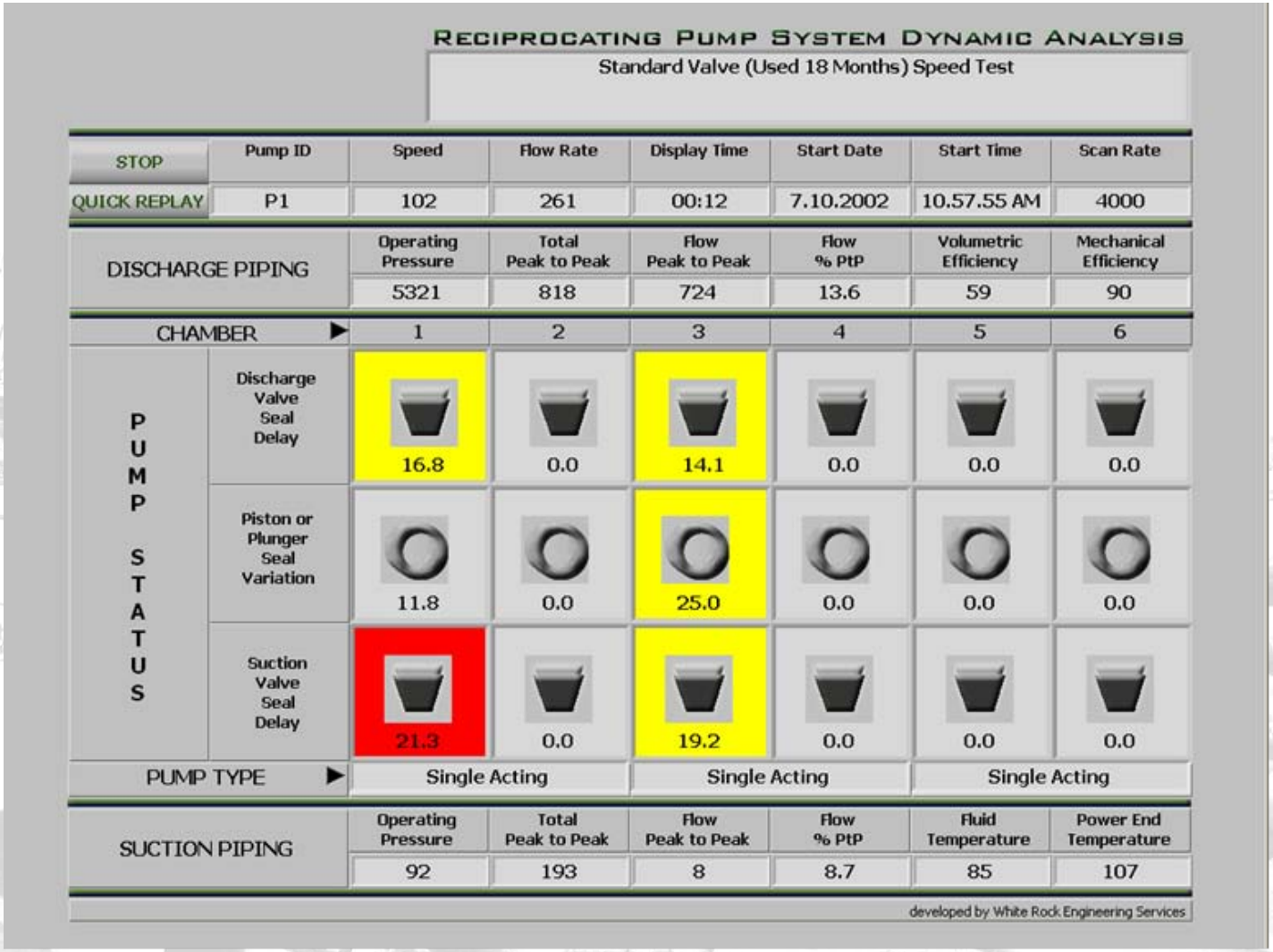
# Methods of Planning Mud Pump Maintenance

- Scheduled Maintenance on fixed time or stroke.
- Wait till component failure
- Targeted Maintenance with Condition Monitor Alarming

# Mud Pump Condition Monitoring

- Monitor Pressures, Temperatures, and Vibration to calculate pump operating values to alarm pump component wear status.
- Worn parts including leaking valves and pistons results in doubling or tripling the fluid pressure dynamics that leads to premature failure of pump and system components from cyclic mechanical stress.

# Typical Pump Monitor Status Display



RECIPROCATING PUMP SYSTEM DYNAMIC ANALYSIS

Standard Valve (Used 18 Months) Speed Test

| STOP | Pump ID | Speed | Flow Rate | Display Time | Start Date | Start Time | Scan Rate |
|---|---|---|---|---|---|---|---|
| QUICK REPLAY | P1 | 102 | 261 | 00:12 | 7.10.2002 | 10.57.55 AM | 4000 |

| DISCHARGE PIPING | Operating Pressure | Total Peak to Peak | Flow Peak to Peak | Flow % PtP | Volumetric Efficiency | Mechanical Efficiency |
|---|---|---|---|---|---|---|
| | 5321 | 818 | 724 | 13.6 | 59 | 90 |

| | | CHAMBER ▶ | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| PUMP STATUS | Discharge Valve Seal Delay | | 16.8 | 0.0 | 14.1 | 0.0 | 0.0 | 0.0 |
| | Piston or Plunger Seal Variation | | 11.8 | 0.0 | 25.0 | 0.0 | 0.0 | 0.0 |
| | Suction Valve Seal Delay | | 21.3 | 0.0 | 19.2 | 0.0 | 0.0 | 0.0 |
| | | PUMP TYPE ▶ | Single Acting | | Single Acting | | Single Acting | |

| SUCTION PIPING | Operating Pressure | Total Peak to Peak | Flow Peak to Peak | Flow % PtP | Fluid Temperature | Power End Temperature |
|---|---|---|---|---|---|---|
| | 92 | 193 | 8 | 8.7 | 85 | 107 |

developed by White Rock Engineering Services

# Pump Cycle

| | |
|---|---|
| Time | DD/MM/YY HH:MM:SS.S |
| Speed | RPM |
| Flow Rate | m3/hr, lpm, gpm, bpm, bph |
| Volume Displaced | meter3, liter, gallon, barrel |
| Volumetric Efficiency | % |
| Hydraulic Power | kW, HP |
| Work | kW-Hours, HP-Hours |
| Input Power | kW, HP |
| Mechanical Efficiency | % |
| Vibration Frequency | Hertz |
| Vibration Maximum Peak to Peak Acceleration | g |
| Vibration Maximum Peak to Peak Location | Degrees |
| Fluid Temperature | °C, °F |
| Power End Lubrication Temperature | °C, °F |
| Dampener Delta Volume | Factor |

# Suction and Discharge Manifold

| | |
|---|---|
| Operating Pressure | Pa, kPa, mPa, psi, bar |
| Maximum Pressure | Pa, kPa, mPa, psi, bar |
| Minimum Pressure | Pa, kPa, mPa, psi, bar |
| Peak to Peak Pressure | Pa, kPa, mPa, psi, bar |
| Peak to Peak Pressure | % |
| Flow Maximum Pressure | Pa, kPa, mPa, psi, bar |
| Flow Minimum Pressure | Pa, kPa, mPa, psi, bar |
| Flow Peak to Peak Pressure | Pa, kPa, mPa, psi, bar |
| Flow Peak to Peak Pressure | % |
| Primary Frequency | Hertz |
| Primary Peak to Peak Pressure | Pa Pa, kPa, mPa, psi, bar |
| Primary Peak to Peak Pressure | % |
| Frequency/Pump Fundamental | Factor |

# Individual Chamber Cycle

| | |
|---|---|
| **Volumetric Efficiency** | **%** |
| **Suction Valve Leak Rate** | **%** |
| **Piston/Plunger Leak Rate** | **%** |
| **Discharge Valve Leak Rate** | **%** |
| **Stress Cycles/Rev** | **Factor** |
| **Estimated Fluid Chamber Life** | **Years** |
| **Dynamic Work per Revolution** | **kW, HP** |
| **Crosshead Shoe Temperature** | **°C, °F** |

# Individual Chamber Discharge Stroke

| | |
|---|---|
| **Suction Valve Seal - Chamber Cycle** | **Degrees** |
| **Suction Valve Seal - Pump Cycle** | **Degrees** |
| **Compression Degrees Compression Rate** | **Factor** |
| **Seal Pressure Variation** | **%** |
| **Overshoot Pressure** | **%** |
| **Discharge Valve Opening - Chamber Cycle** | **Degrees** |
| **Discharge Valve Opening - Pump Cycle** | **Degrees** |

# Individual Chamber Suction Stroke

| | |
|---|---|
| Discharge Valve Seal - Chamber Cycle | Degrees |
| Discharge Valve Seal - Pump Cycle | Degrees |
| Decompression | Degrees |
| Decompression Rate | Factor |
| Suction Valve Opening - Chamber Cycle | Degrees |
| Suction Valve Opening - Pump Cycle | Degrees |
| Suction Minimum Pressure | Pa, kPa, mPa, psi, bar |
| Acceleration Delay | Degrees |
| Suction Maximum Pressure | Pa, kPa, mPa, psi, bar |
| Crosshead Peak Shock Location - Chamber Cycle | Degrees |
| Crosshead Peak Shock Load | Pa |
| Suction Average Pressure | Pa, kPa, mPa, psi, bar |

# Purpose of System Pulsation Control

- Suction
  - Maintain adequate fluid pressure to fill pump chamber
  - Eliminate cavitation damage
  - Eliminate Cross-Head Shock
- Discharge
  - Protect pump from overstress
  - Protect piping and system components
  - Provide MWD with minimum pressure signal
  - Prevent System Piping hydraulic resonance

# Pulsation Control Technology

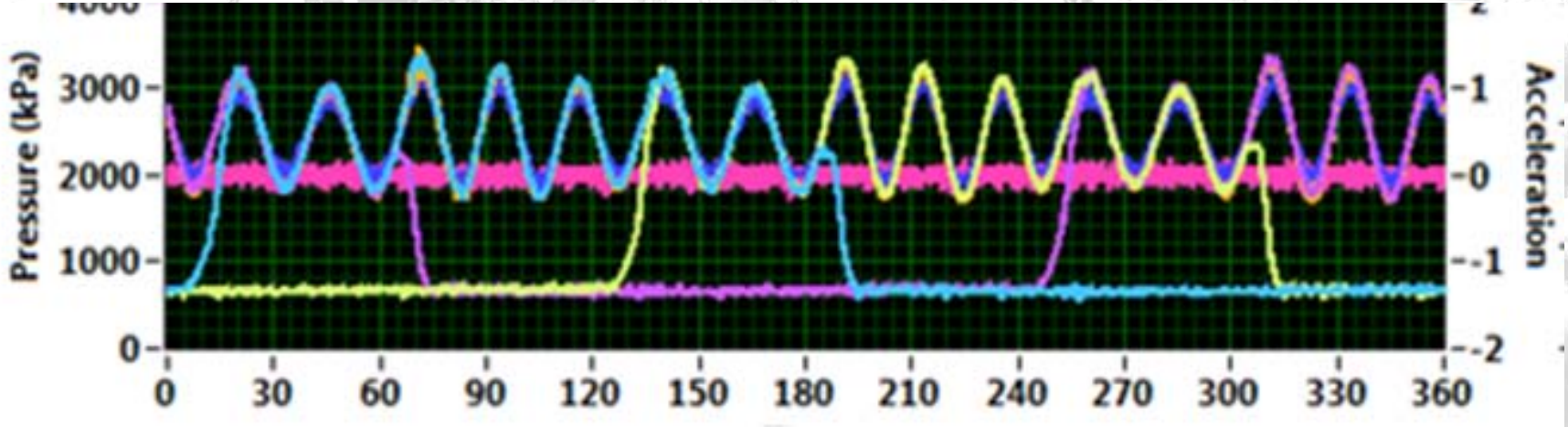
- Residual Pulsation Target
- Sizing Criteria
- Pulsation Control Equipment

# Residual System Pulsation Target

- Suction – Up Stream for 50 psi Supercharge
  - Pump Industry – 10 psi
  - API 674 – Positive Displacement Pumps – Reciprocating – 13 psi
- Discharge – Down Stream for 7500 psi System
  - Pump Industry – 3% - 225 psi
  - API 674 – Positive Displacement Pumps – Reciprocating – 19 psi
  - ISO 16330 – Reciprocating Pump Technical Requirements – <2% - 150 psi

# Cautionary Note

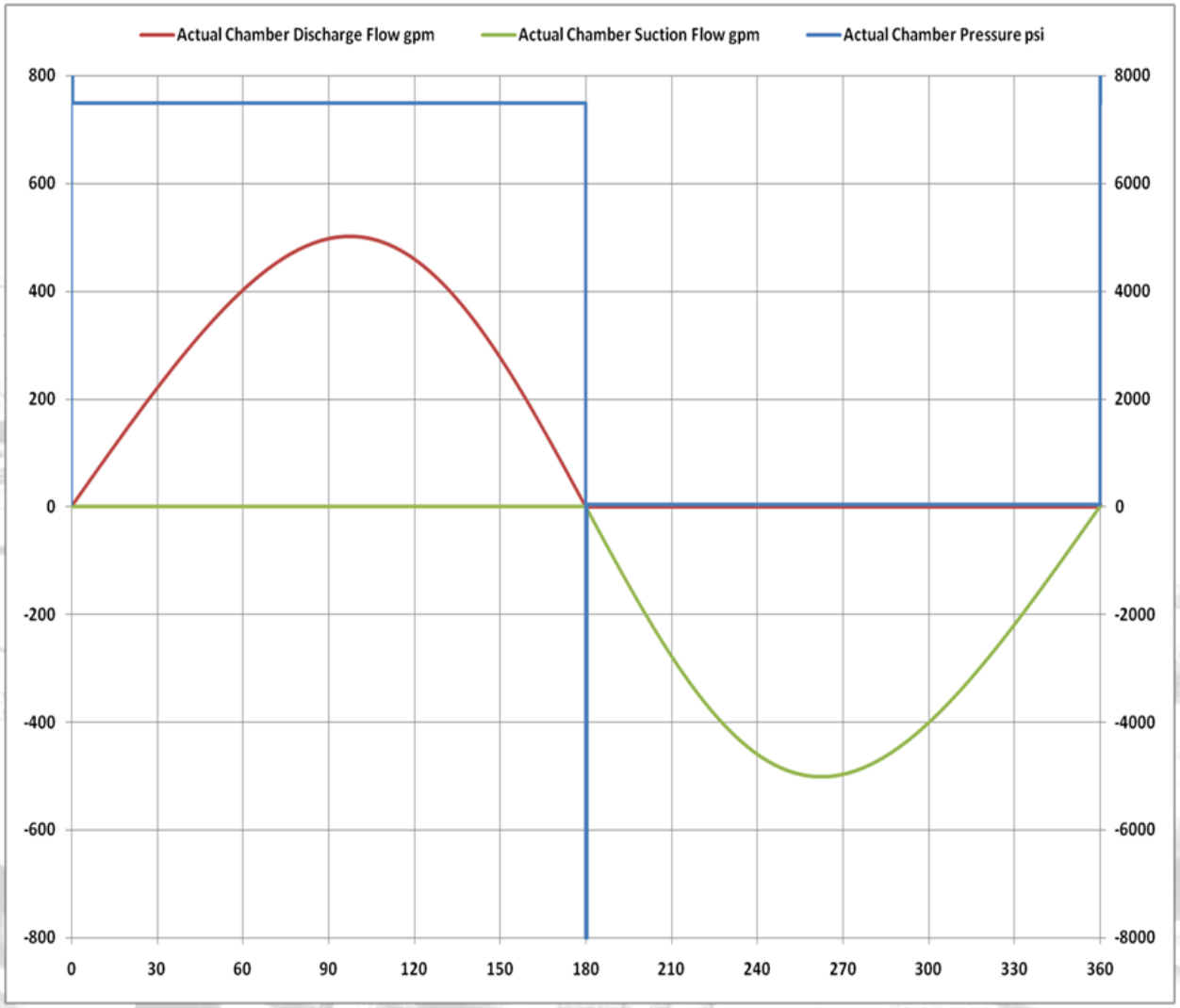
- Inadequate pulsation control can lead to fluid hydraulic resonance in suction and discharge piping systems that will lead to pump and system piping stress failures.



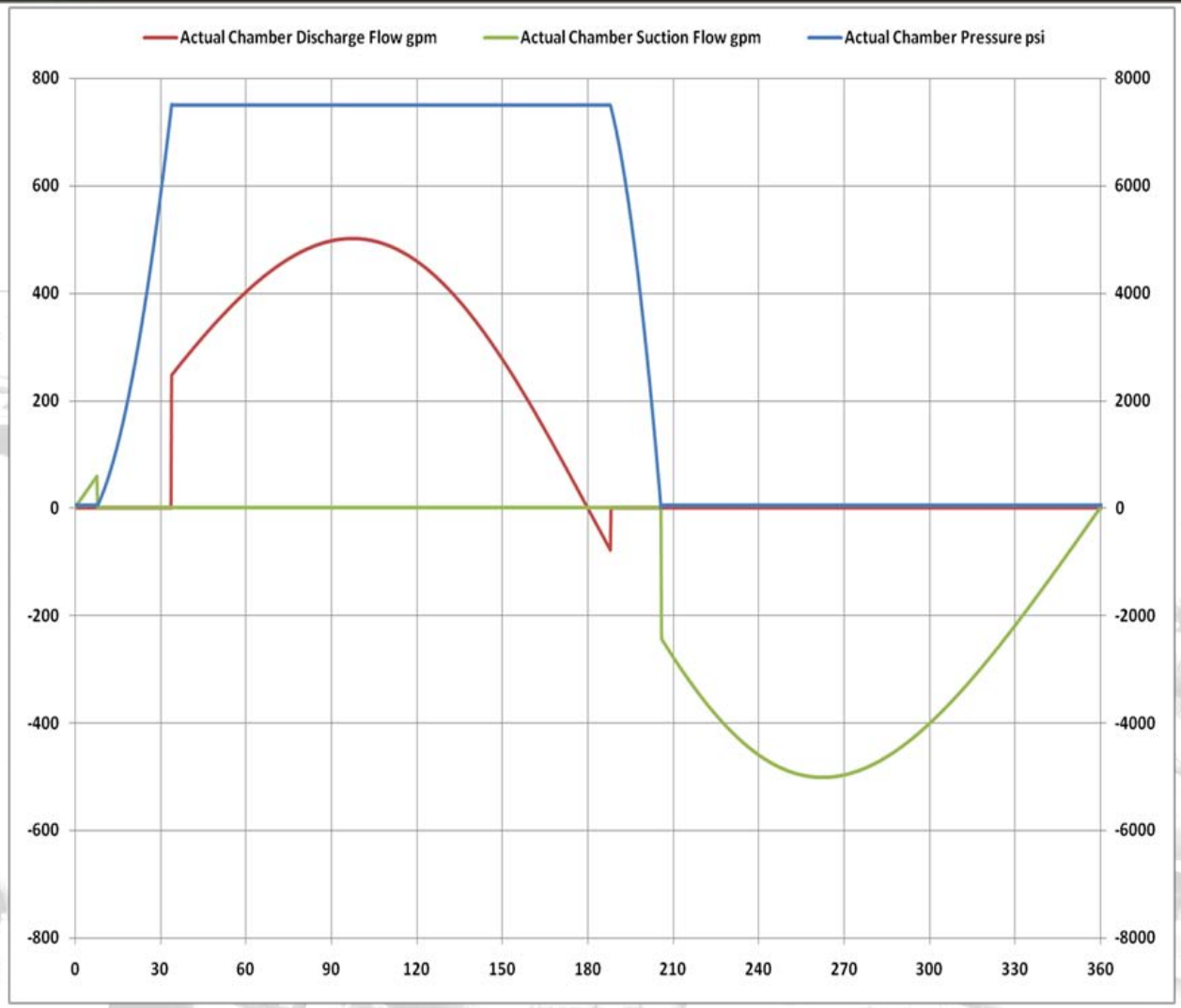
# Mud Pump Pulsation Control Equipment Sizing Criteria

- Type – Triplex, Quintuplex
- Size – Bore and Stroke
- Pressure – 3000, 5000, 7500
- Fluid-End Design
- Pulsation Control Equipment - Suction and Discharge
- Piping System
- Expendables Condition – Valves and Pistons
- Fluid being pumped – Water or Oil Based Mud

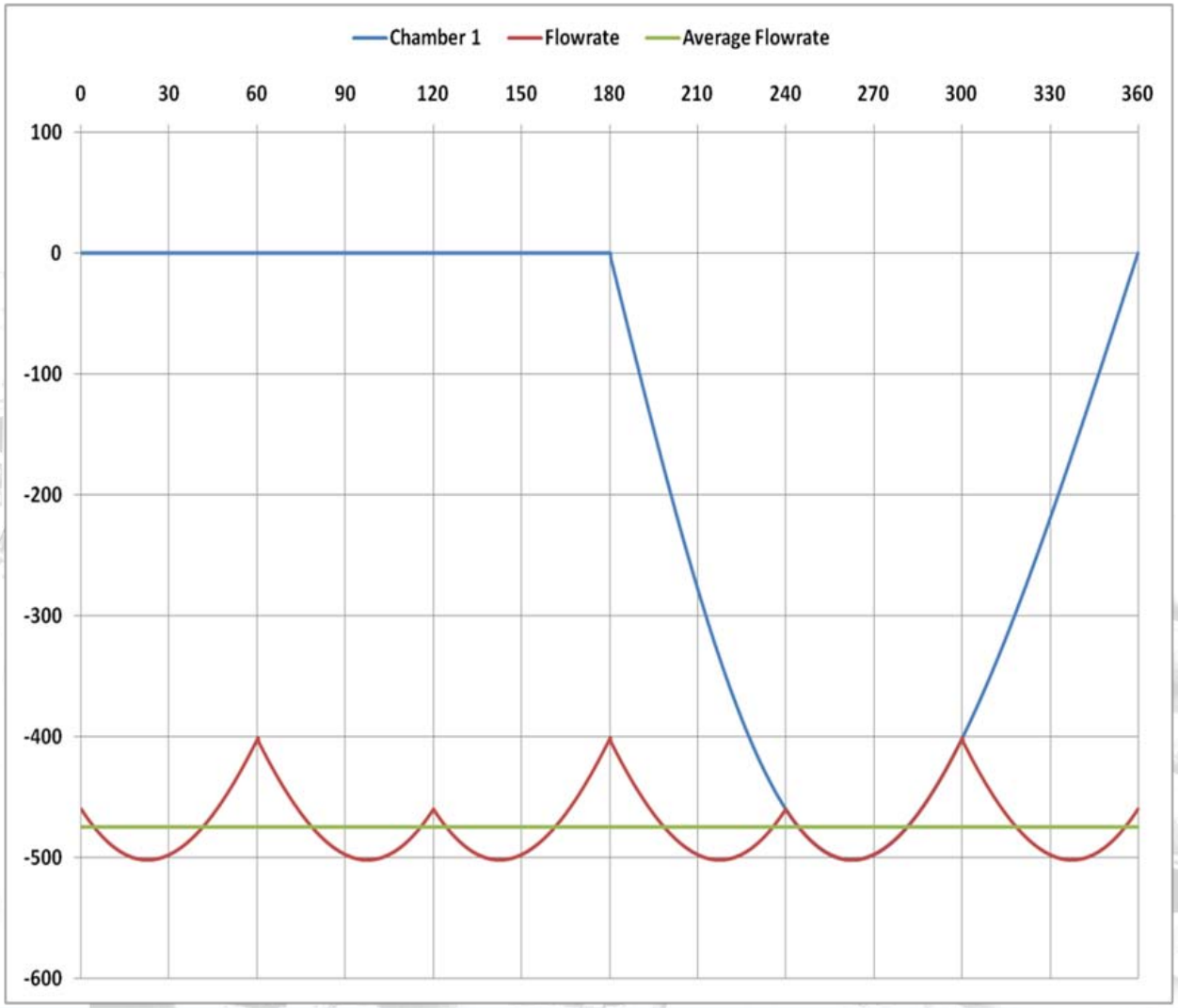
# Pump Chamber Flow and Pressure Model
## No Compression or Valve Seal Delay



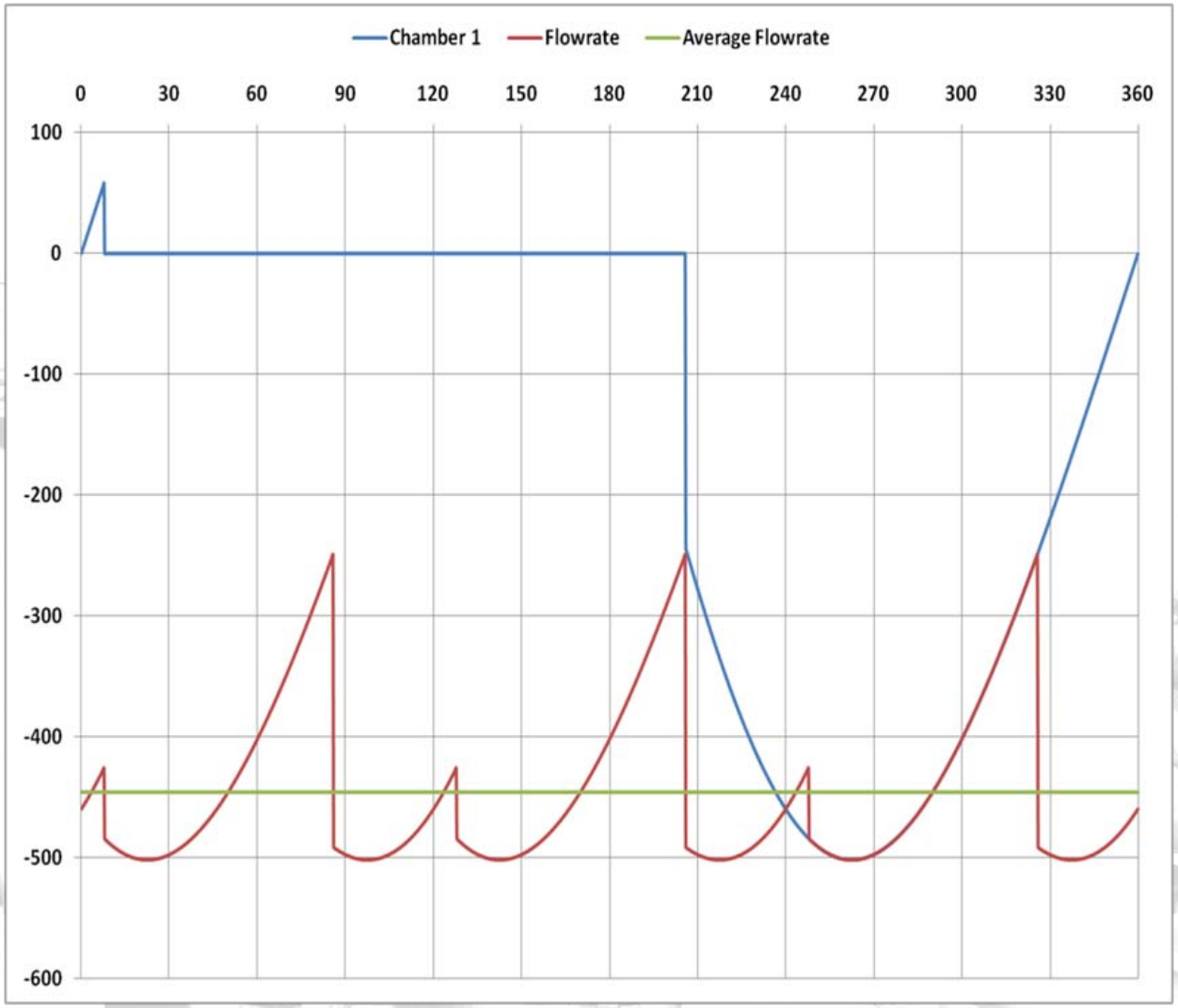
# Pump Chamber Flow and Pressure Model
# Water with 8 Degree Valve Seal Delay



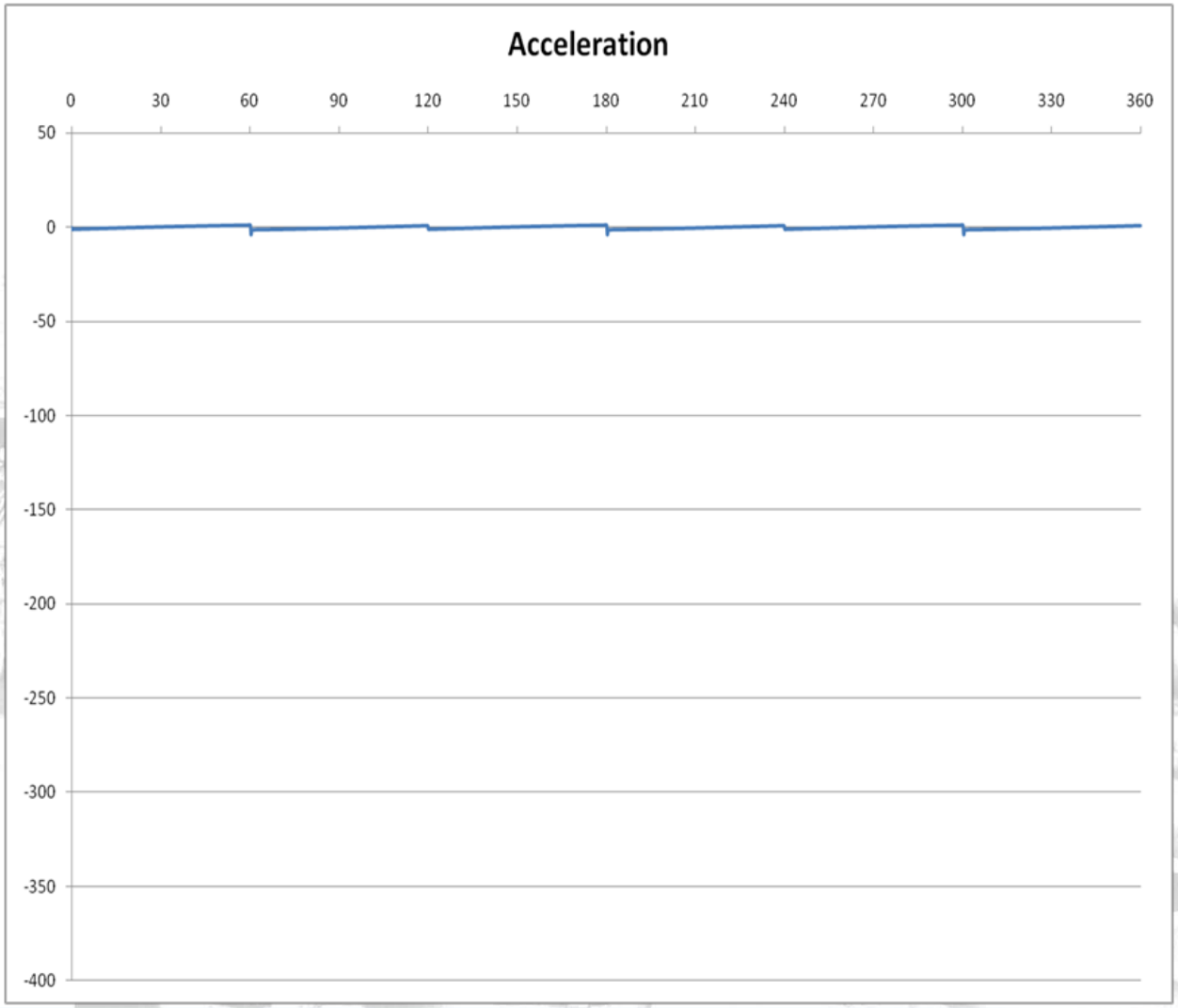
# Pump Chamber and Suction Piping Flow
# No Compression or Valve Seal Delay



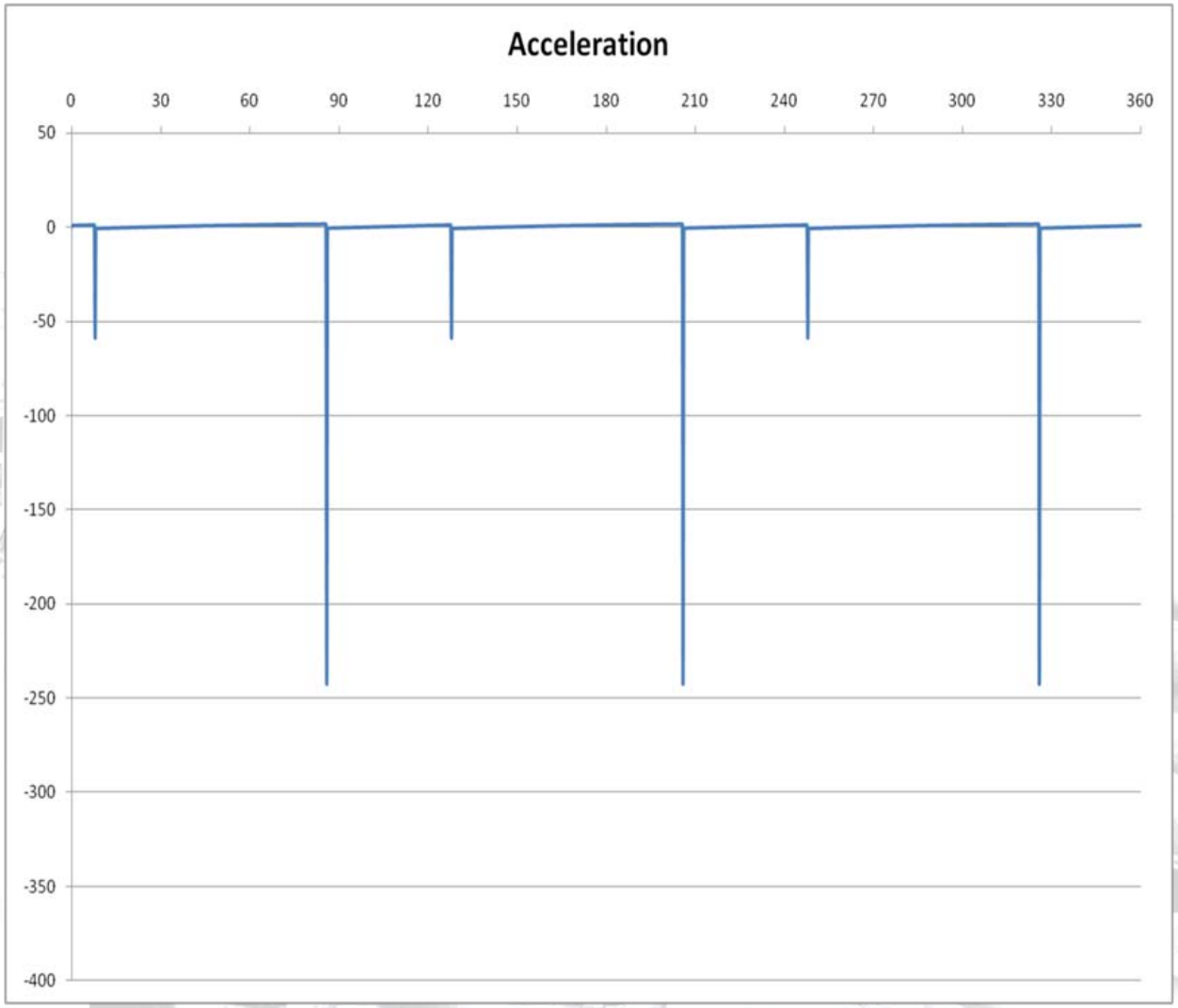
# Pump Chamber and Suction Piping Flow Water with 8 Degree Valve Seal Delay



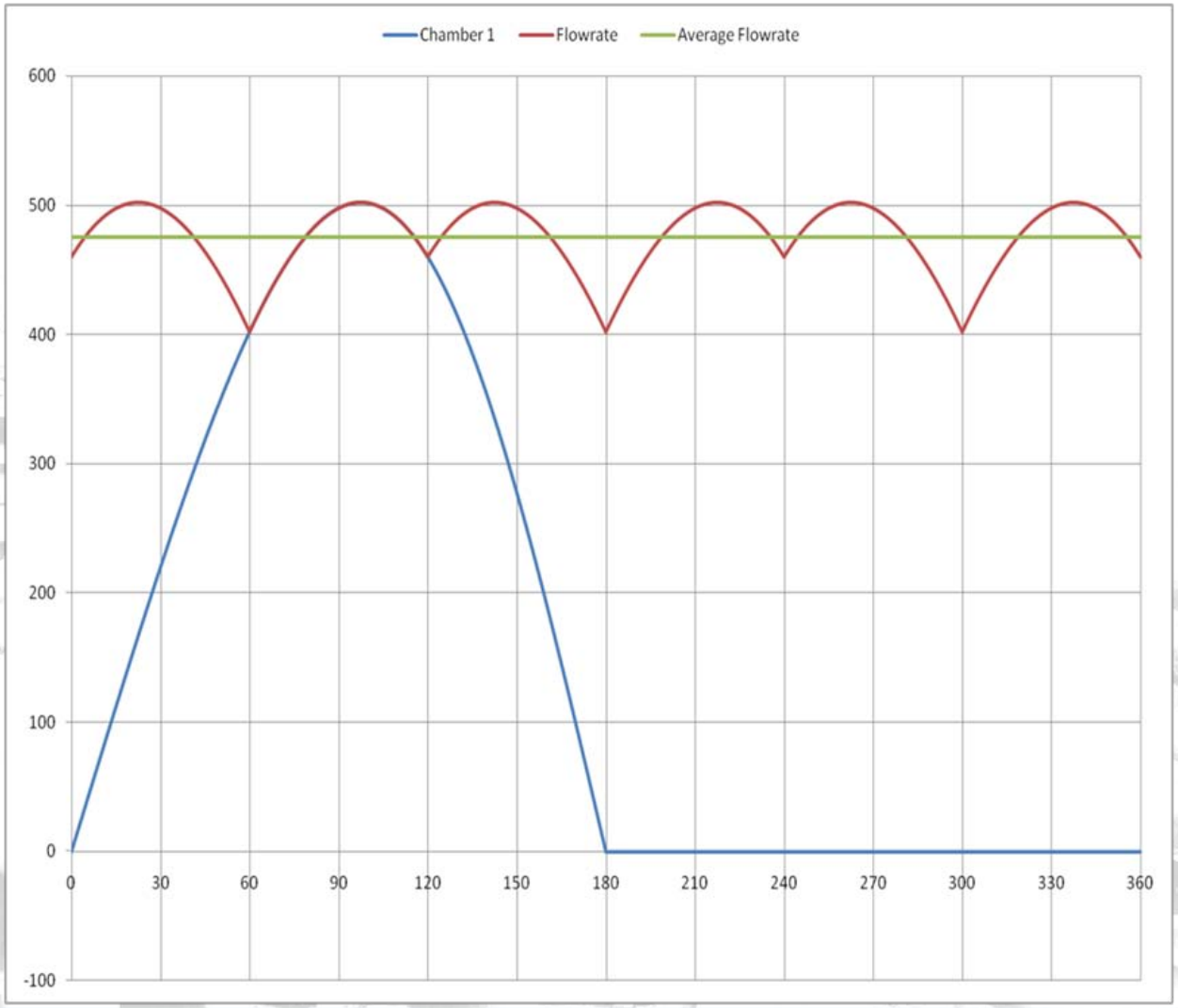
# Suction Piping Acceleration Pressure
## No Compression or Valve Seal Delay



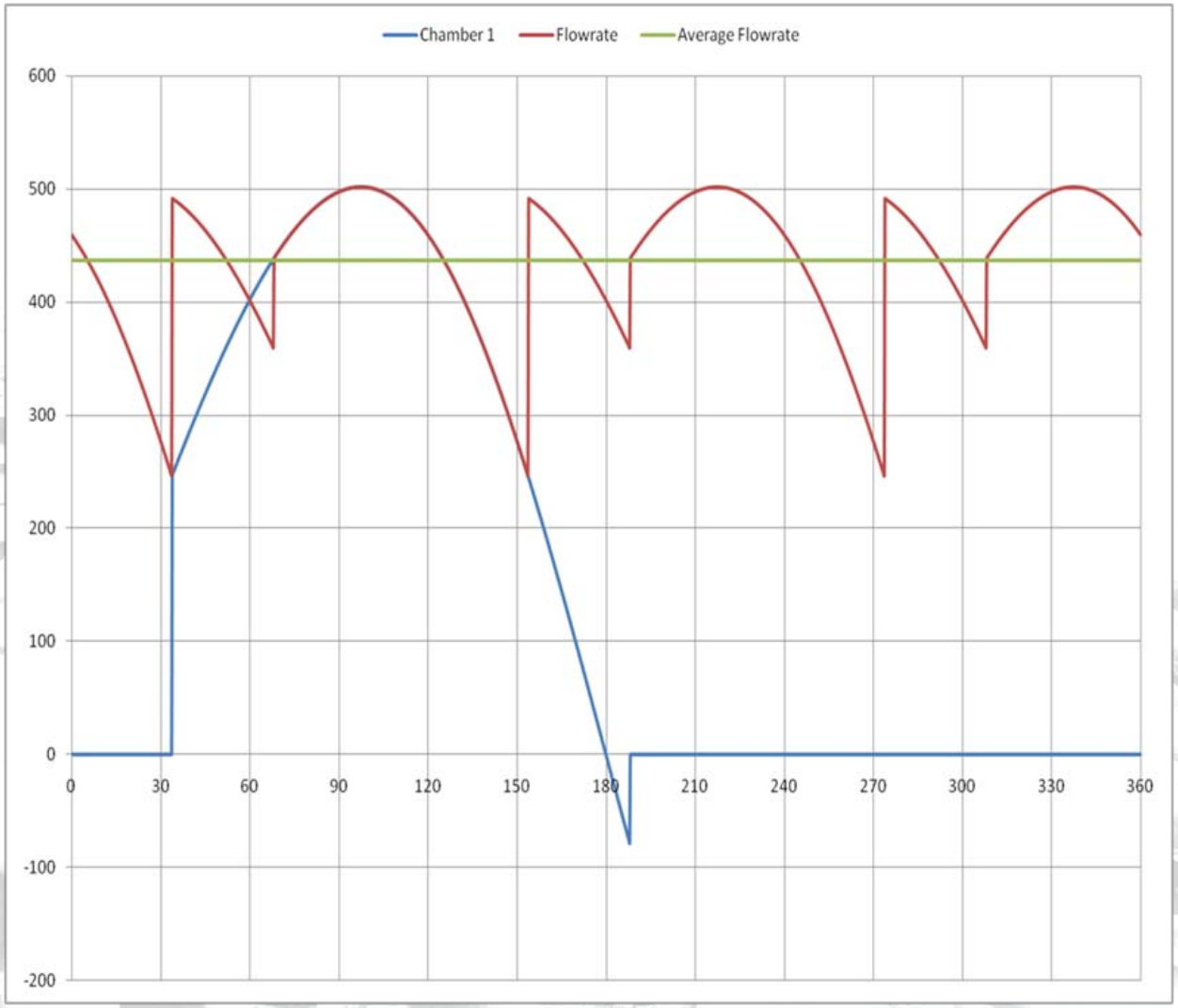
# Suction Piping Acceleration Pressure
# Water with 8 Degree Valve Seal Delay



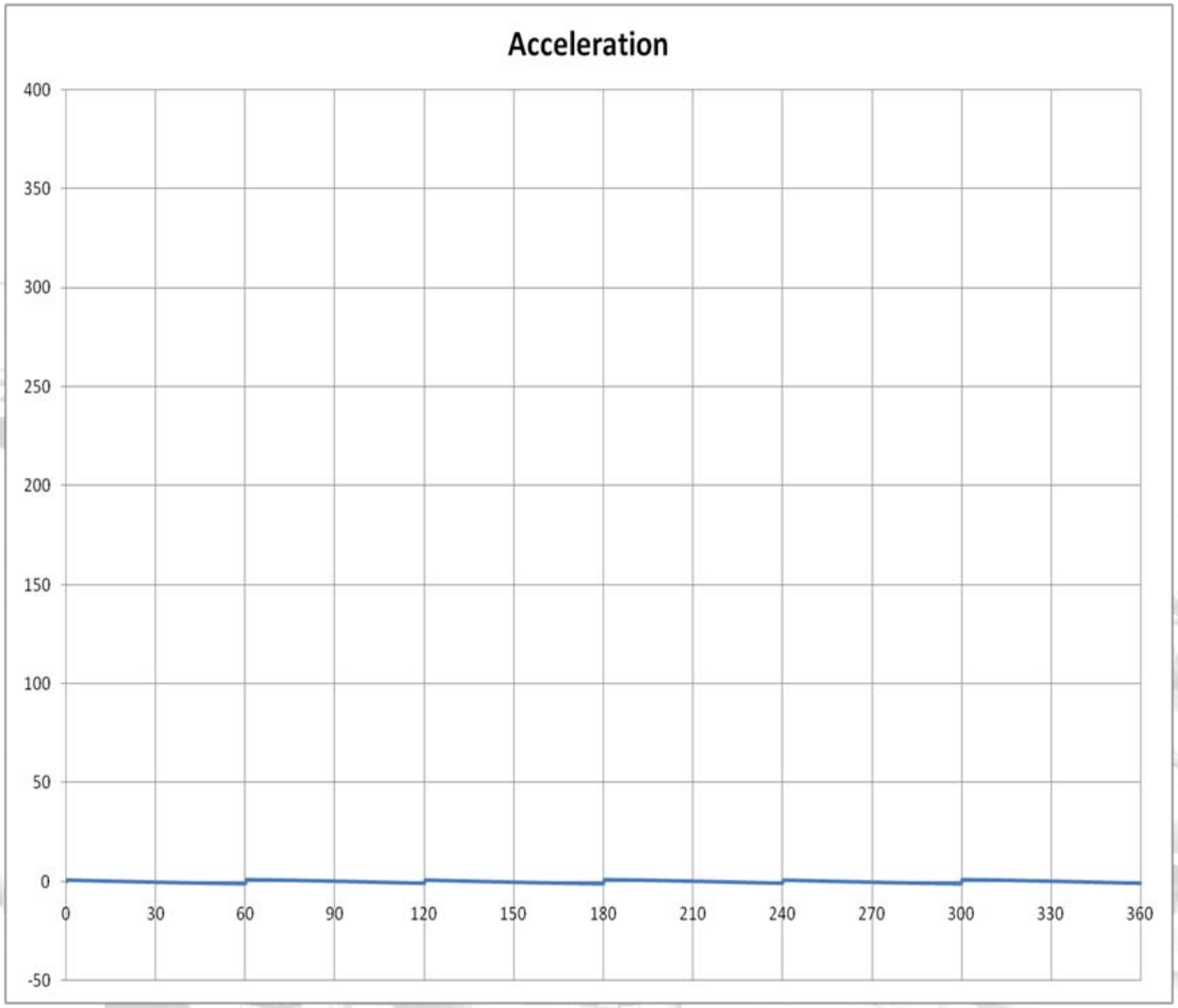
# Pump Chamber and Discharge Piping Flow
## No Compression or Valve Seal Delay



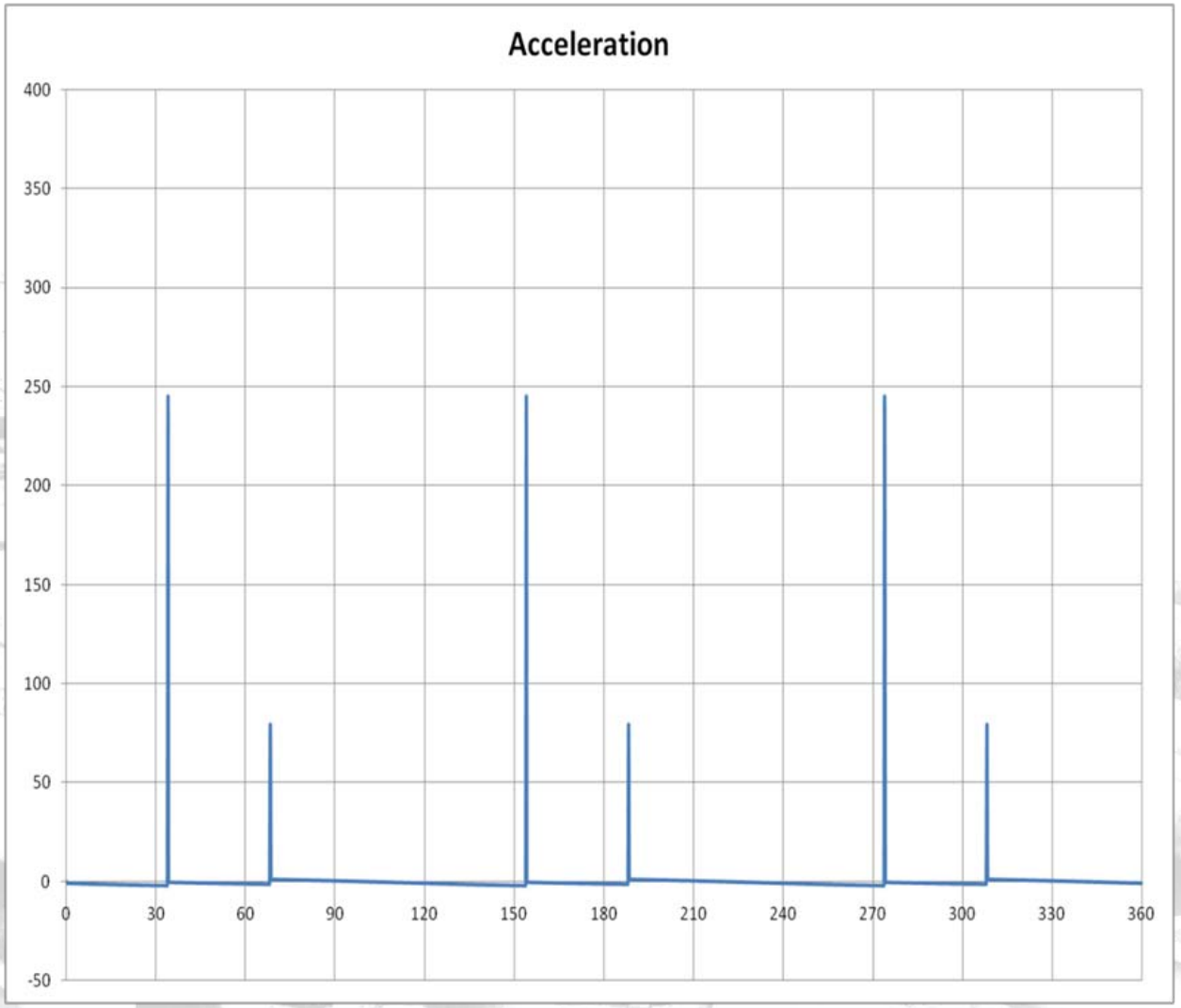
# Pump Chamber and Discharge Piping Flow Water with 8 Degree Valve Seal Delay



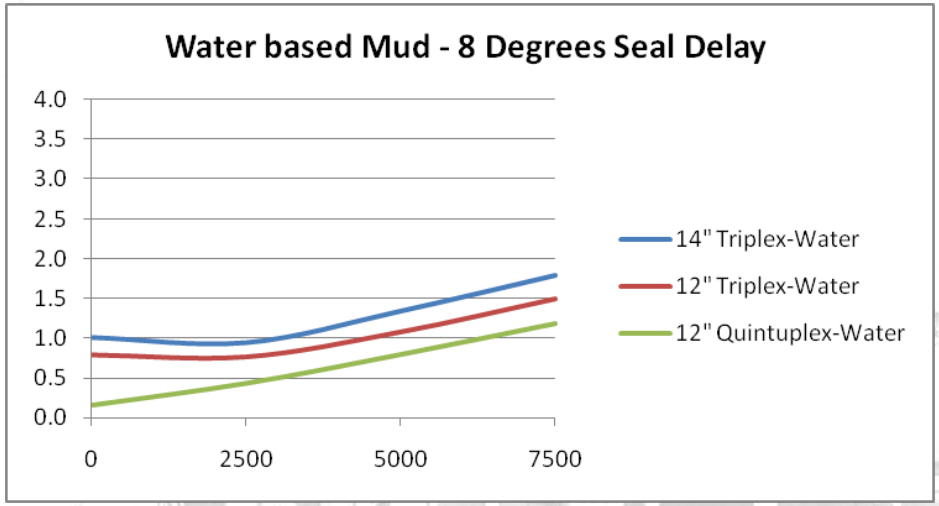
# Discharge Piping Acceleration Pressure
# No Compression or Valve Seal Delay

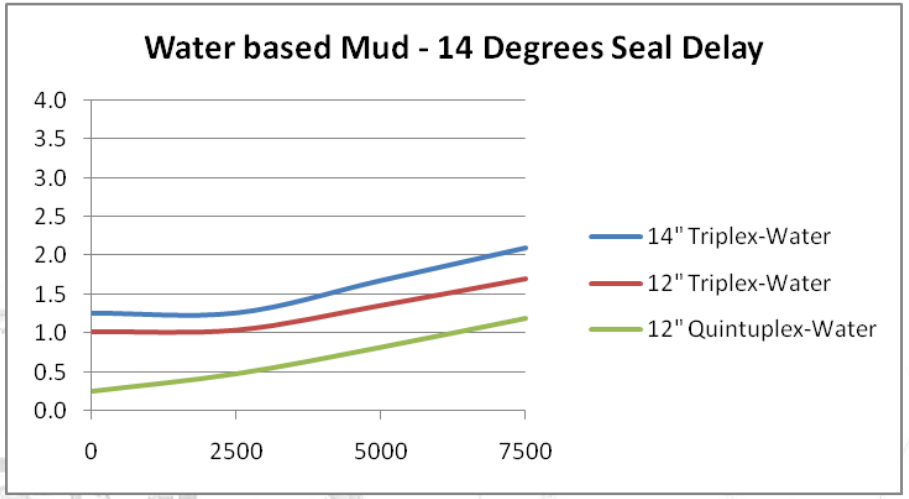


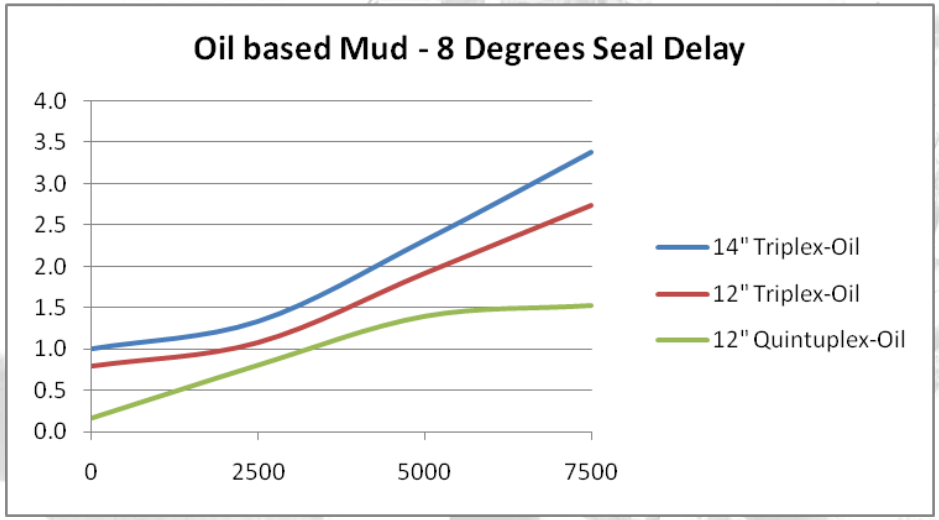
# Discharge Piping Acceleration Pressure Water with 8 Degree Valve Seal Delay

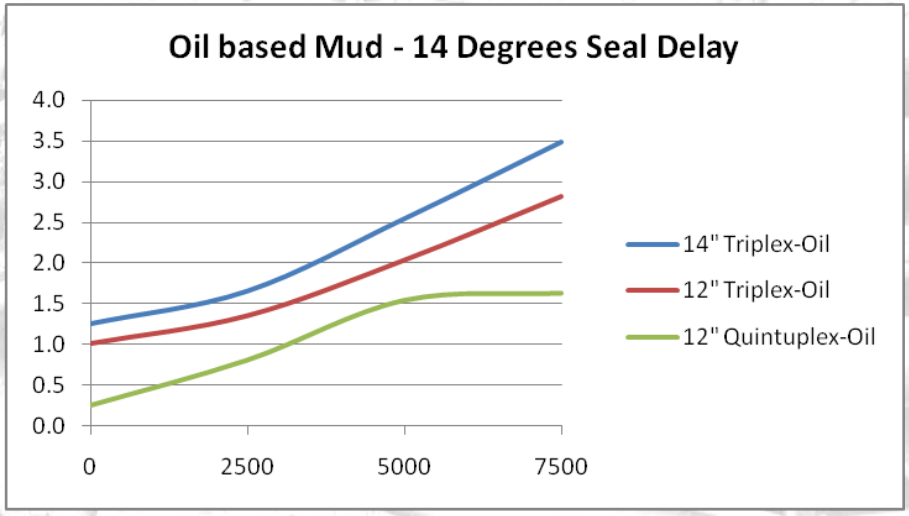


# Relative Delta Volume



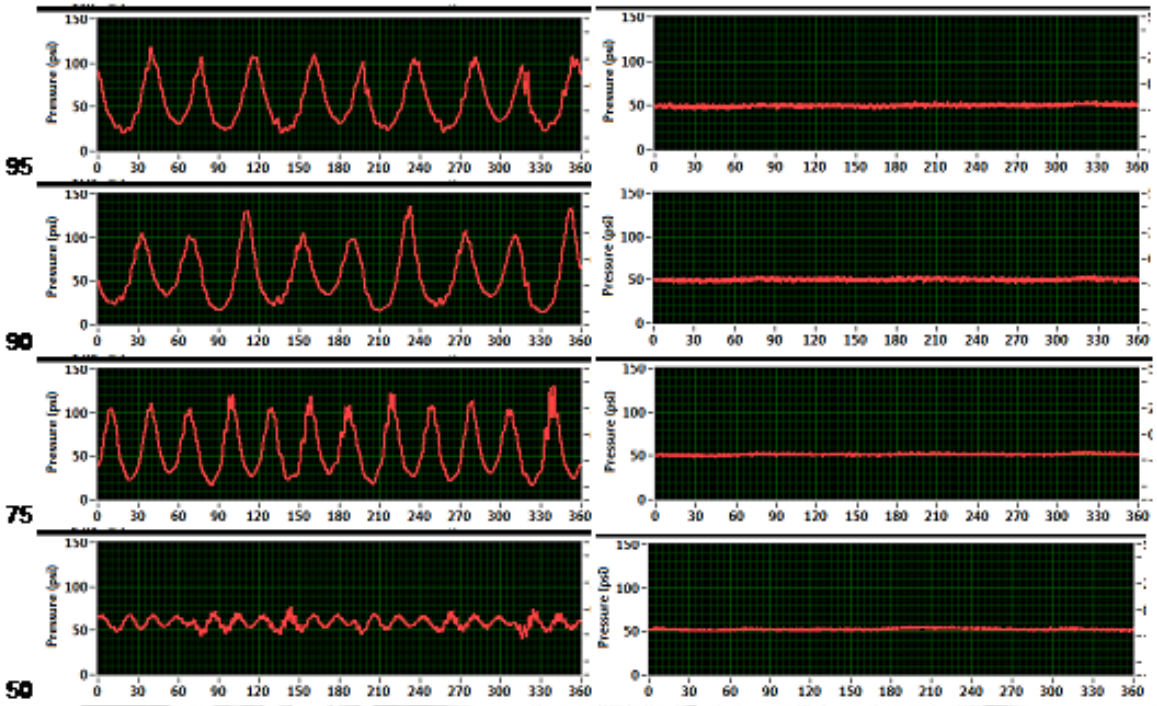



# Mud Pump Suction Manifold Pressure

Inline

Pump Suction Manifold



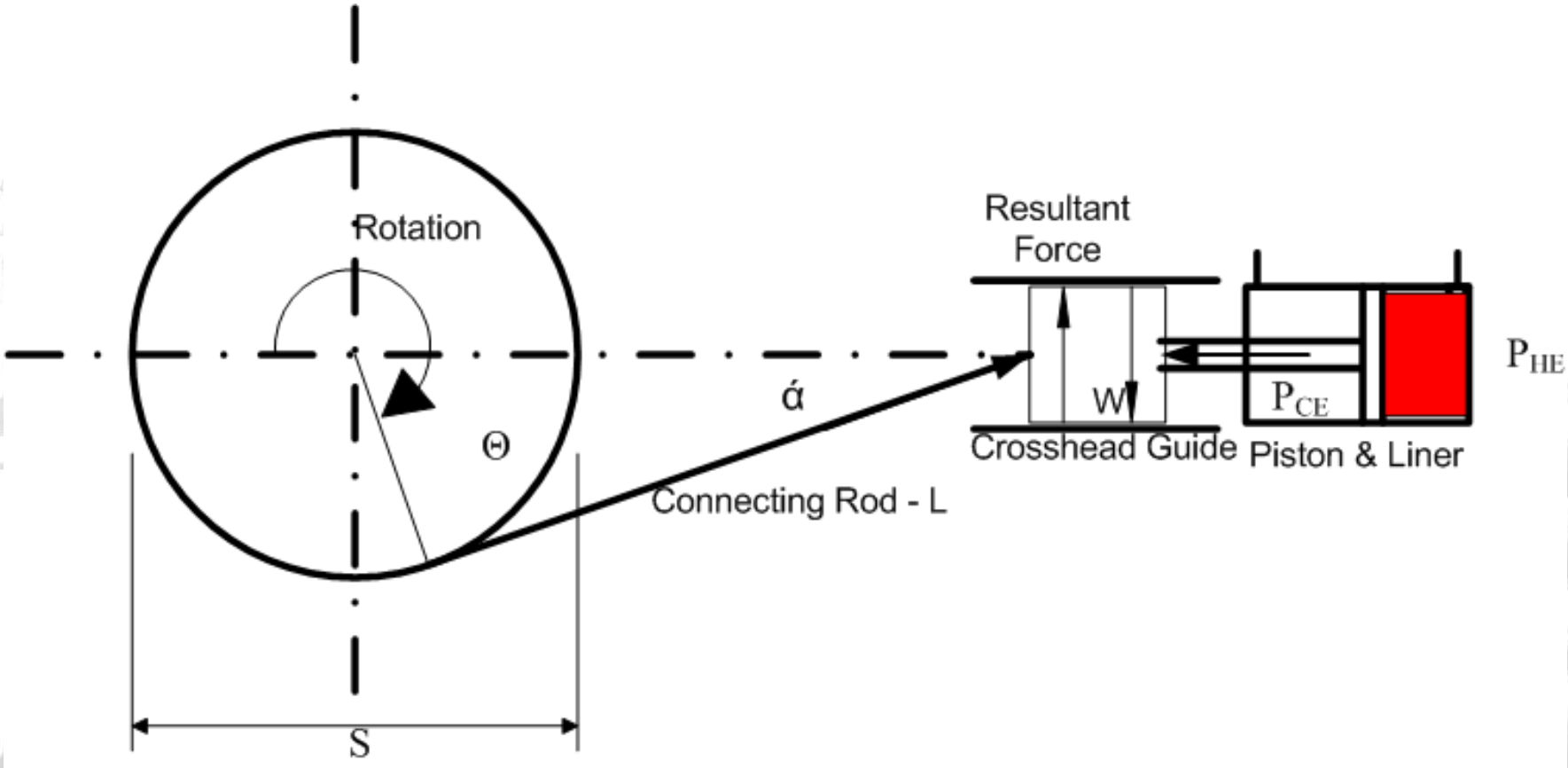
# Benefits of Manifold Suction Stabilizer

- Suction System Centrifugal Charge Pump selected to match Mud Pump Flow Rate because fluid flow variation and acceleration are eliminated.
- Use smaller suction piping to reduce potential for sanding out.
- Significant reduction in potential cavitation and crosshead shock.

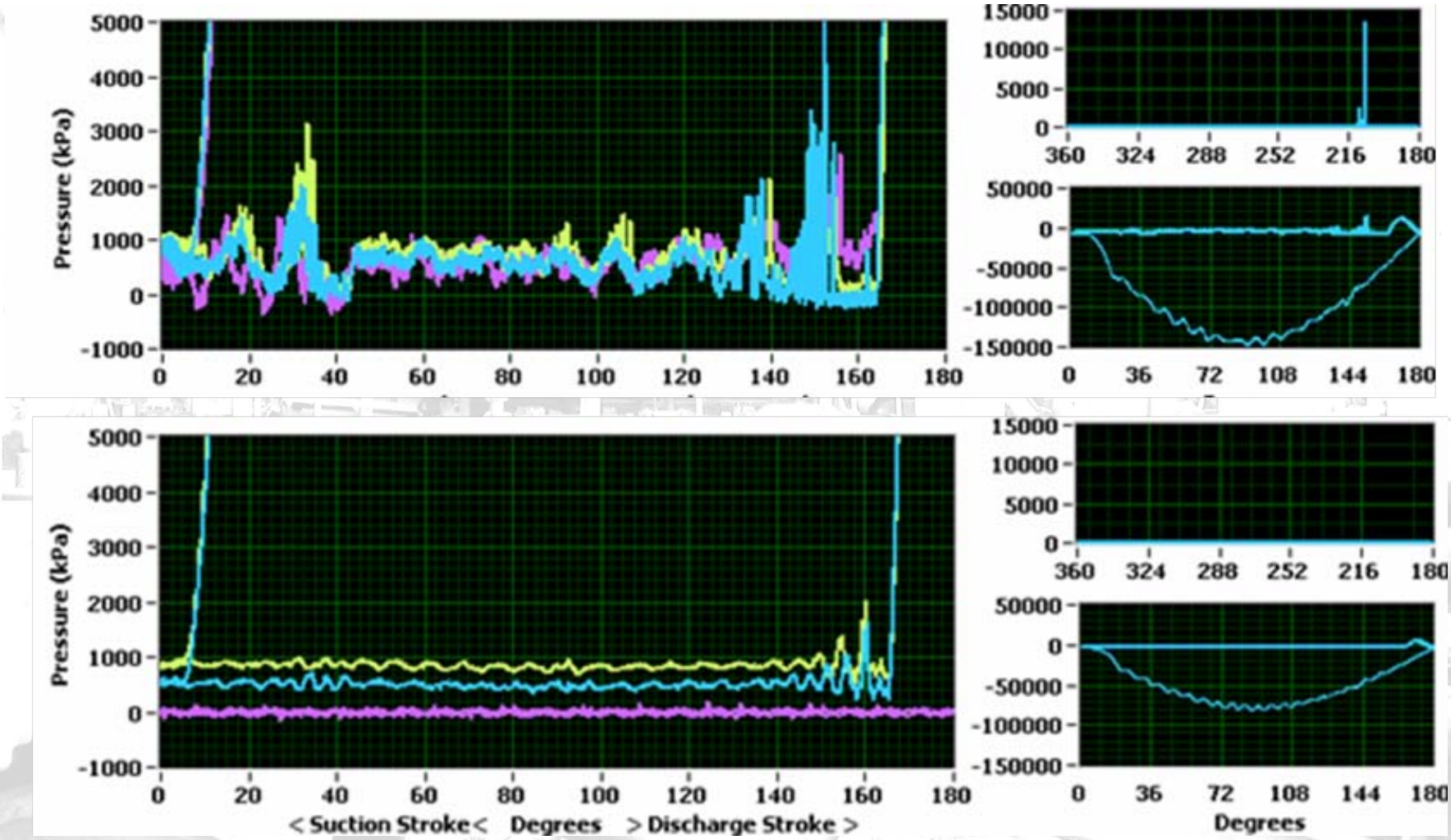
# Crosshead Lift and Potential Shock

- The Crosshead in a horizontal reciprocating pump lifts to the top crosshead guide at the beginning of the suction stroke when pumping at high pressure.
- If chamber filling is delayed because of acceleration head loss or cavitation, the crosshead will drop to the bottom crosshead guide.
- With delayed filling of the pump chamber the incoming fluid velocity will exceed the piston or plunger velocity resulting in a high surge pressure that causes the crosshead to lift instantaneously resulting in a mechanical shock to the power-end components.

# Crosshead Lift and Potential Shock



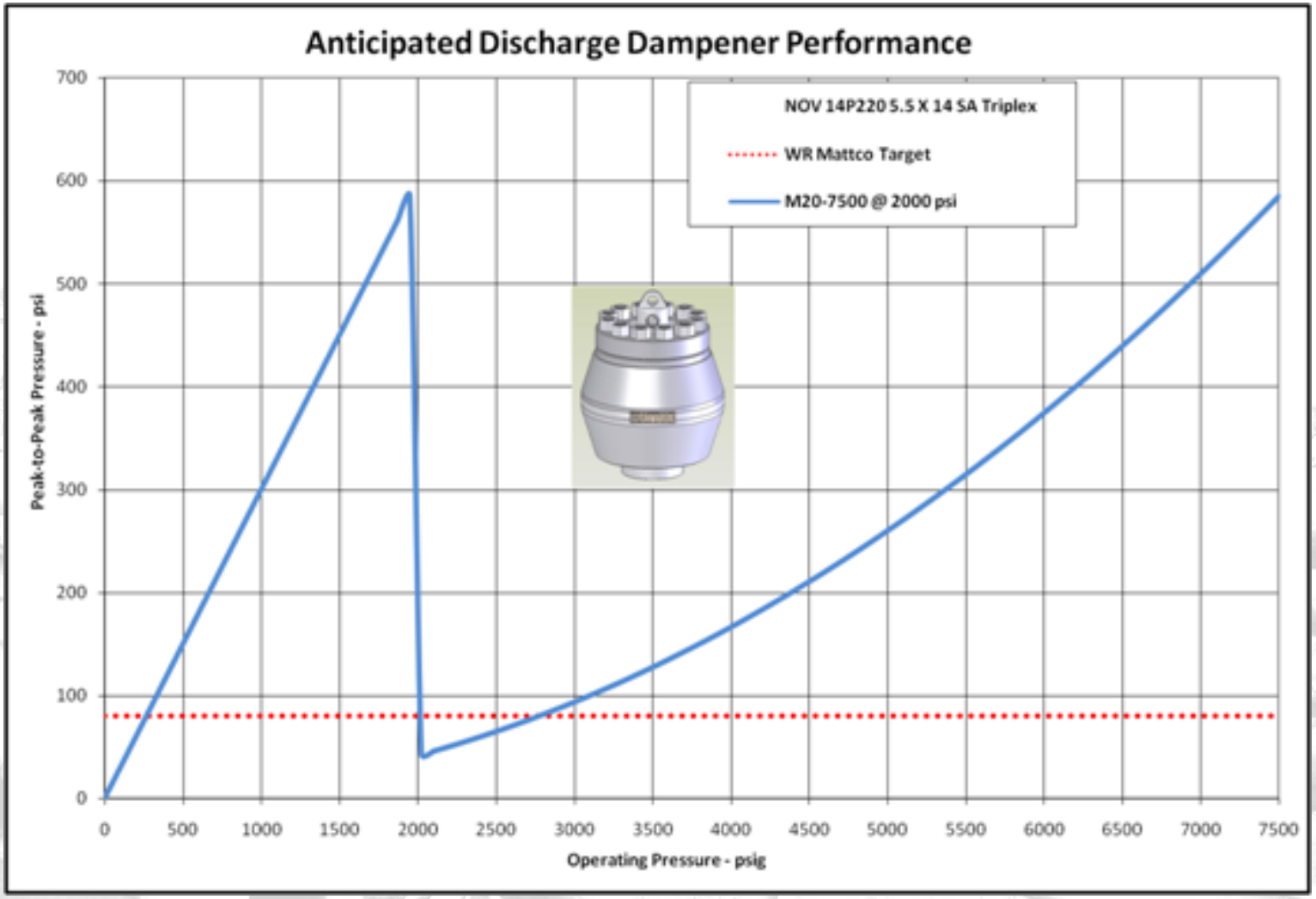
# Crosshead Lift and Potential Shock



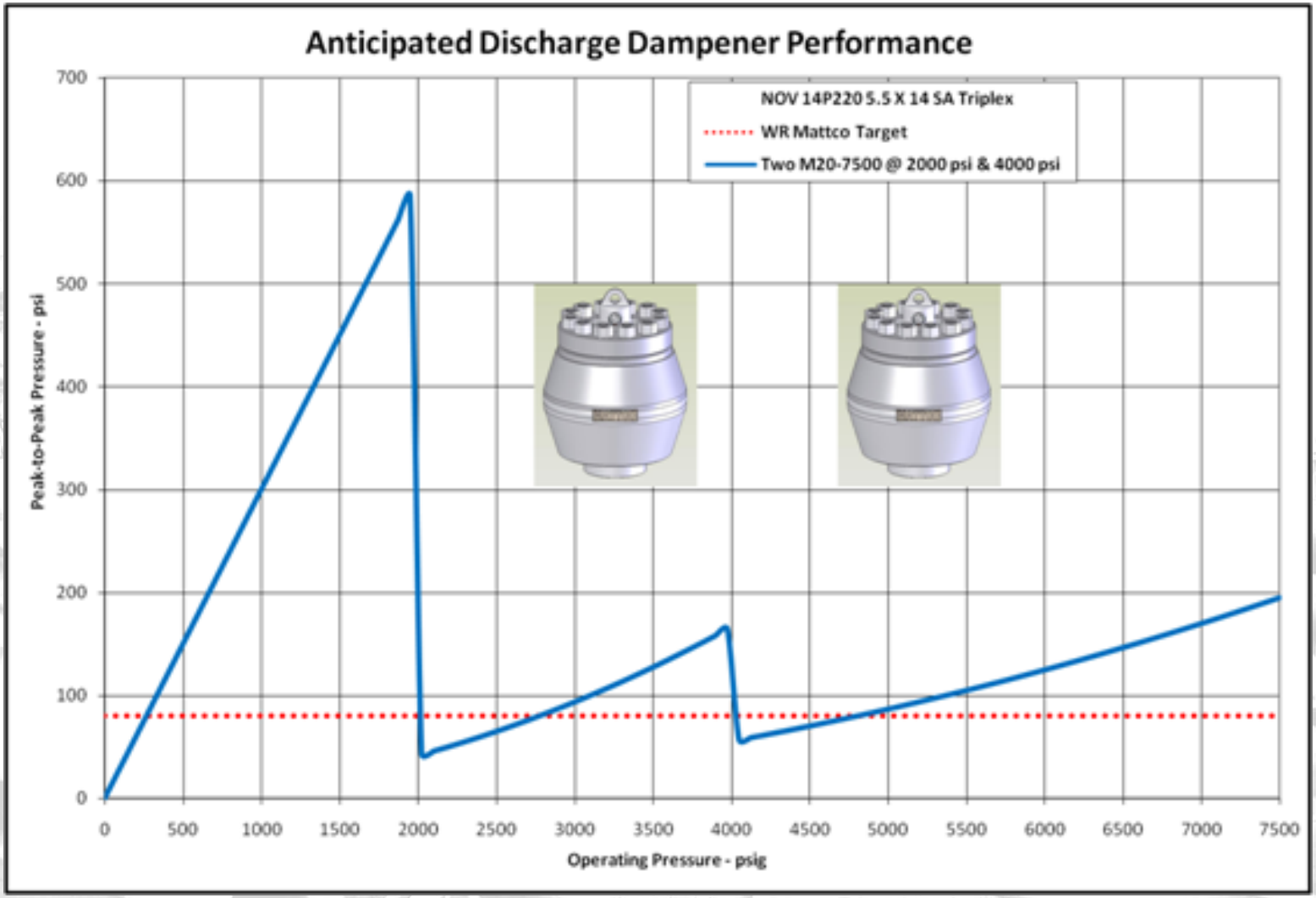
# Dampener Selection and Performance

- Single Pneumatic
- Dual Pneumatic
- Liquid
- Combination

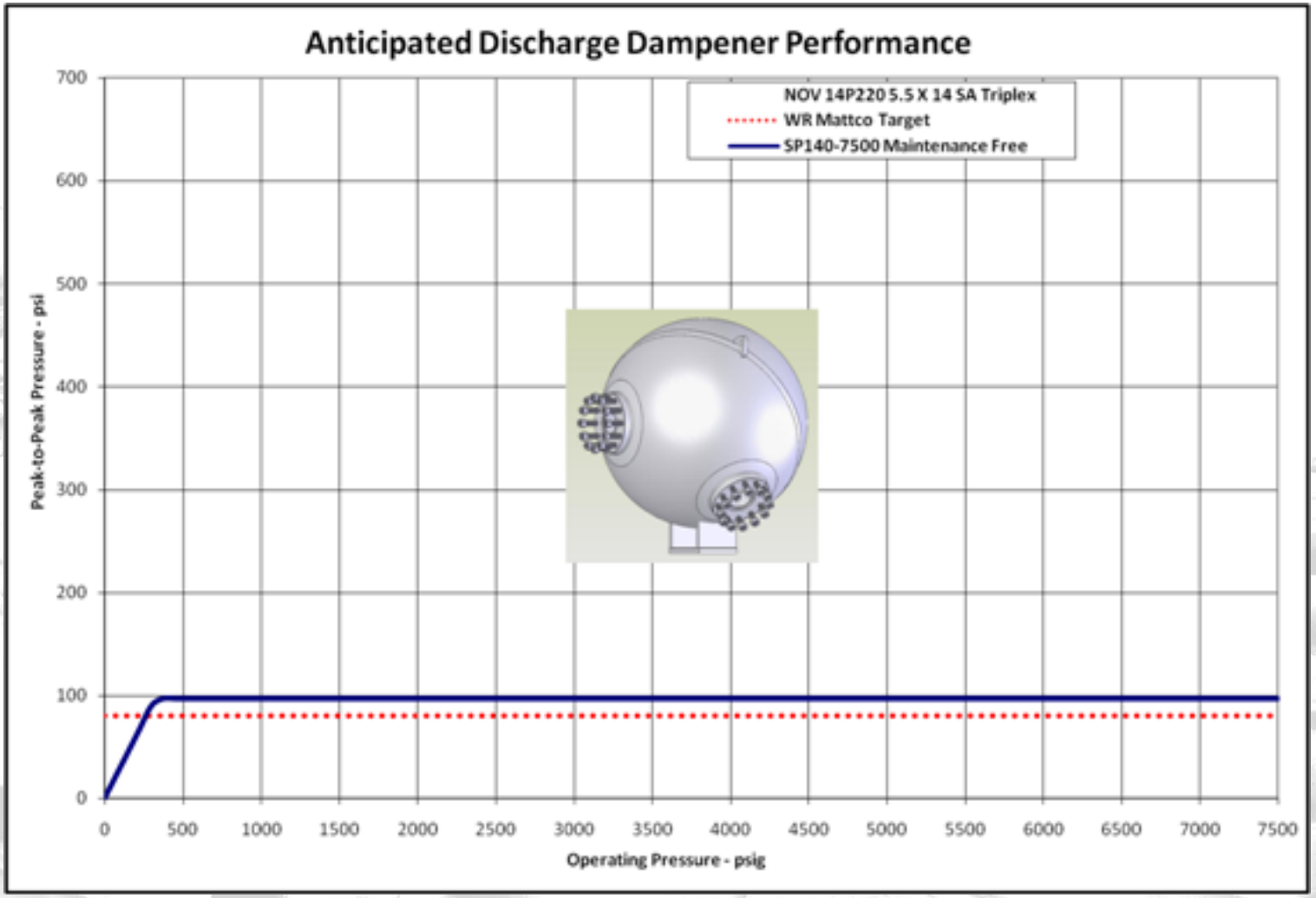
# 20 Gallon Pneumatic Dampener Performance



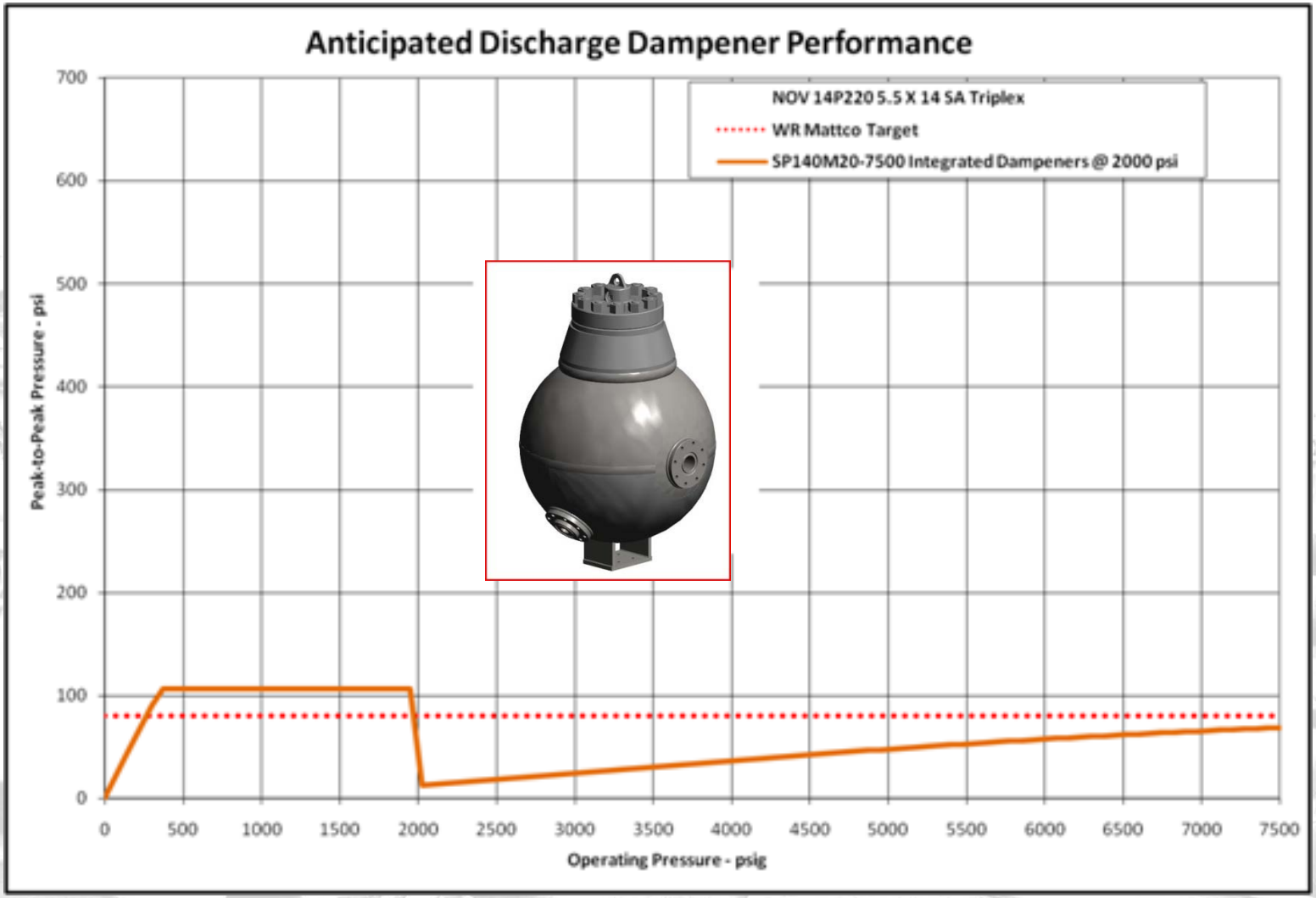
# Dual 20 Gallon Pneumatic Dampeners Performance



# 140 Gallon Liquid Dampener Performance



# Combination 140 Gallon Liquid 20 Gallon Pneumatic Dampener Performance



# Mud Pump Discharge Manifold Pressure