



# **Agitating Explosives in Extended Reach Wells – A Good Idea?**

---

**Jack Kolle, Tempres OSES**

**Kerry Daly, Expro Group**

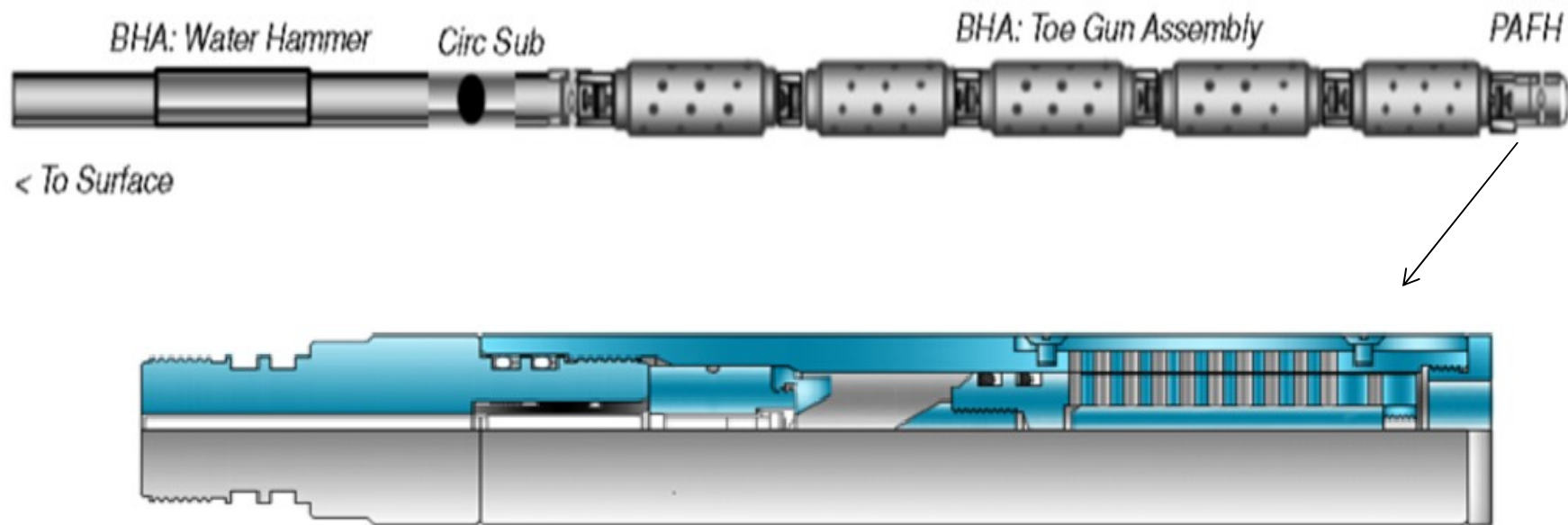
# Introduction

---

- ◆ Tubing conveyed perforating guns (TCP)
  - Toe valve fails to provide circulation
  - Wireline conveyance is unreliable
- ◆ Evaluation of water hammer TCP conveyance
  - Bench testing of axial vibration levels
  - Pressure pulse and vibration fatigue analysis
  - Successful case history
- ◆ One-trip clean & perf system

# TCP Gun Configuration

- ◆ Actuated by casing annulus pressure



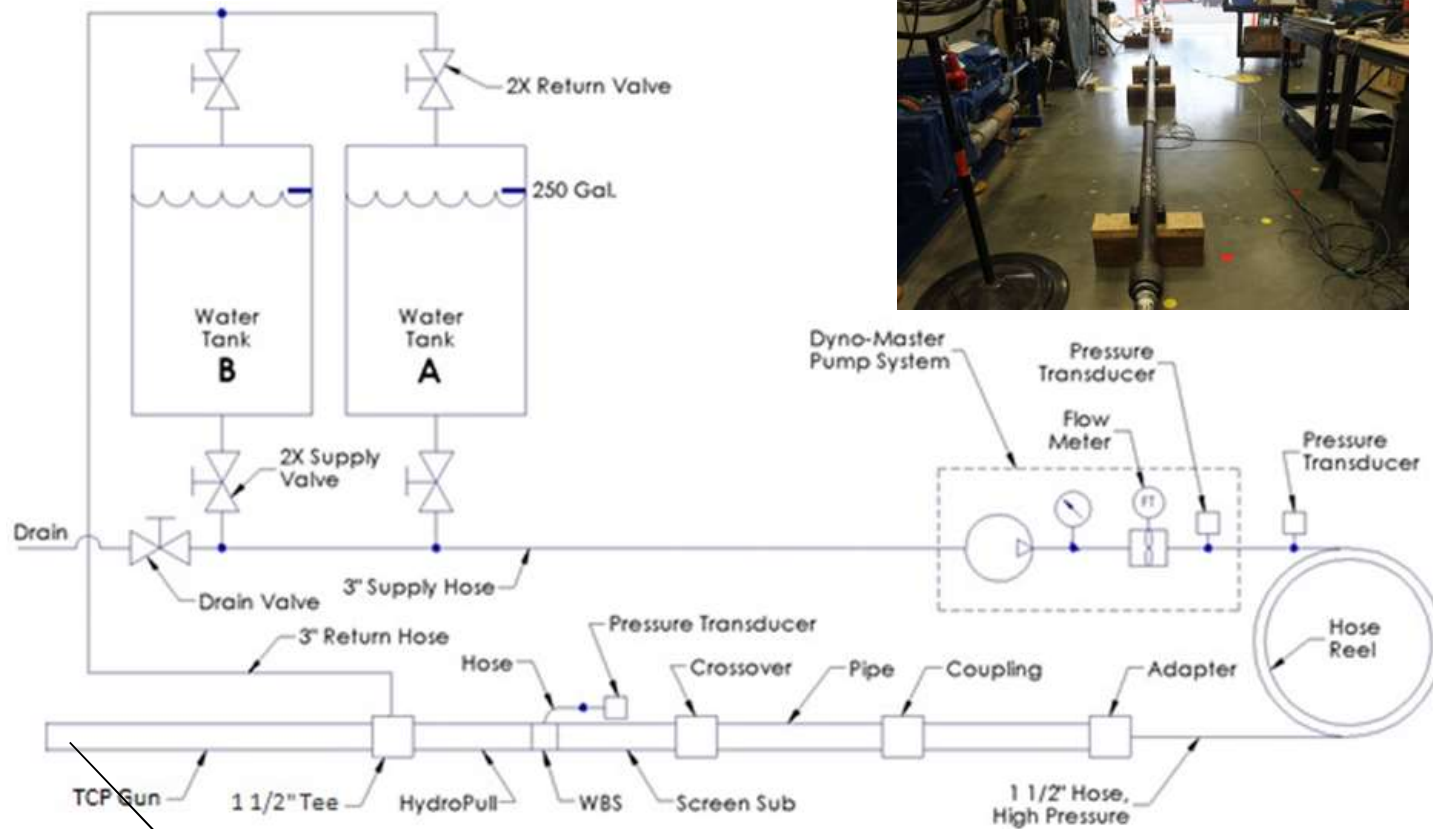
Pressure Actuated Firing Head

# Concerns

---

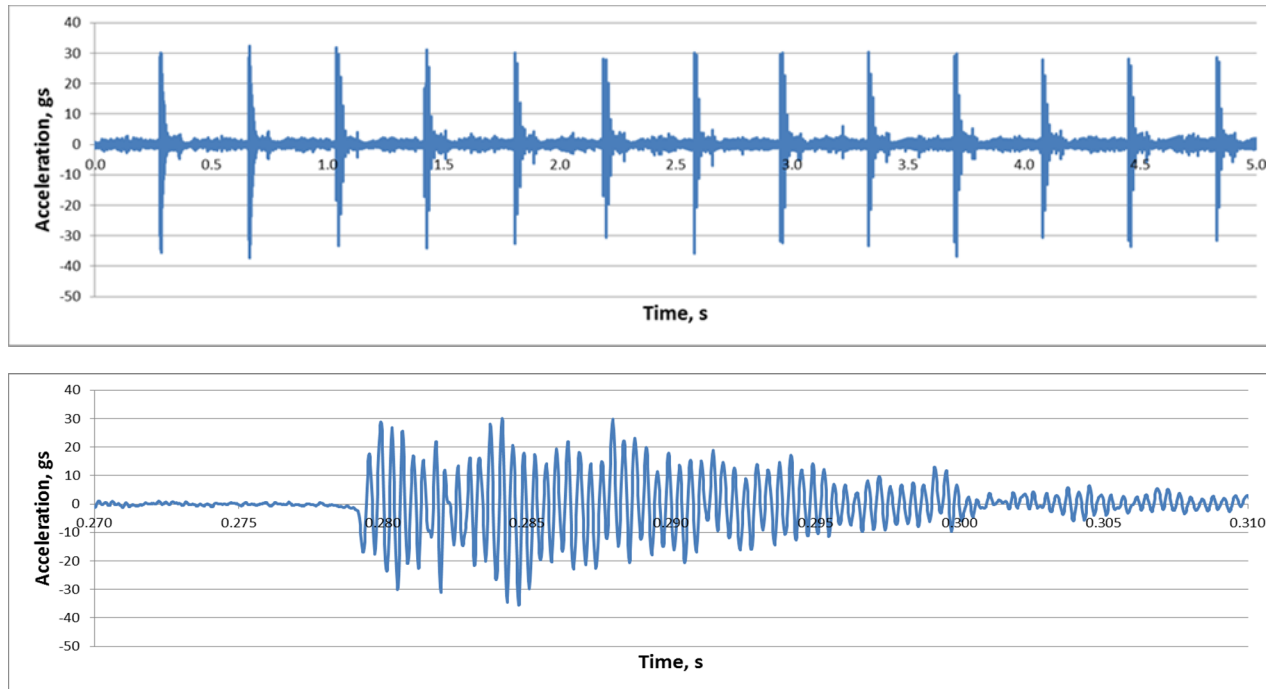
- ◆ Premature actuation of the PAFH
  - Annulus pressure cycles
  - Axial vibration
- ◆ Damage to the gun carrier, detonating cord or shaped charges
  - Axial vibration

# Bench Testing



PAFH and Accelerometer

# Axial Acceleration on PAFH Piston



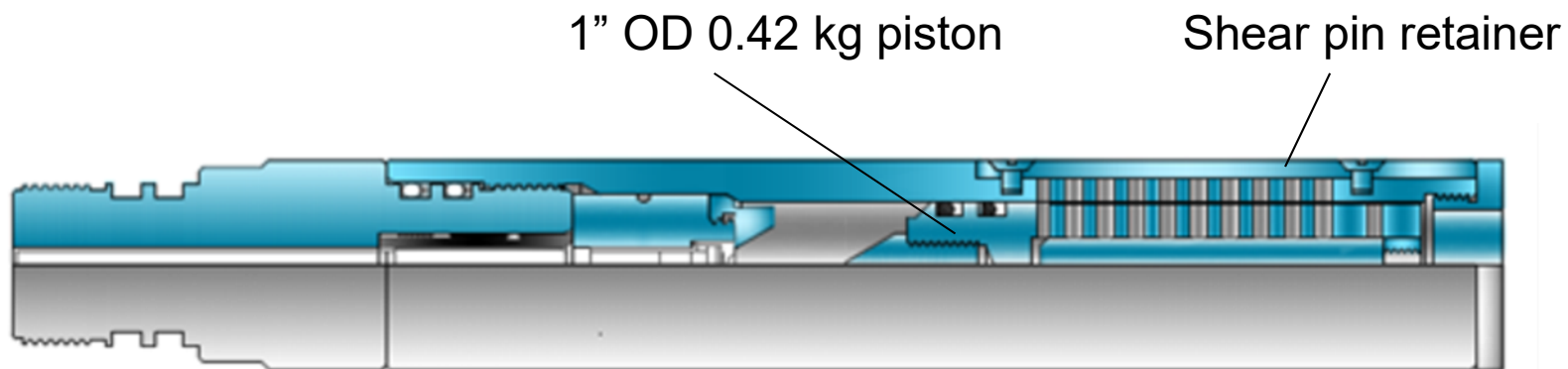
$$\pm 32g \times 0.42kg \text{ piston} = \pm 132N$$

Equivalent to  $\pm 40$  psi on 1" piston

# Fatigue Analysis

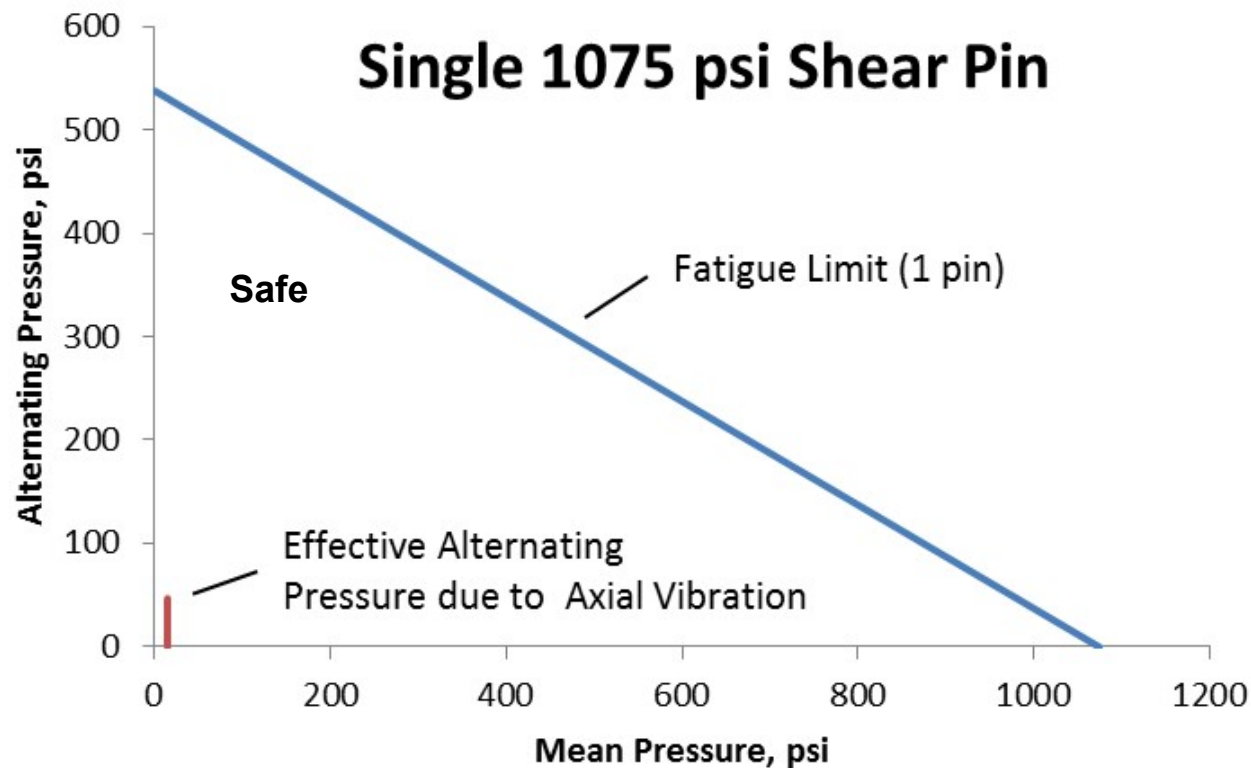
---

- ◆ Evaluate high-cycle fatigue of shear pins
  - Annular pressure fluctuations from water-hammer calculation
  - + Acceleration force over piston section area



# Bench Test Fatigue Diagram

$$P_a = \frac{P_{max} - P_{min}}{2}$$



$$P_m = \frac{P_{max} + P_{min}}{2}$$

Assumes fatigue limit is  $\frac{1}{2}$  ultimate strength



# 11 hr Test: 100,000 Load Cycles

---

Dummy charges and detonating cord



Before



After

No damage to charges, carrier or detonating cord

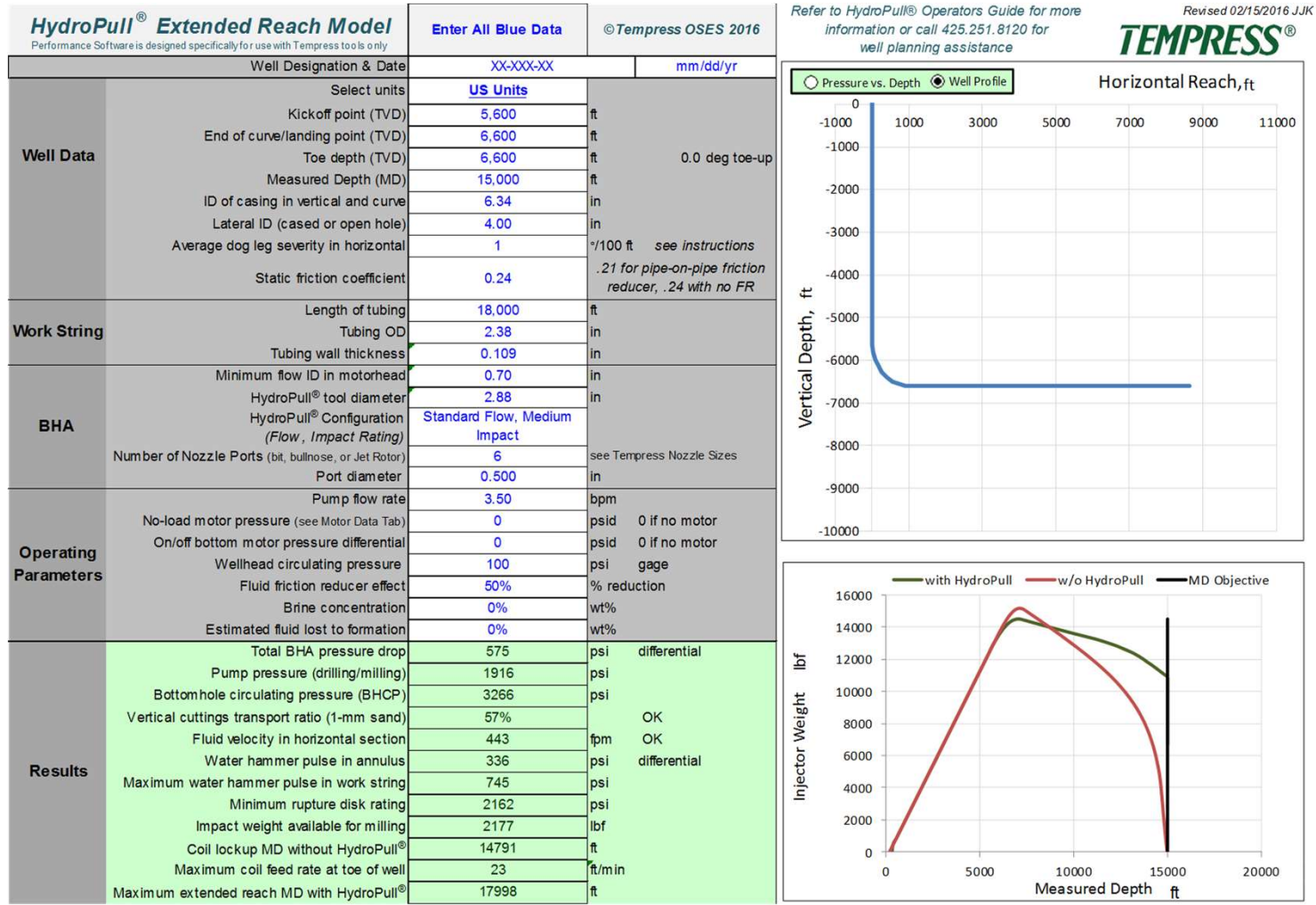


New

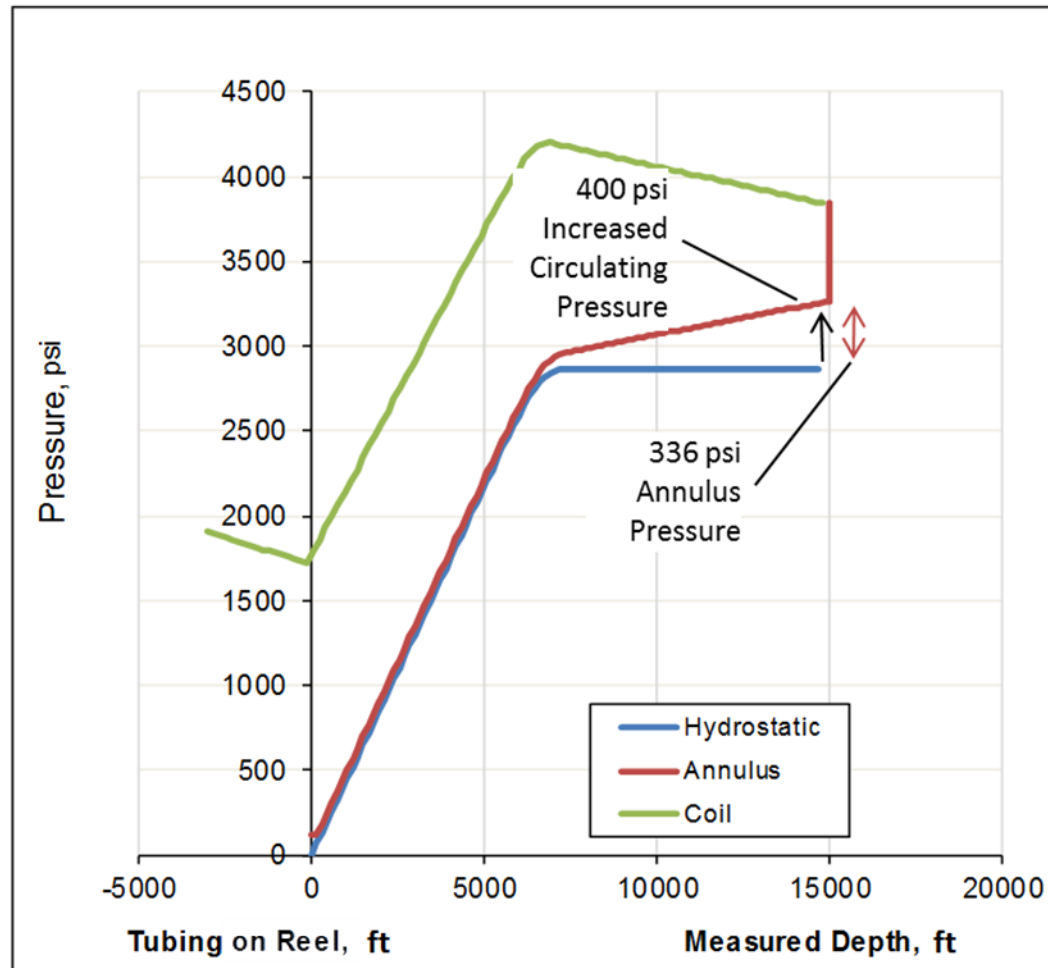
After

No damage to shear pin  
Pin tested as new

# Case History Modeling

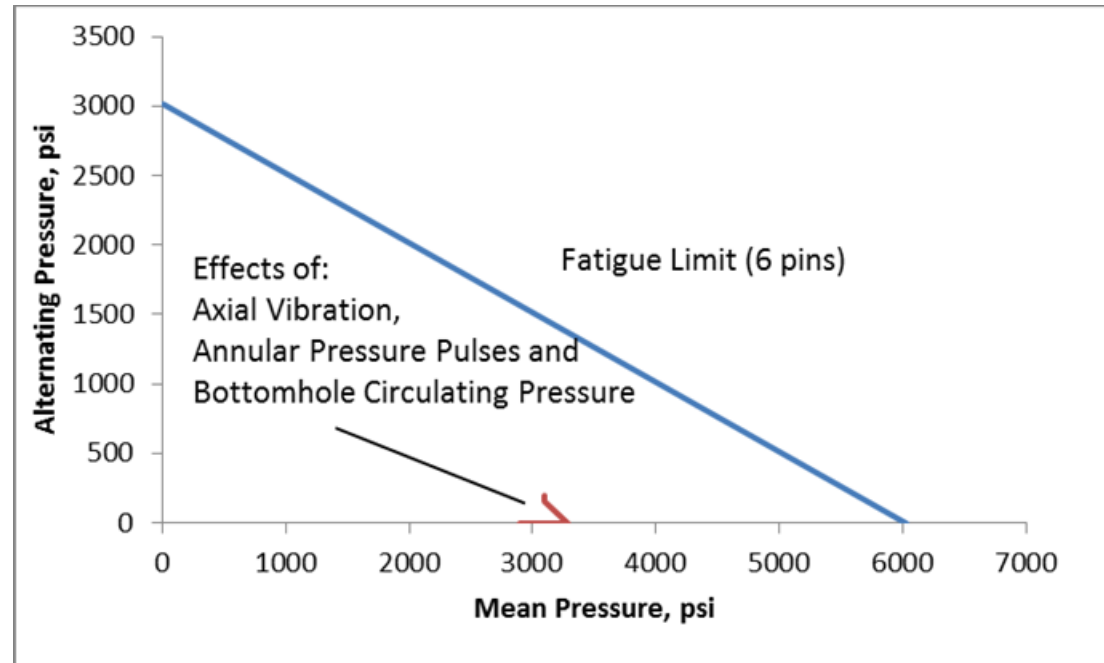


# Circulating Pressure Analysis



# Downhole Fatigue Analysis

$$P_a = \frac{P_{max} - P_{min}}{2}$$



$$P_m = \frac{P_{max} + P_{min}}{2}$$

- ◆ Pressures are well within the fatigue limit
- ◆ Pins will not fatigue

# Field Trial Success

---

- ◆ **VD of 6600-ft, MD of 15000-ft, PAFH loaded with 6 pins:**
- ◆ **Actuating Pressure= 6036 psi, Surface Applied Pressure= 3148 psi**

RU and RIH with water hammer above Gun BHA

@6600-ft, up to 1.5 bpm @ 800-1100 psi circ pressure

@8900-ft, up to 2.5 bpm @1500-1800 psi circ pressure

@10,200-ft, up to 3.5 bpm @2300-2650 psi circ pressure

Slowed rate to 3.25 bpm @2100-2400 psi circ pressure

@14,989, can't go any further.

Take up slack, prepare to shoot.

Shut in well and pressure up.

Toe gun fired at 3120 psi> good indication. Moved BHA

Delay 1 fired at 5.54 min> good indication. Moved BHA

Delay 2 fired at ?> no indication. Moved BHA @ 6.5 min

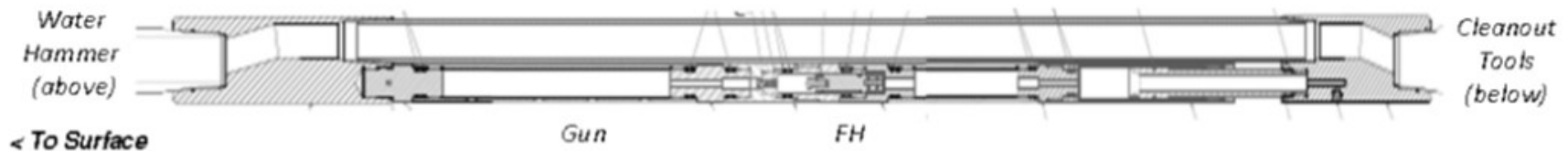
Delay 3 fired at ???> no indication. Moved BHA at 6.5 min

Delay 4 fired at 5.03 min> good indication

Waited 10 min, POOH

OOH with BHA> all shots fired

# One-Trip Clean & Perf Tool



- ◆ Combines the toe-prep run with the first TCP run
- ◆ Ensures circulation for subsequent wireline gun runs

# Summary

---

- ◆ It is possible to safely run a TCP gun on coil with a water hammer tool
- ◆ Circulating pressures can be modeled to ensure the firing head will not actuate prematurely
- ◆ A one-trip Clean & Perf deployment tool is coming