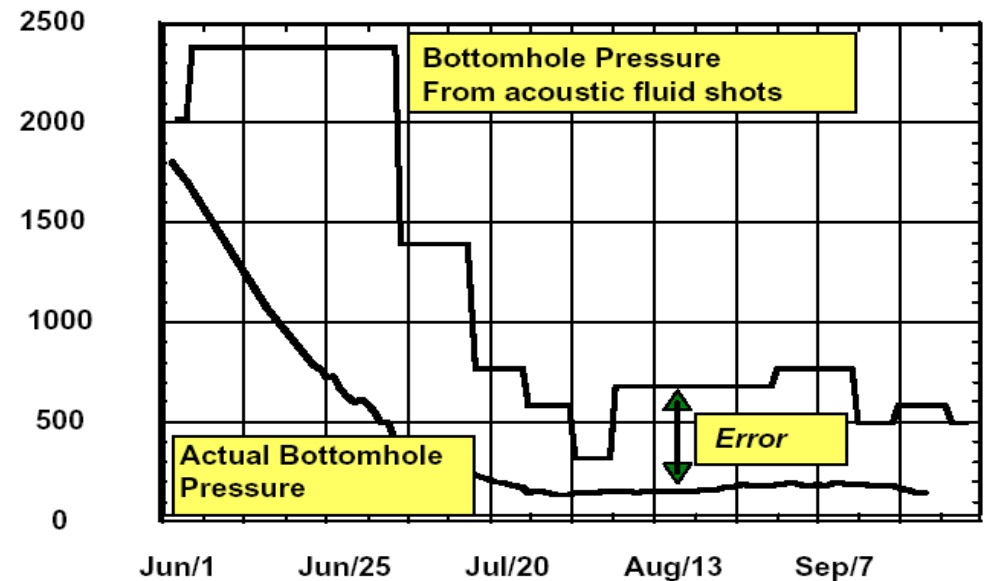


# Monitoring and Analysis Using Pressure

Gordon Kappelhoff

# The “Traditional” Way.....

- Fluid Shots to determine fluid level and calculate bottom hole pressures
- ESP under-load and over-load settings
- Shut down production for Static logs
- Basic down hole pressure readings

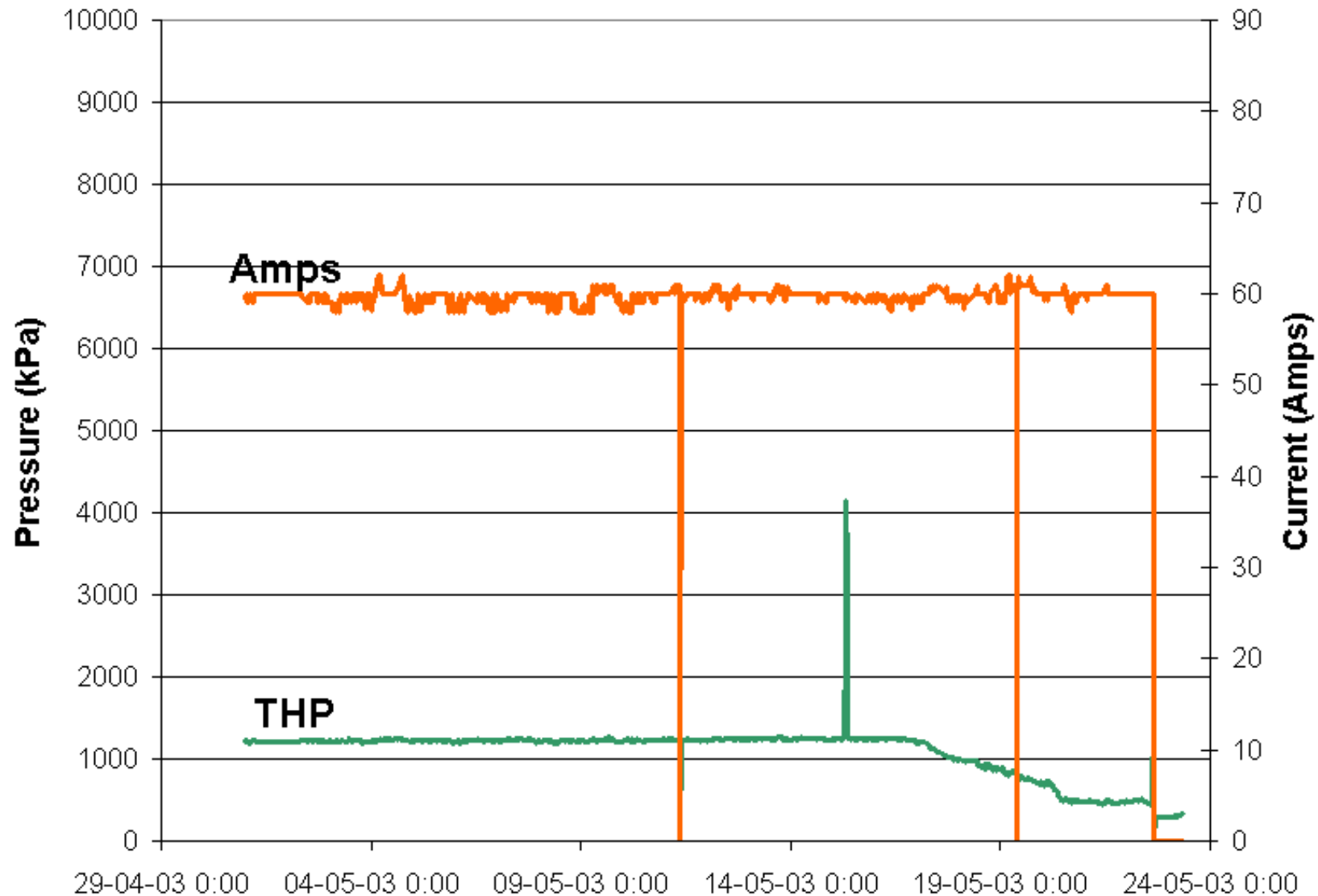


When we think of monitoring ESP's, we often talk about overload or underload – what are we really talking about?

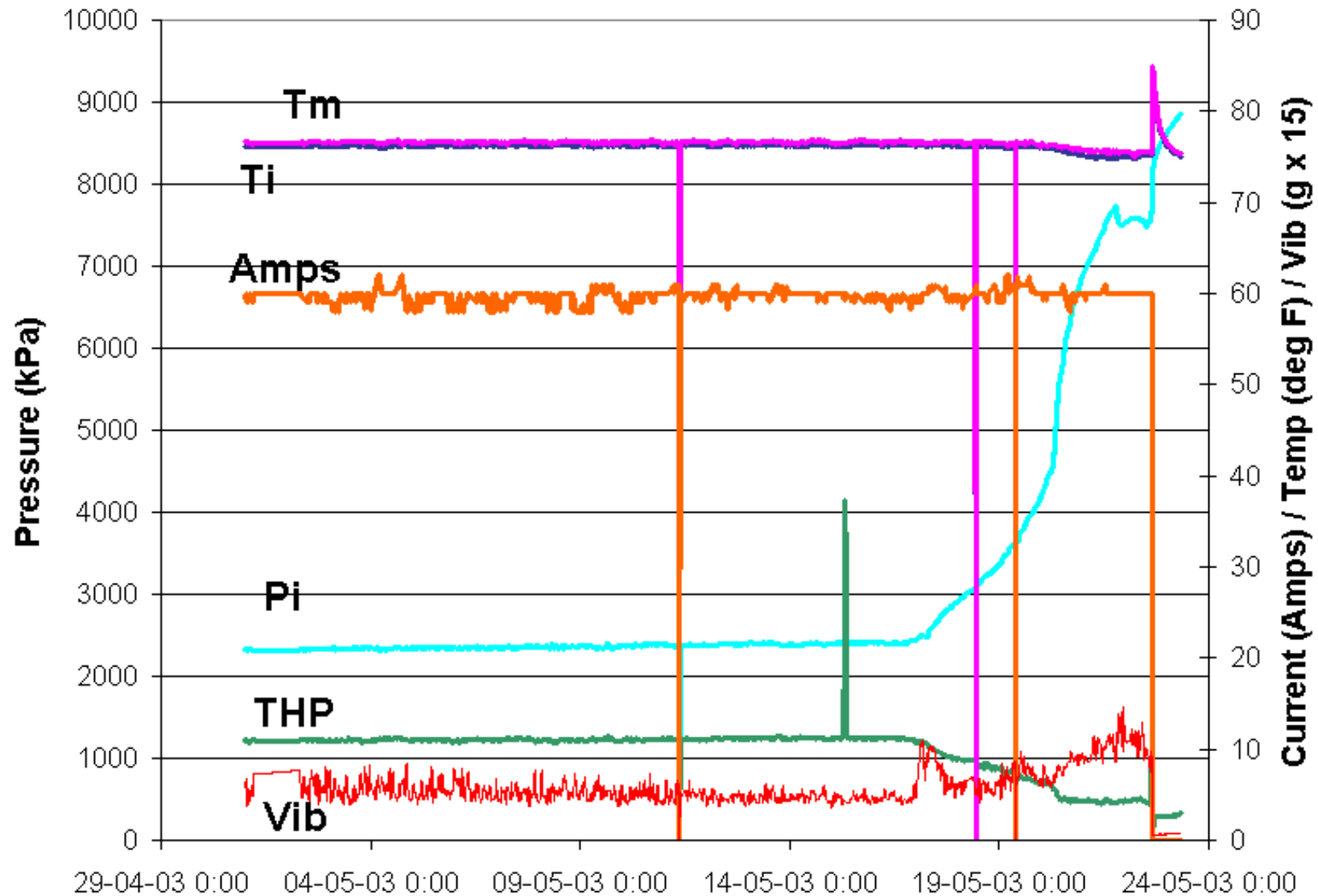
Sensitive	Insensitive
Broken shaft	Watercut
Stuck Pump	Flowrate
Gas	Pump performance
Shut in (zero flow)	THP
Voltage change	Reservoir Pressure & Productivity Index

# Amps insensitive.....

- Amps constant and THP dropping...what's happening?

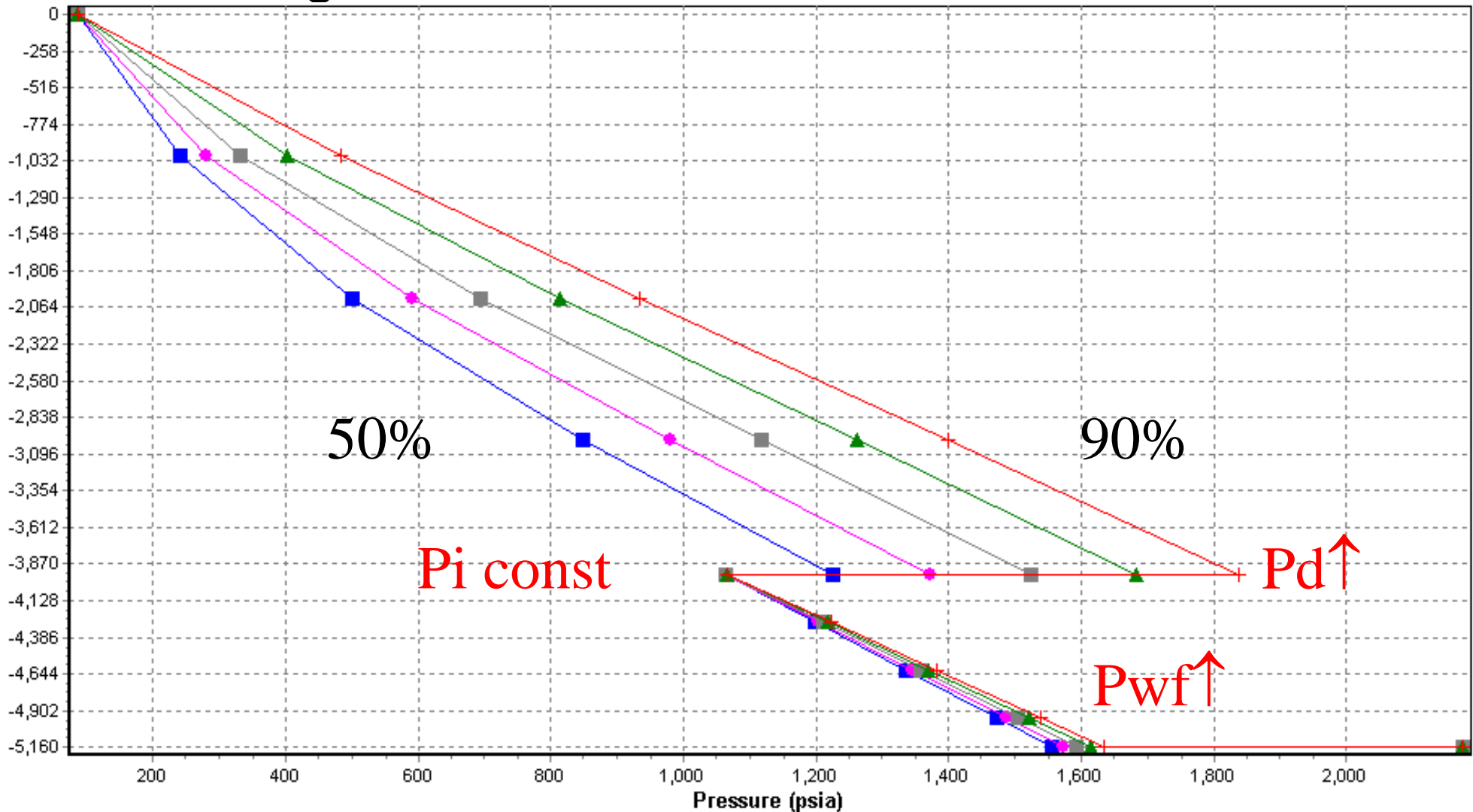


# Pressure shows more.....now what is happening?



# Two pressures even better.....

- Increasing watercut

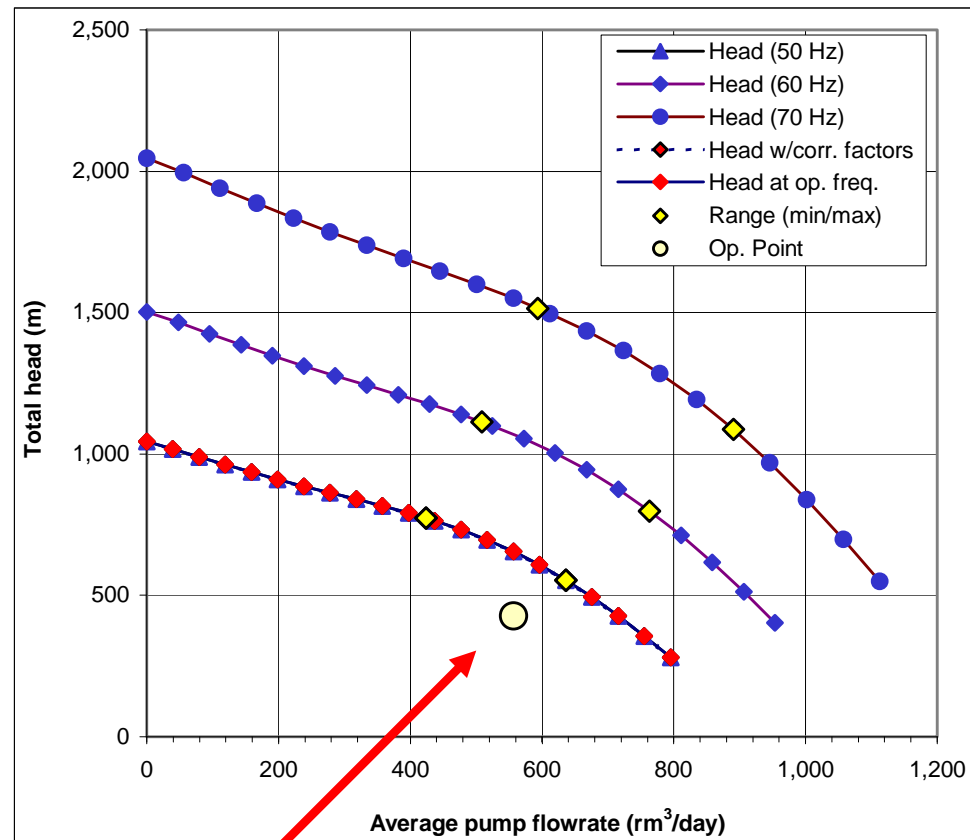
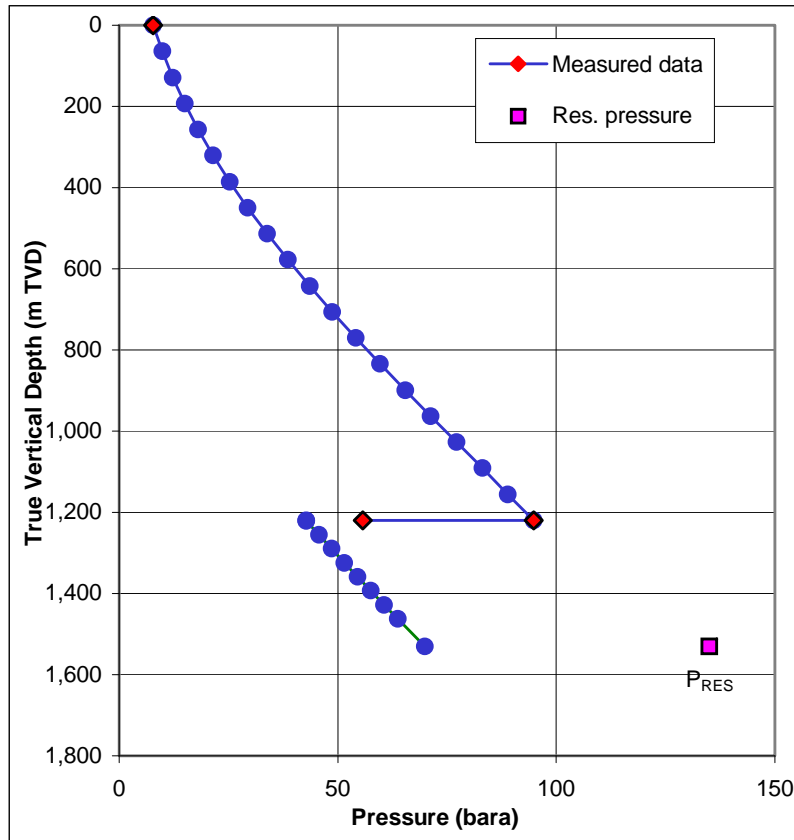


# What pressures tell us.....

	Controlled by	Used to validate
Pd	THP, Fluid density, Friction (Flowrate dependent)	Watercut
Pi	Pd, Pump performance, Flowrate, Reservoir pressure, Well productivity, Fluid density	Pr and or PI
Pd - Pi	Pump flowrate vs head curve	Pump Wear Flowrate Recirculation

# Modelling can .....

- Provide preliminary indication that says:

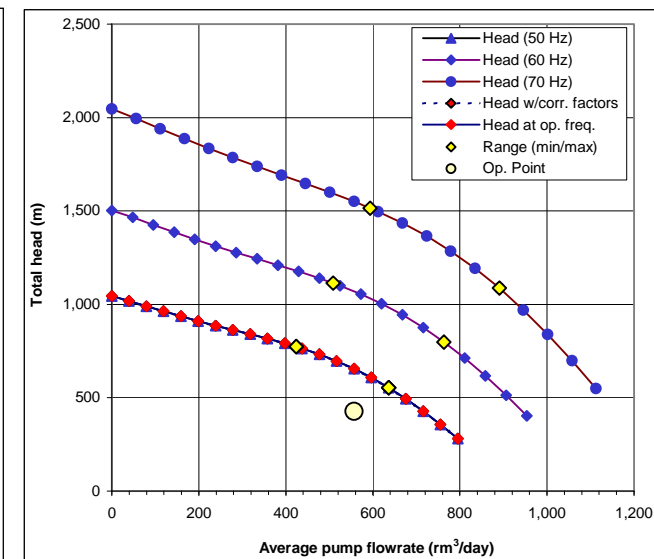
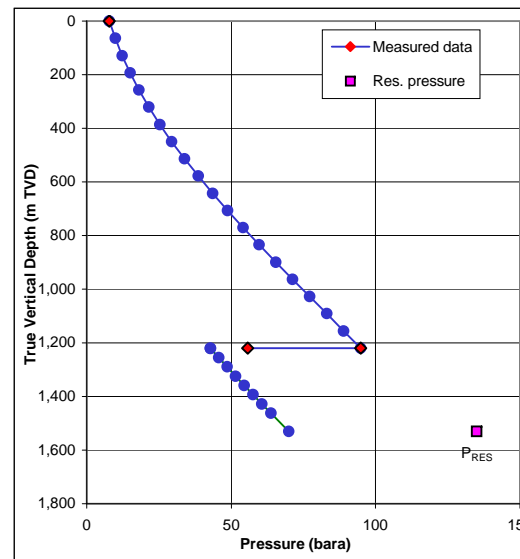


we have a problem....what is the problem?

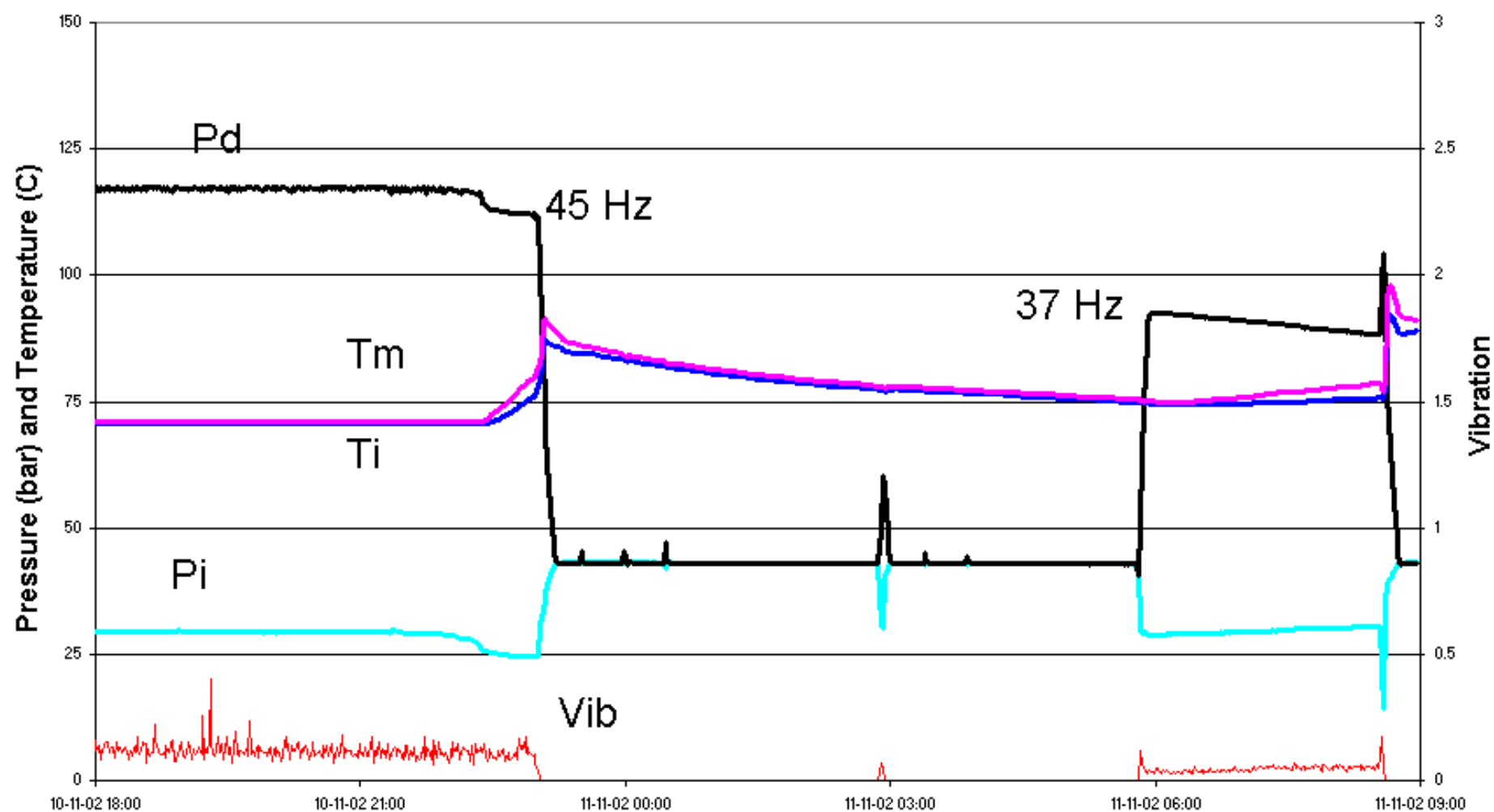


# Requires analysis skills to say .....

- Pump not providing correct head (lost stages or wear)?
- Water cut wrong?
- THP wrong?
- Flowrate measurement wrong?
- High viscosity?
- .....which is it?



# Example .....



# Advice

- Pay attention to pressure and rate .....

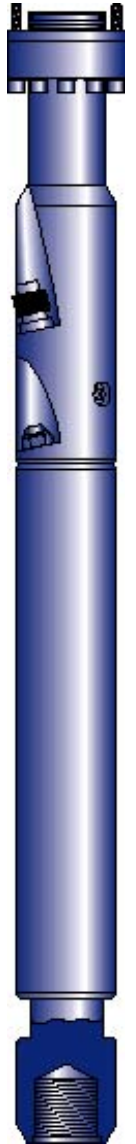


# Monitoring & Control

## The Phoenix MultiSensor System

- Intake Pressure
- Discharge Pressure
- Motor Winding Temperature
- Intake Temperature
- Vibration
- Current Leakage

If you had to prioritize these, how would you rank them?



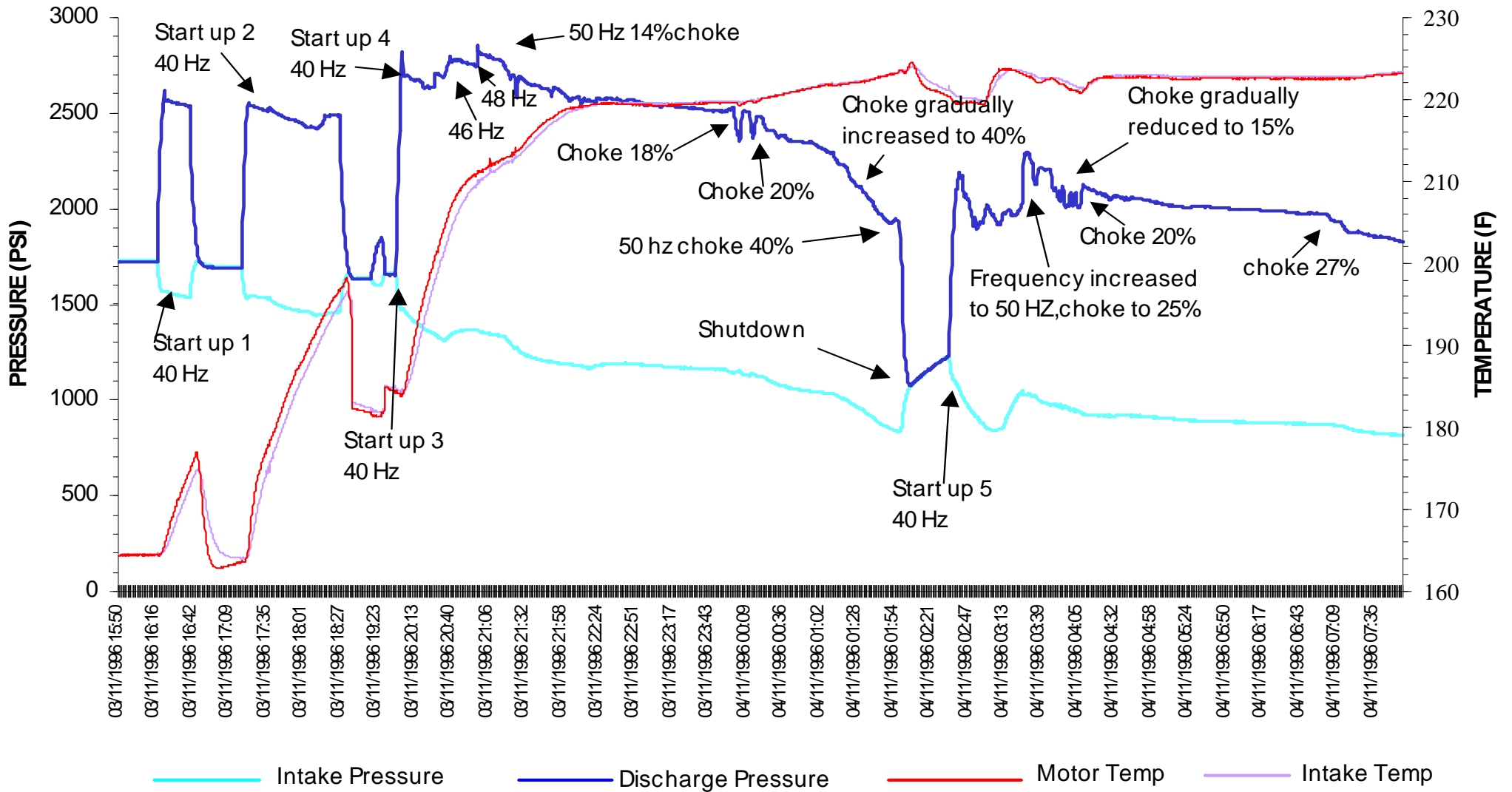
# What can we do with this data?

- Monitoring
- Trending
- Protection
- Validation & Analysis
- Use the analysis results for optimisation

# Typical Monitoring Data

<b>Time</b>	<b>Pi</b>	<b>Pd</b>	<b>Ti</b>	<b>Tm</b>	<b>Vib</b>	<b>Cl</b>
9:56:34	3029	4414	125.6	133.8	0.23	0.1
9:56:55	3027	4426	125.8	134	0.253	0.102
9:57:16	3026	4410	125.8	134.1	0.249	0.105
9:57:36	3031	4418	125.5	133.8	0.24	0.101
9:57:57	3024	4408	125.8	134	0.231	0.105
9:58:17	3023	4404	125.5	133.8	0.246	0.102
9:58:38	3033	4420	125.8	134.1	0.251	0.099
9:58:58	3029	4410	125.6	134	0.262	0.096

# Data Trending



# ESP Diagnosis

Exercise.

Draw

- i) Gradient plot
- ii) Pump curve
- iii) Trend over time of P Discharge & P intake
- iv) Amp Chart

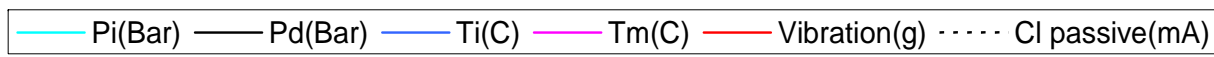
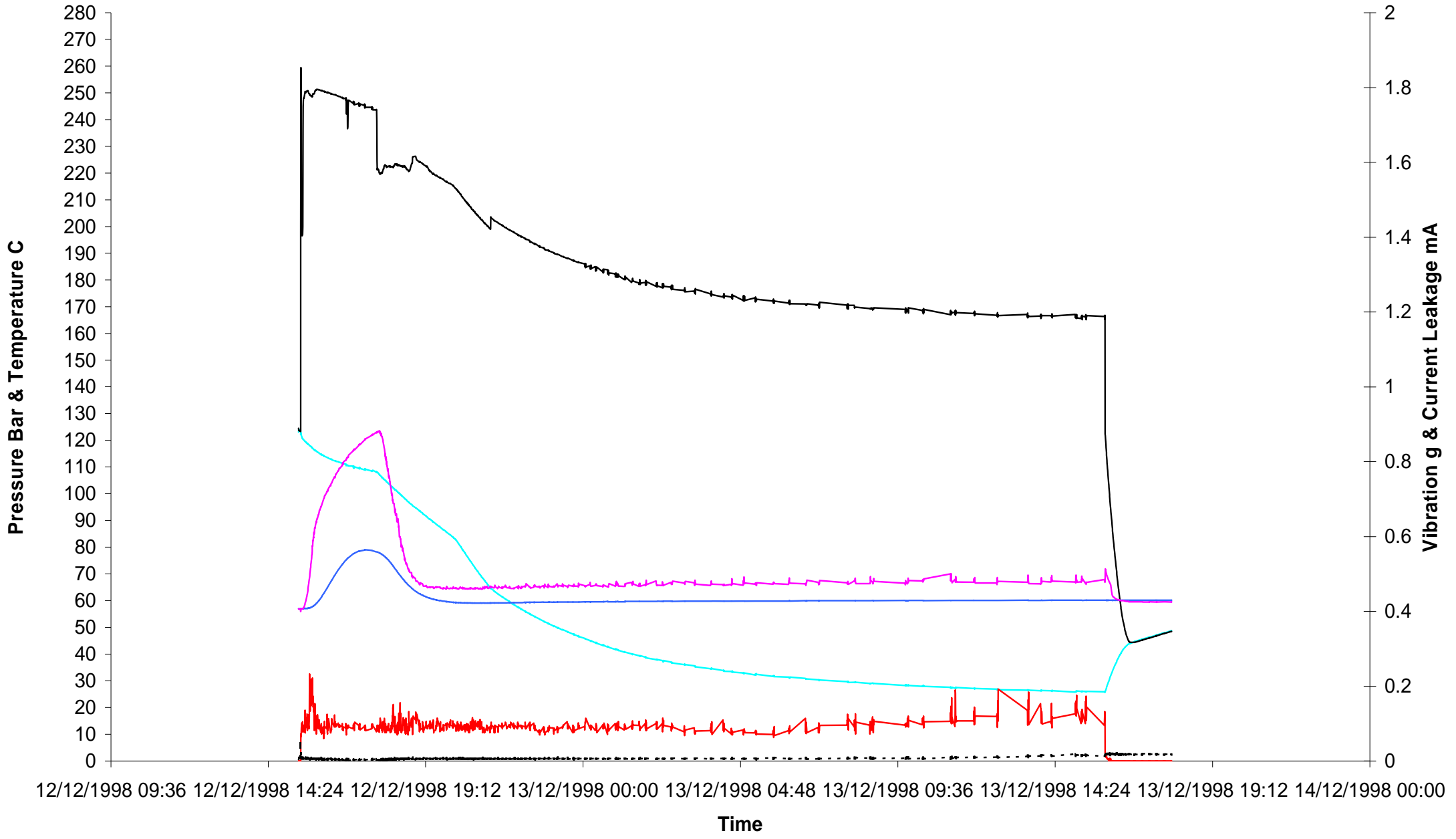


**for the following cases**

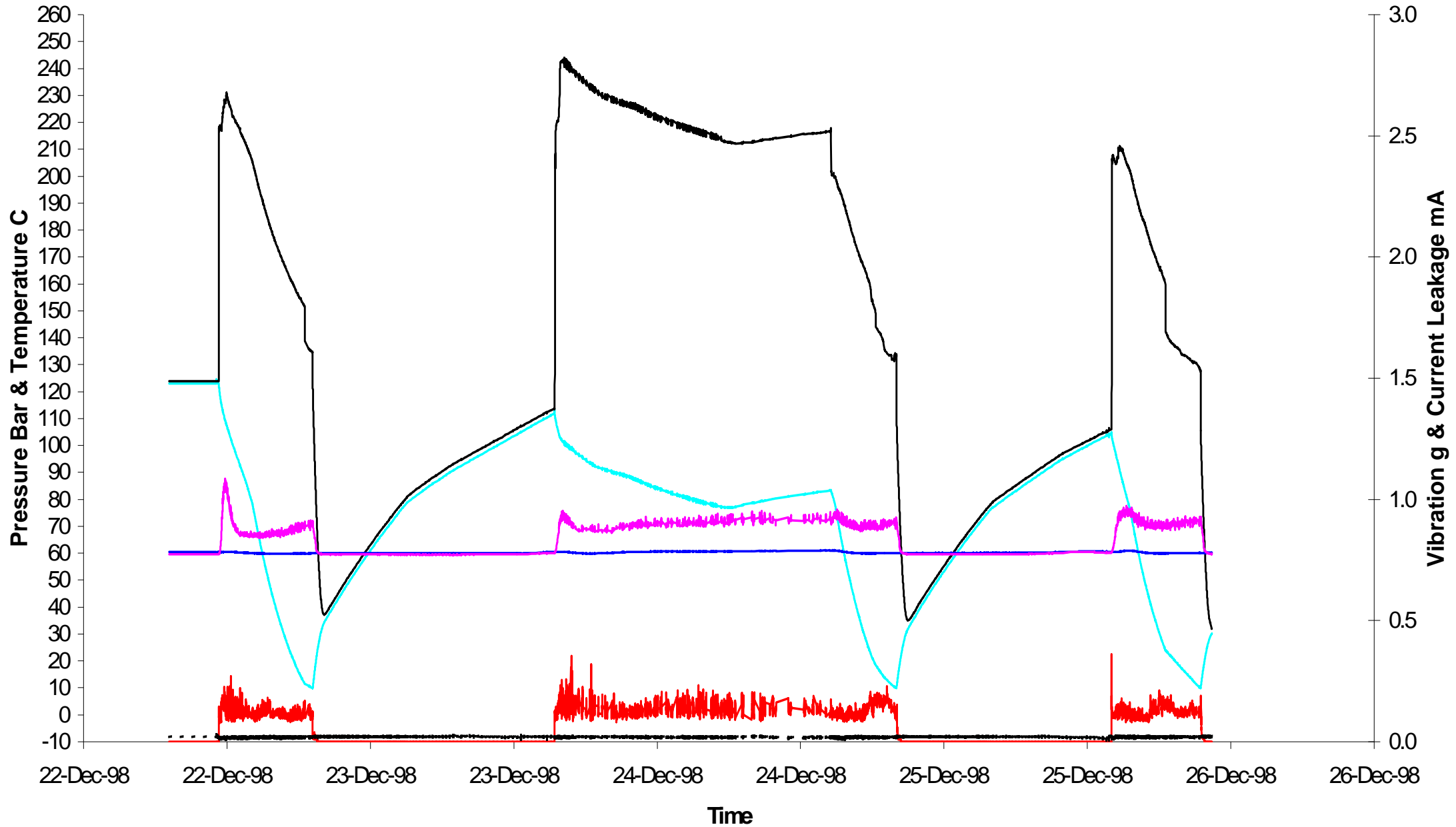
1. Well head valve closed – pump continues to operate
2. Frequency change 50 –60 hz
3. Broken Shaft Between Pump and Protector
4. Pump wear
5. Hole in Tubing



# Phoenix ESP Monitoring & Protection

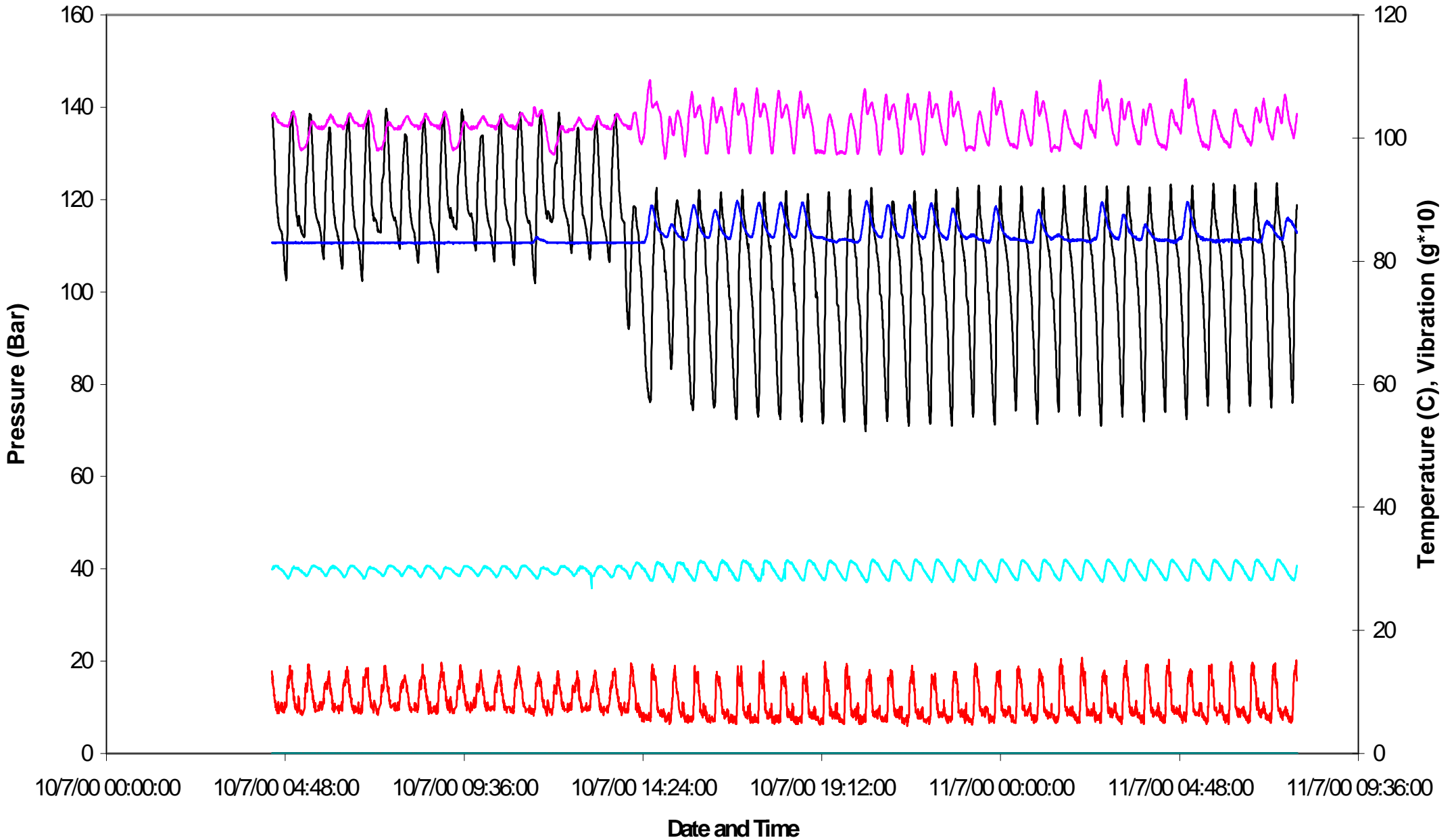


# Monitoring and Protection

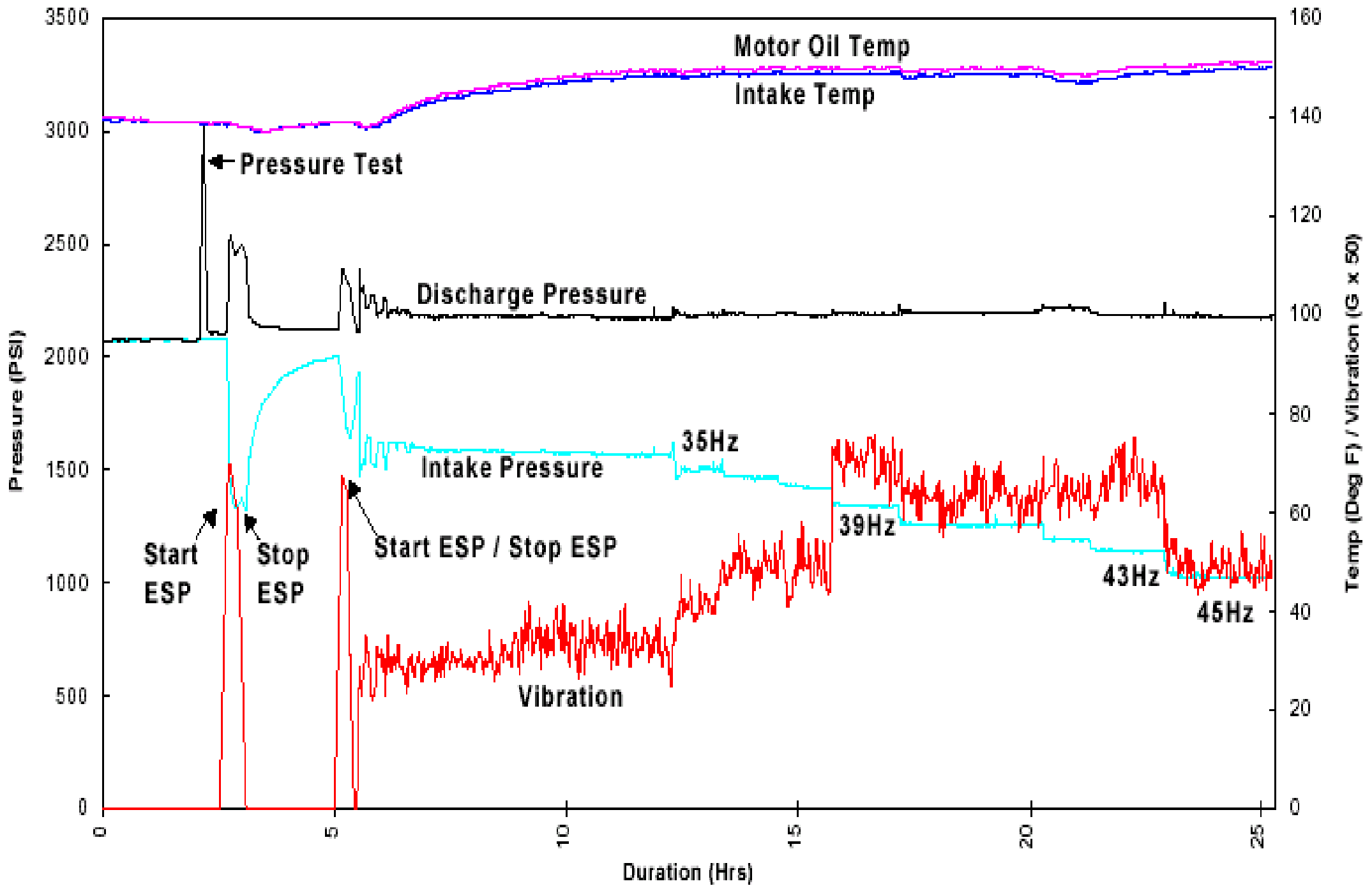


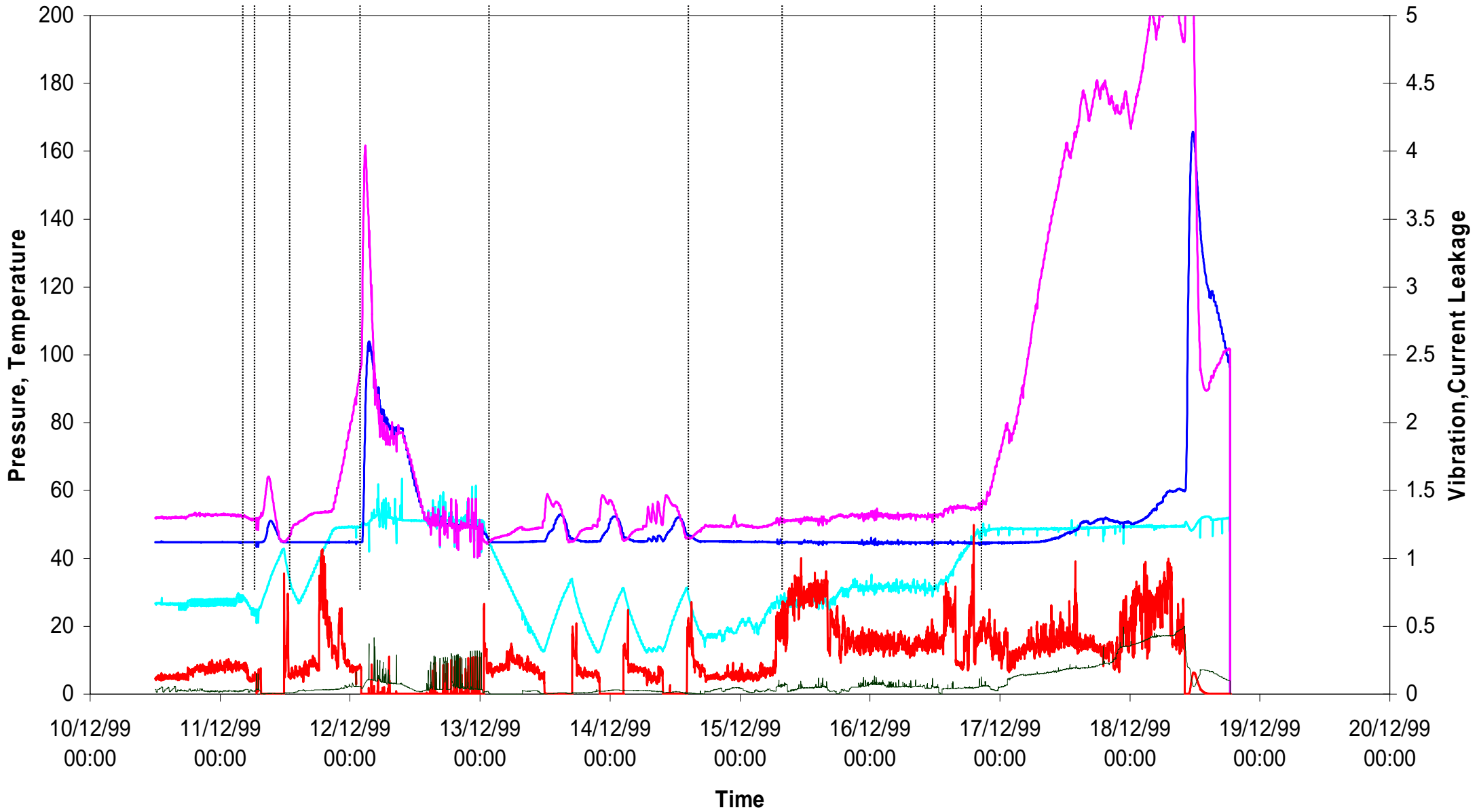
— Pi (Bar) — Pd (Bar) — Ti (C) — Tm (C) — Vibration (g) - - - Cl passive (mA)

# Monitoring and protection



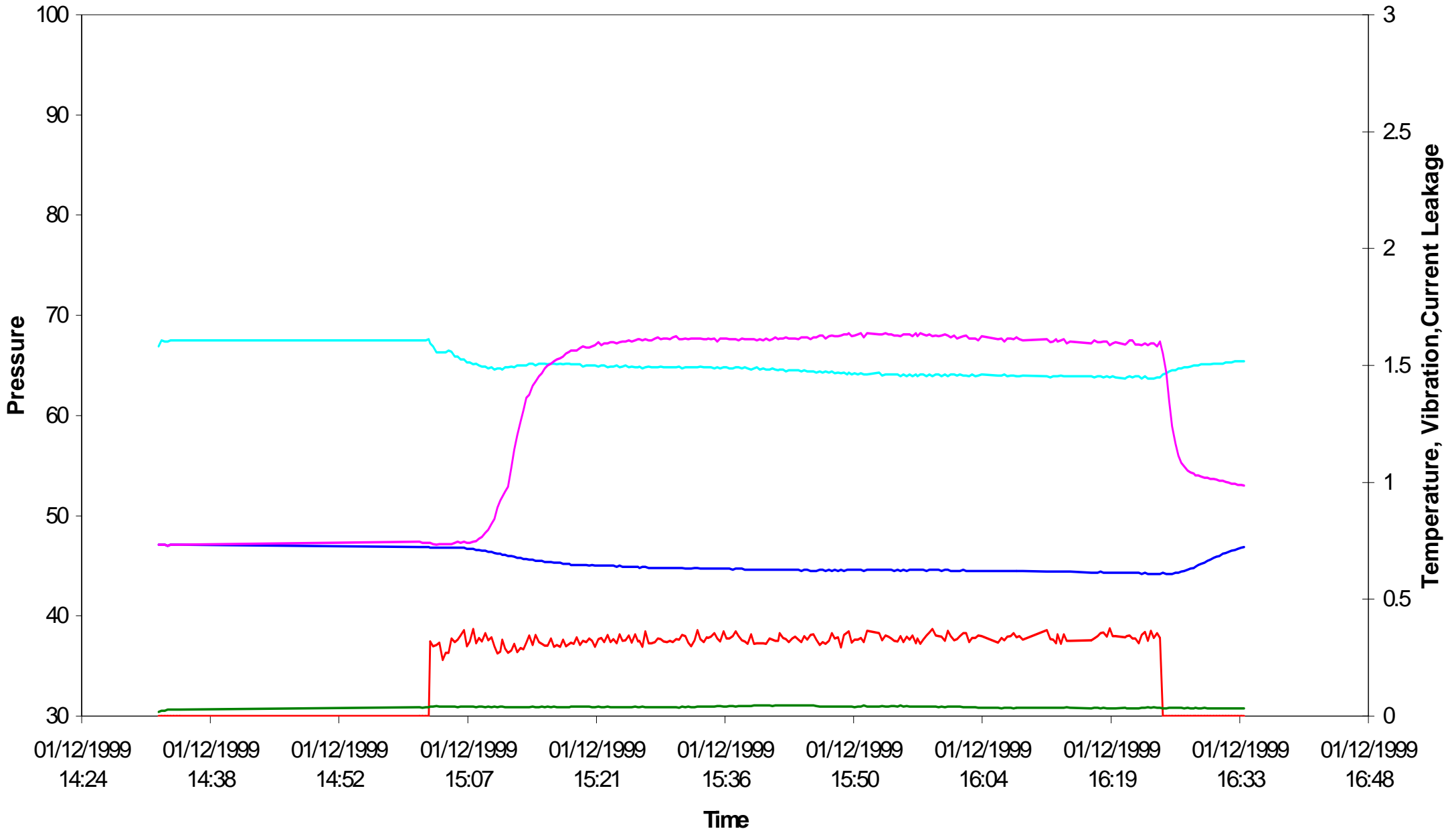
— Pi (psi) — Pd (psi) — Cl passive (mA) — Cl active (mA) — Ti (C) — Tm (C) — Vibration (g\*100)





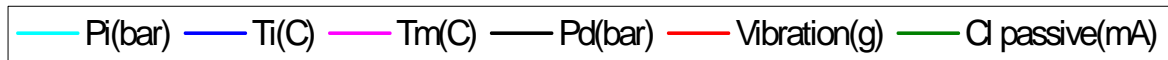
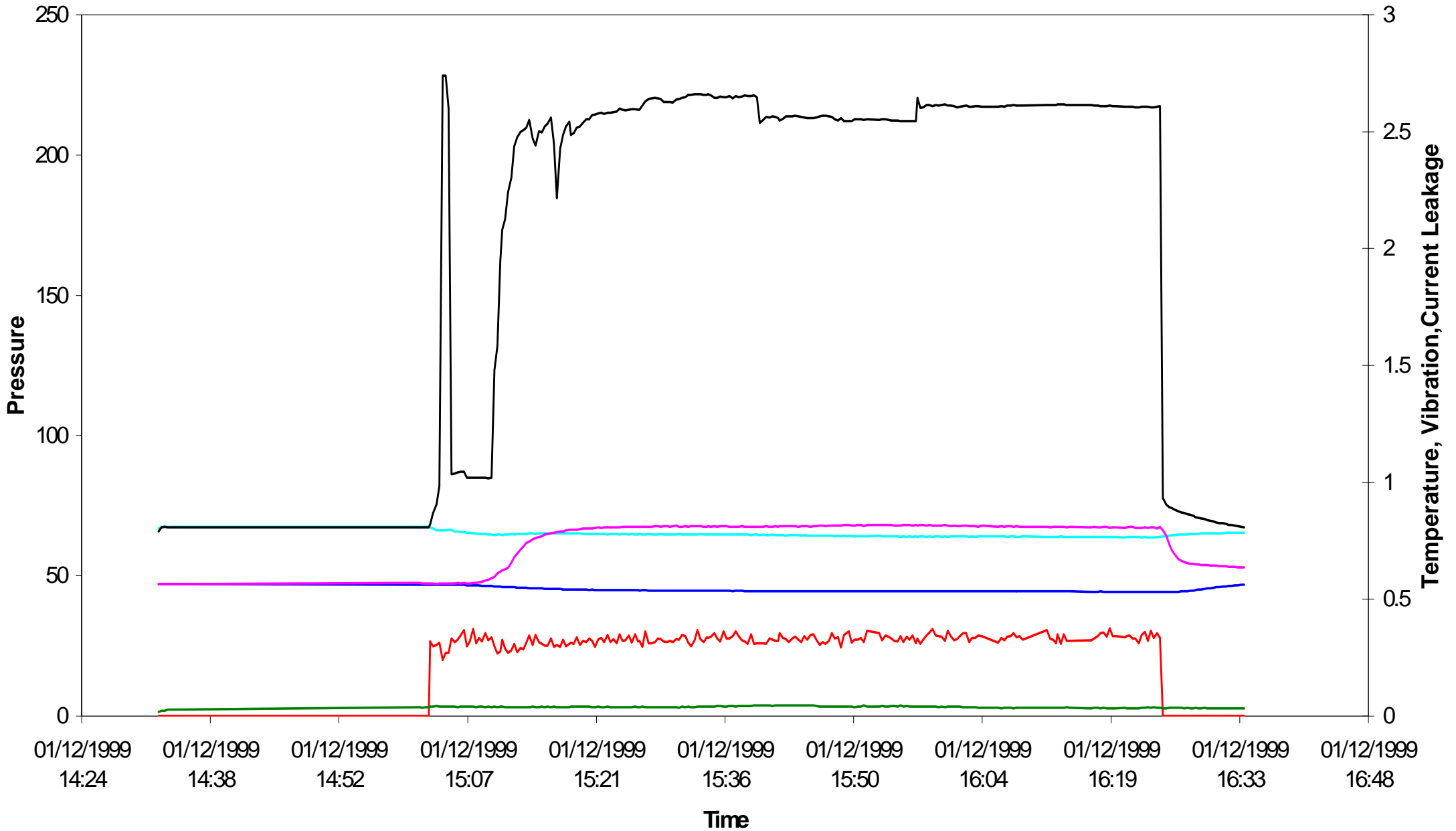
# Discharge Pressure

# Monitoring and Protection



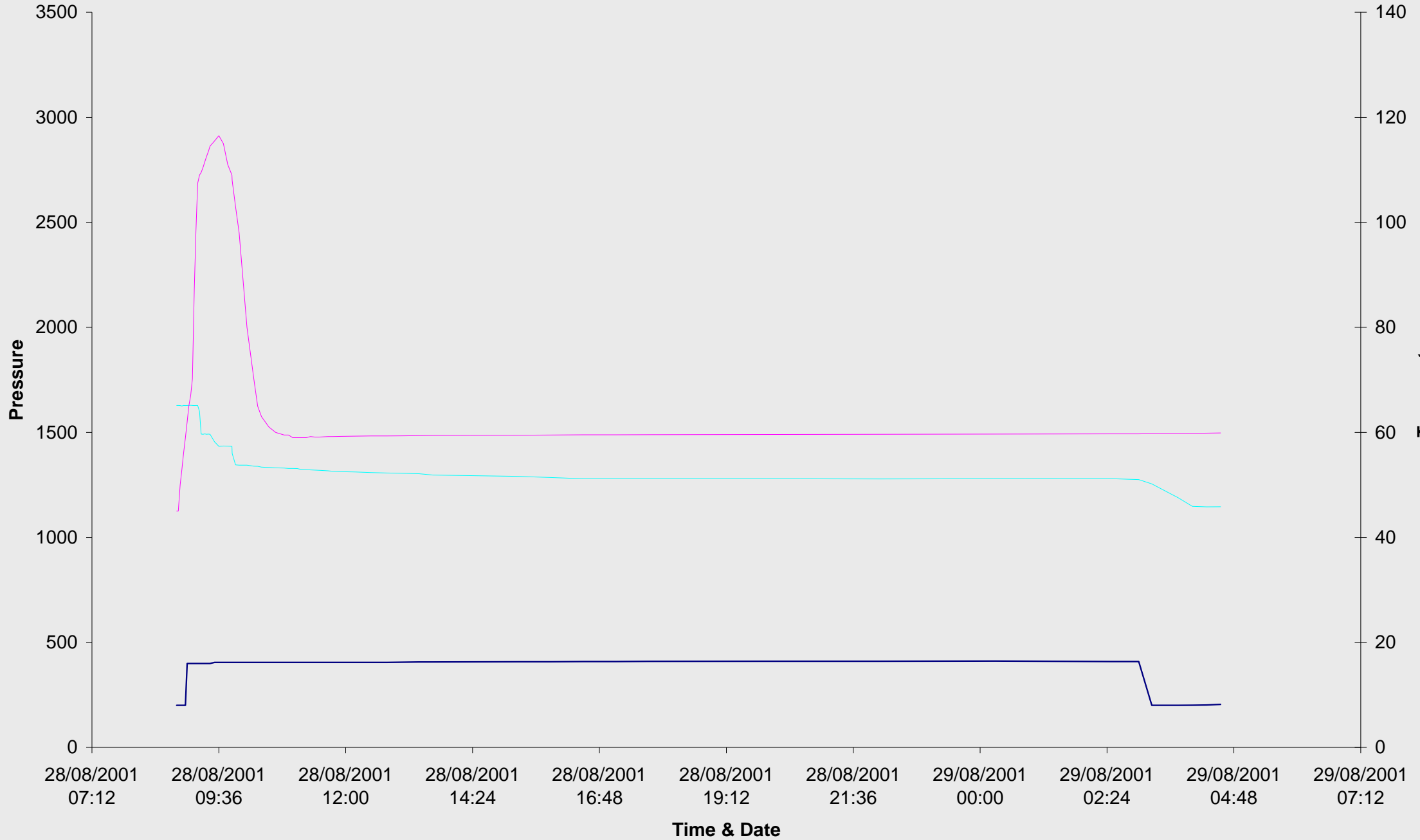
— Pi(bar) — Ti(C) — Tm(C) — Vibration(g) — Cl passive(mA)

# Monitoring and Protection



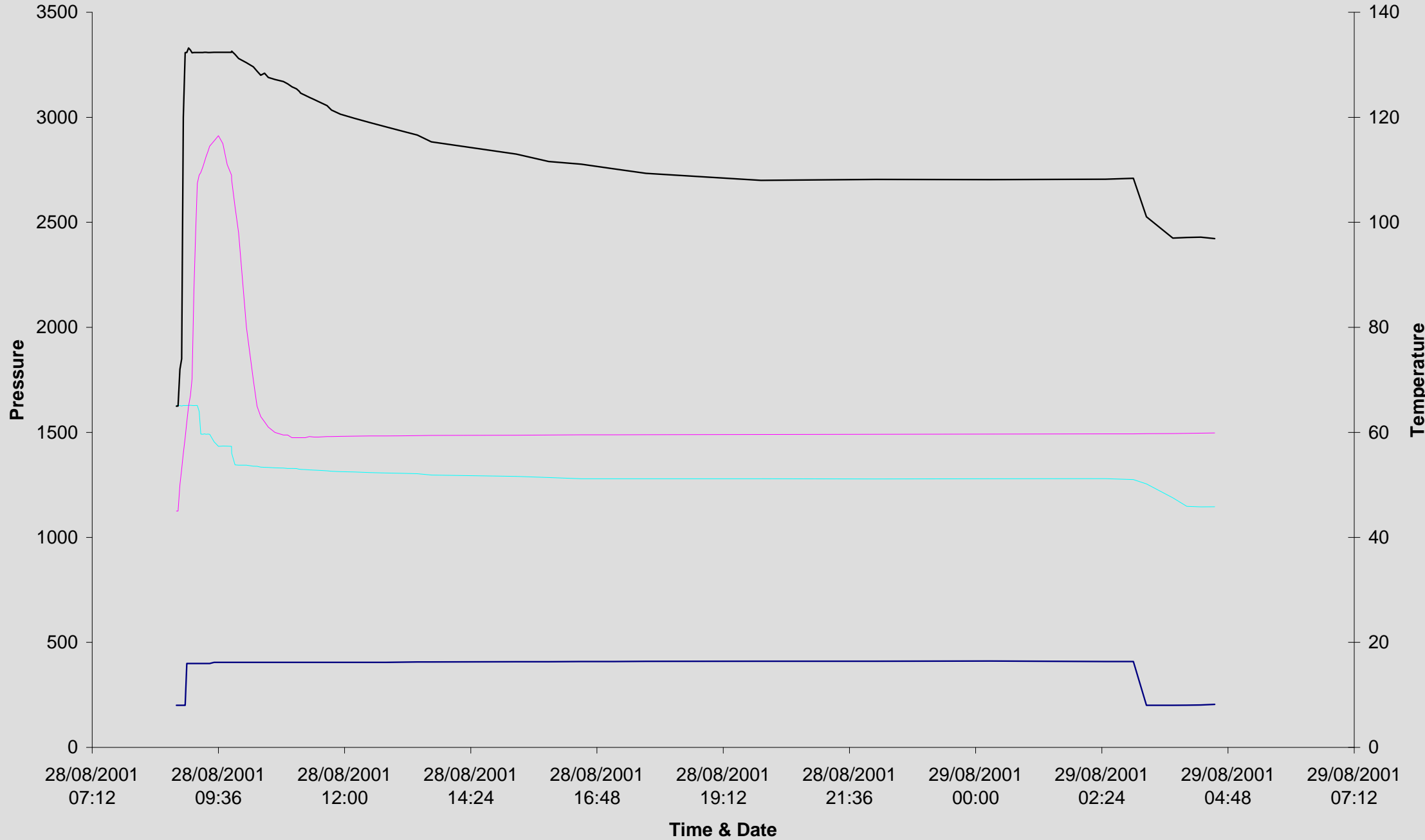


# MultiSensor Monitoring



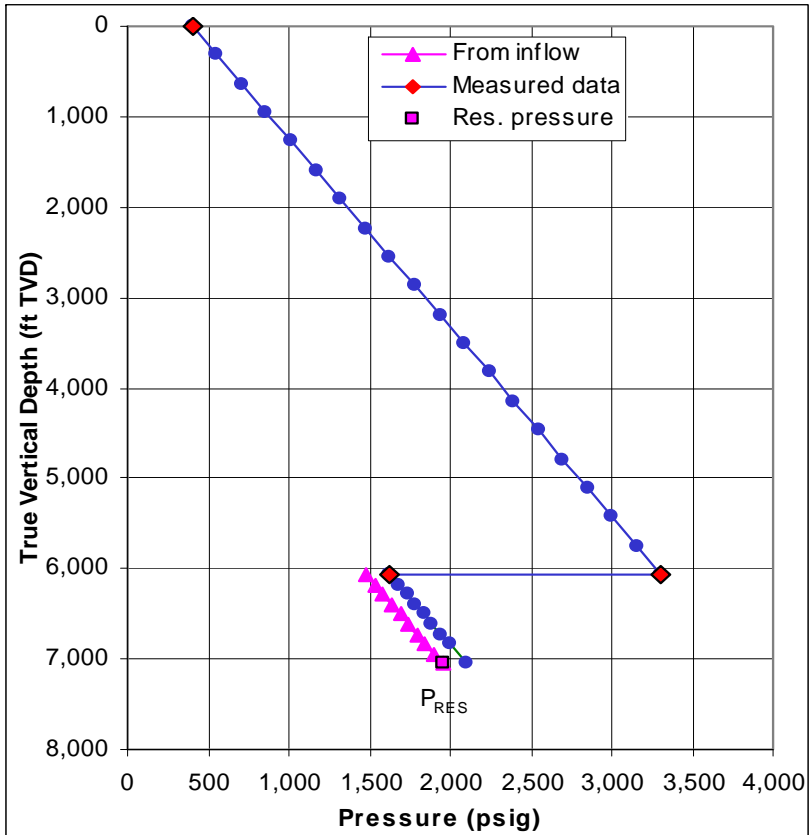
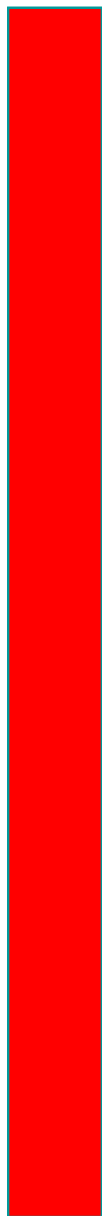
— WHP(psi) — PI (Psi) — Tm( c )

# MultiSensor Monitoring

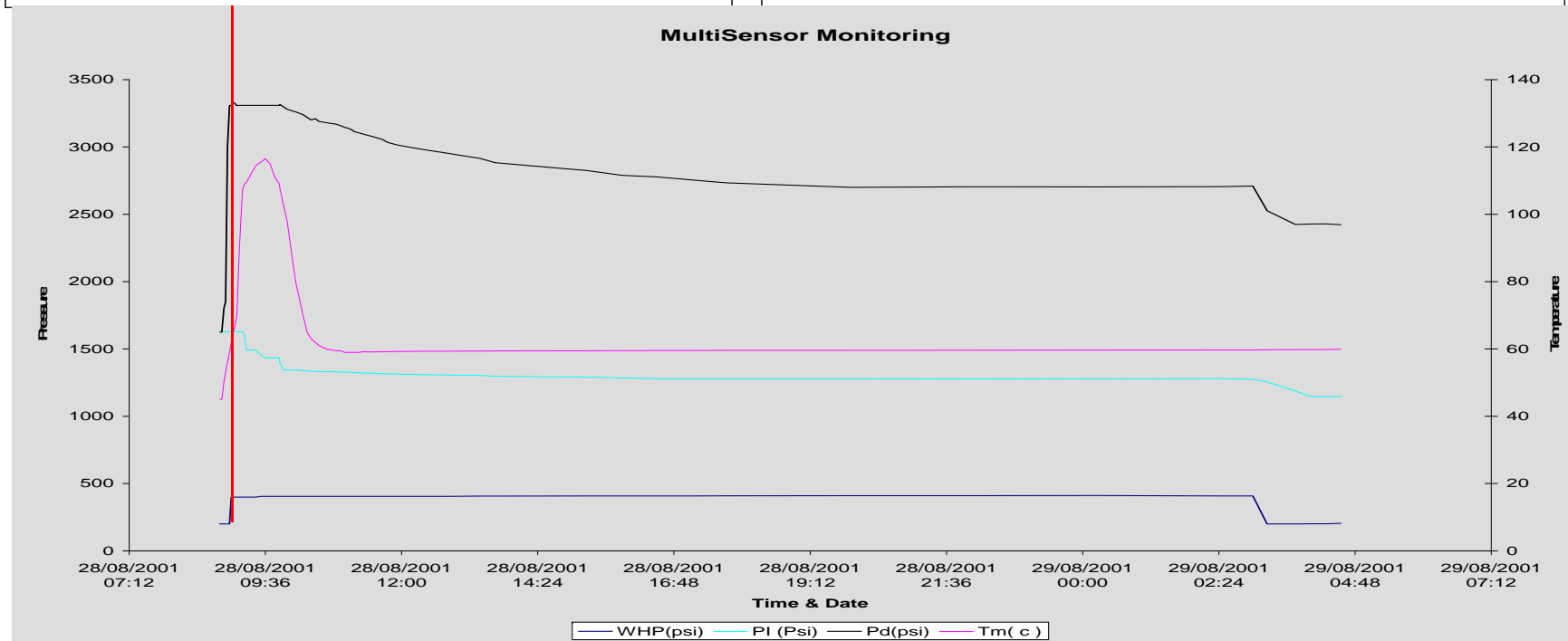
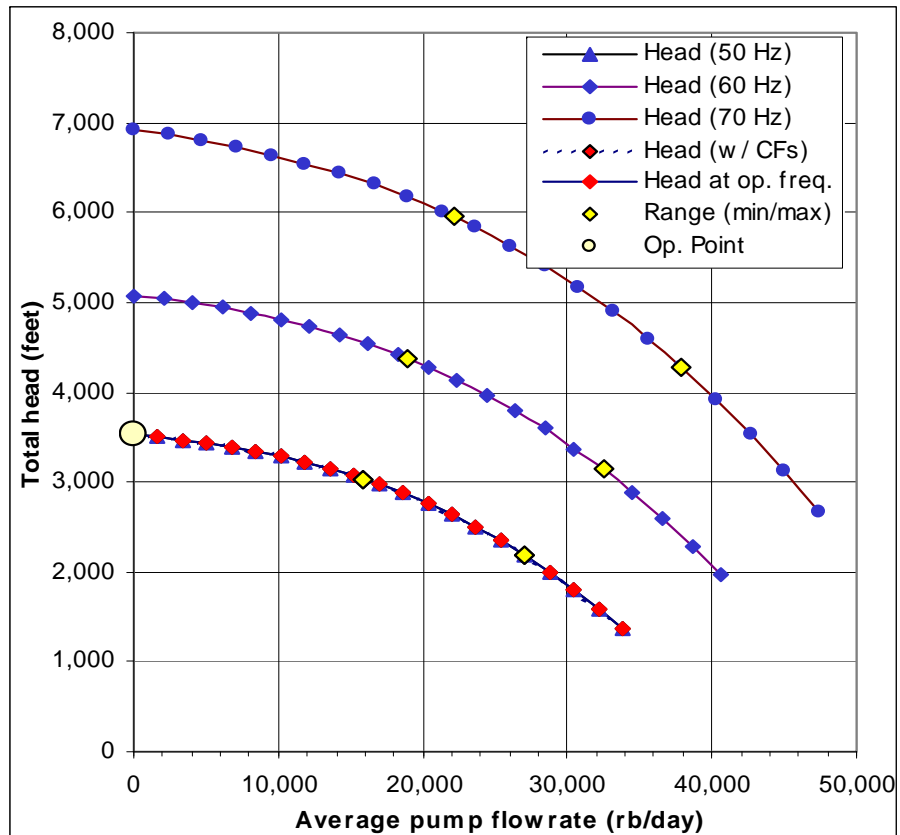
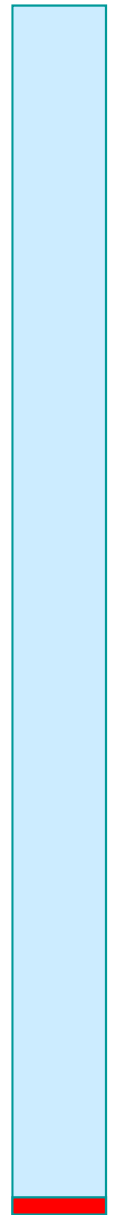


— WHP(psi) — PI (Psi) — Pd(psi) — Tm( c )

WCut

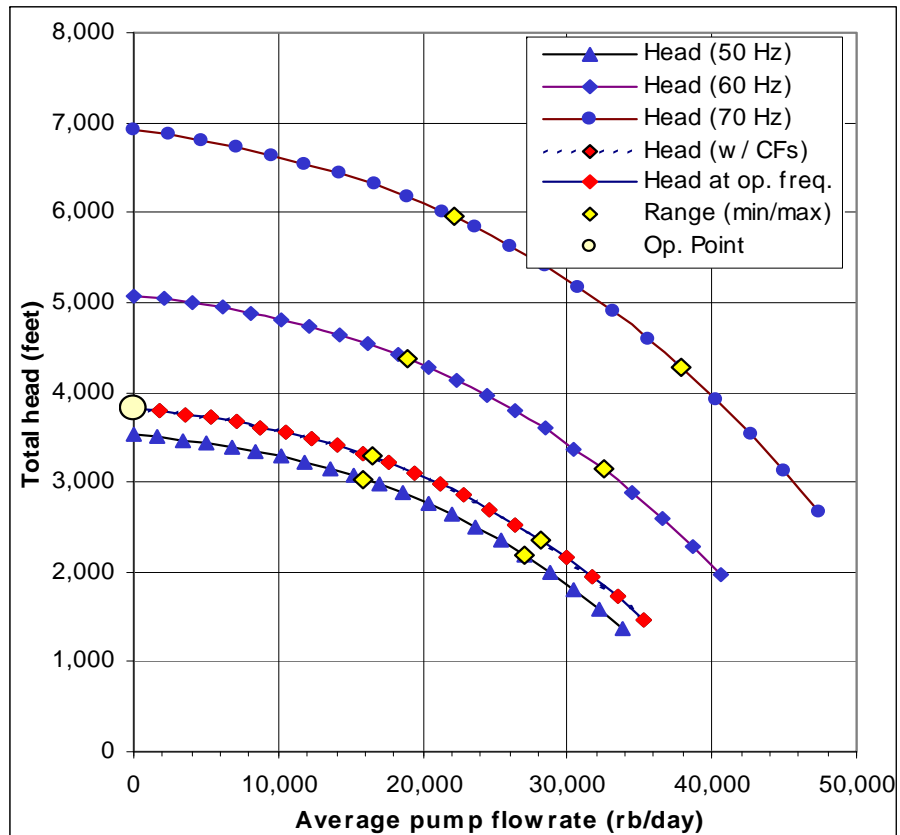
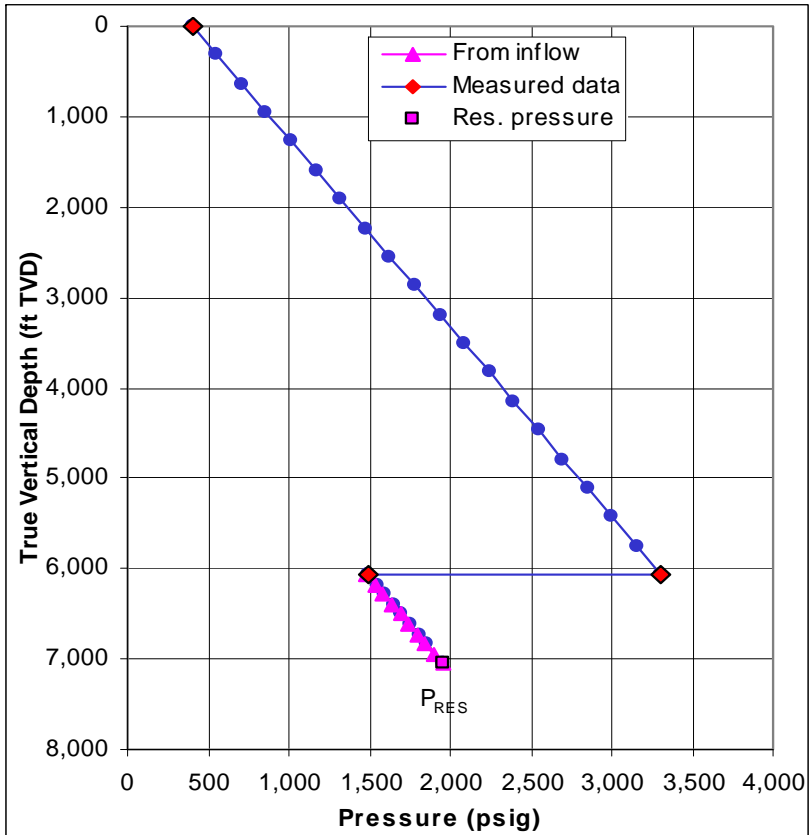
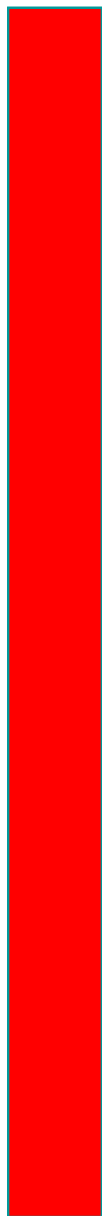


Flow

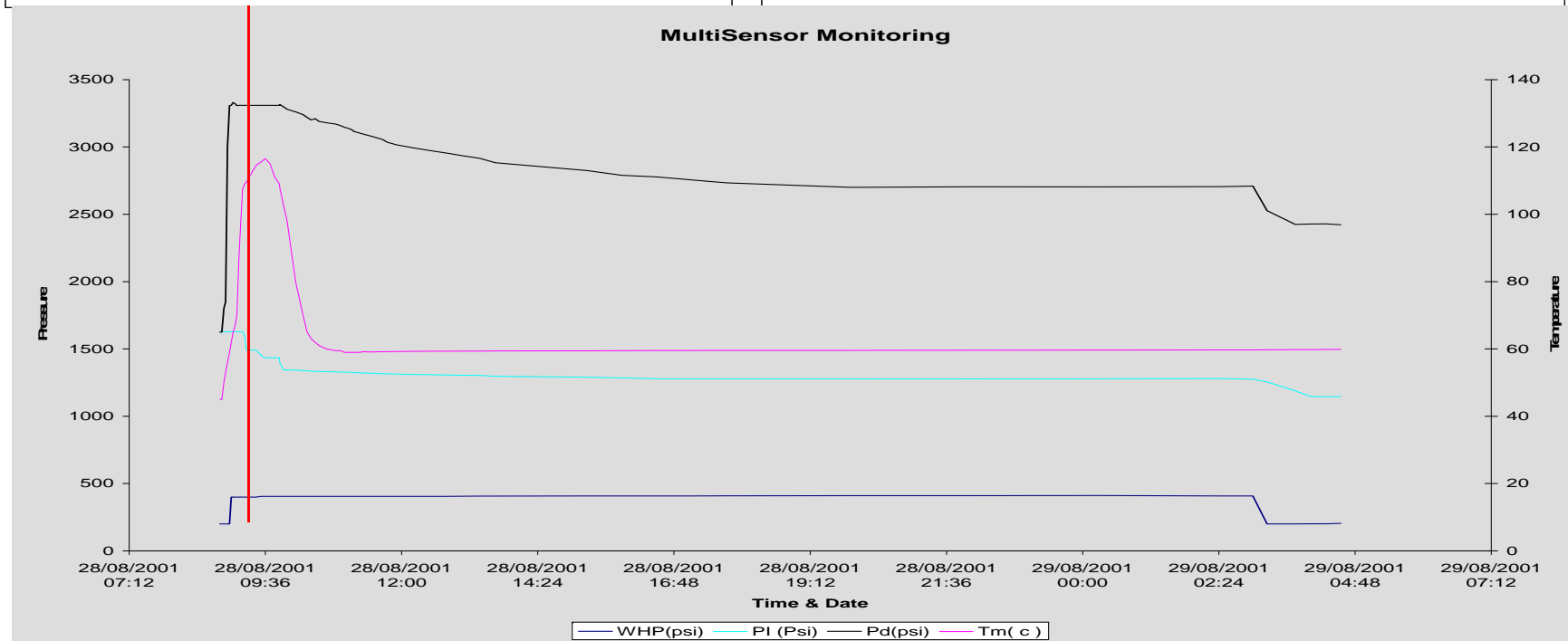
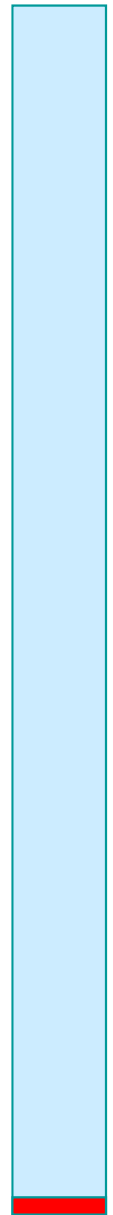


— WHP(psi) — PI (Psi) — Pd(psi) — Tm (c)

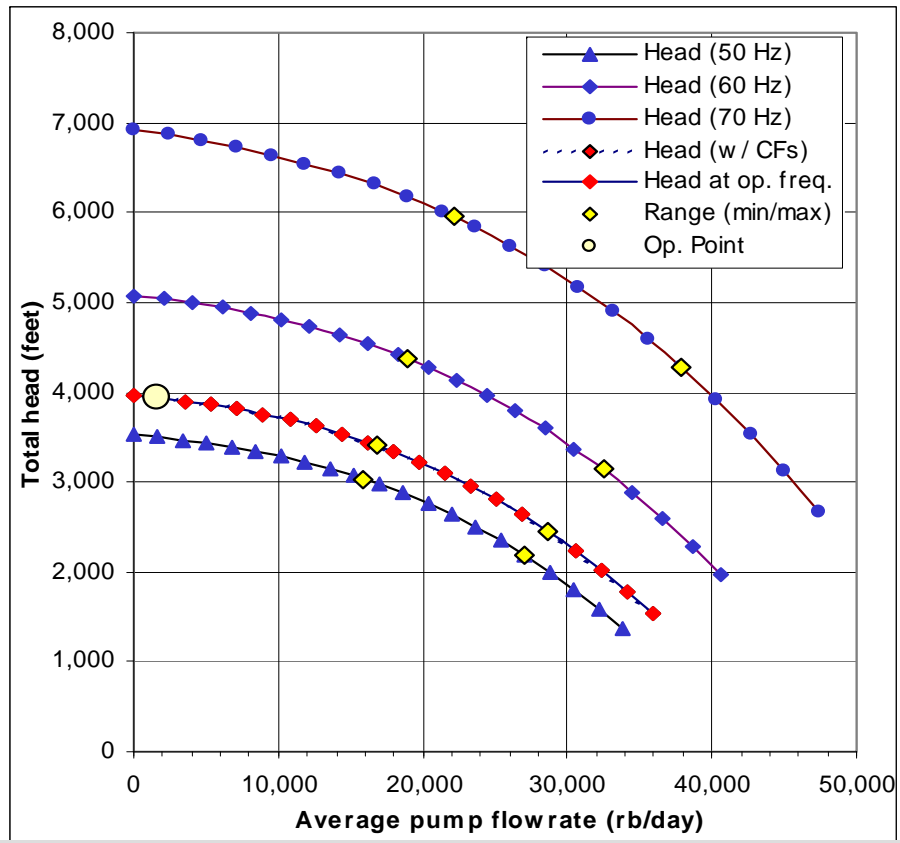
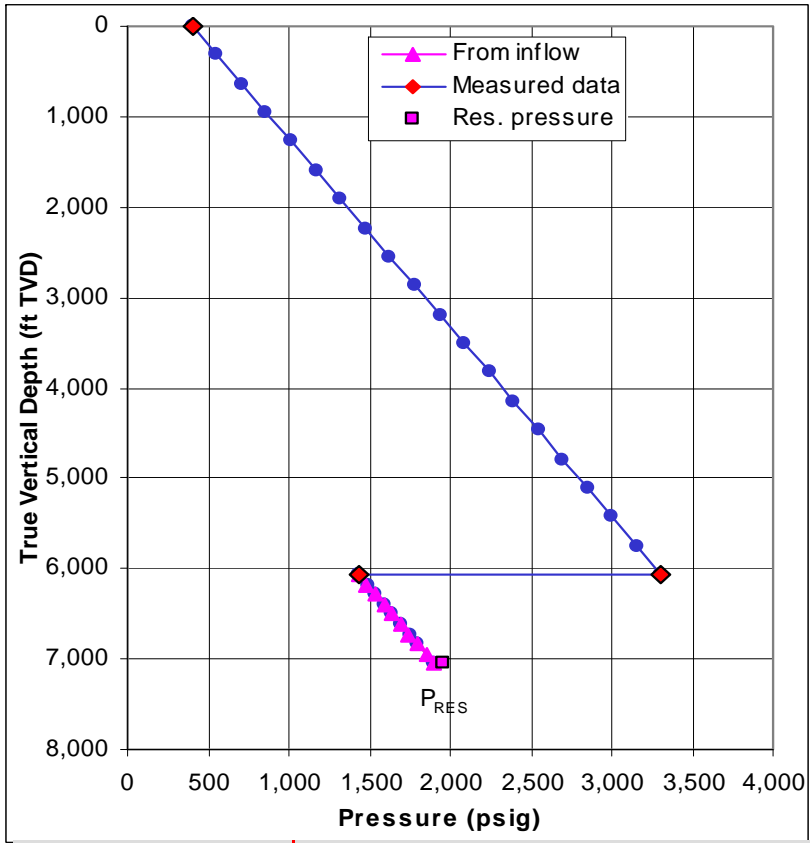
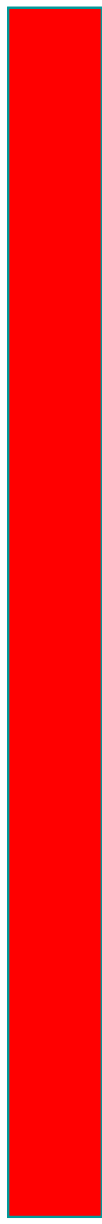
# WCut



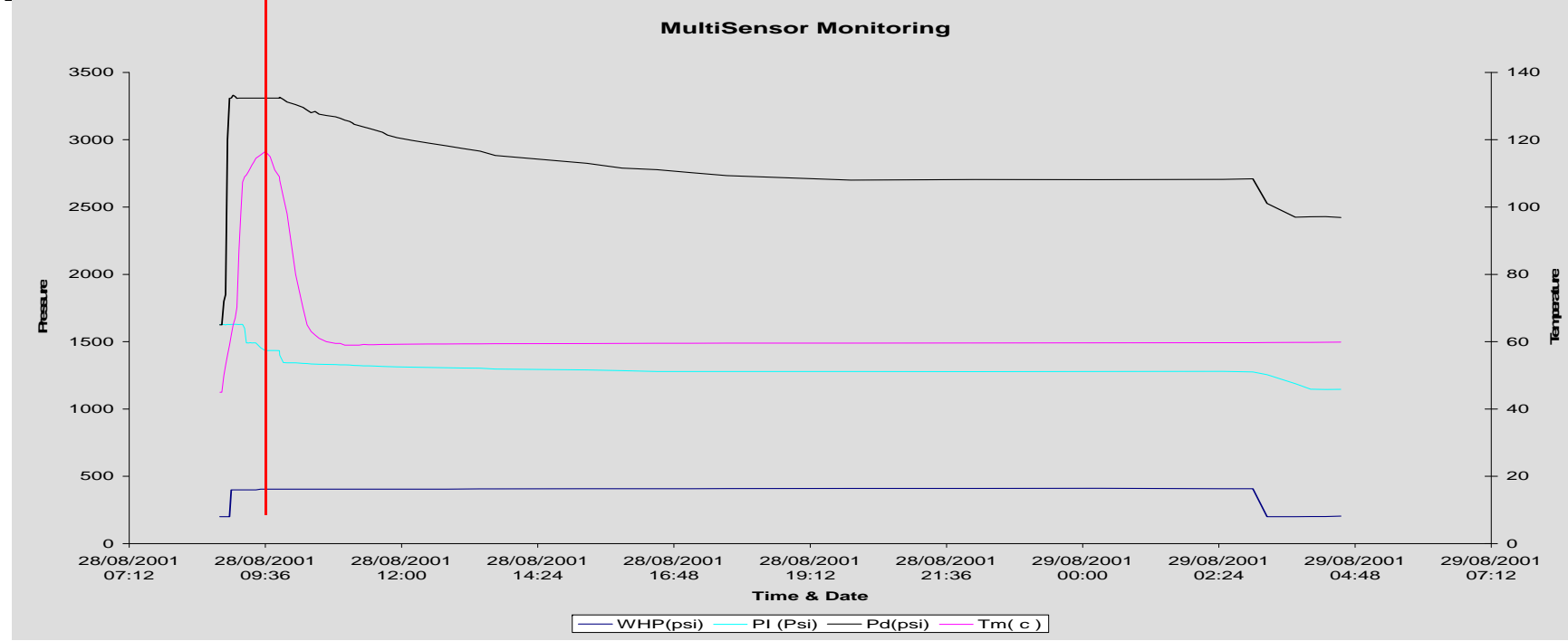
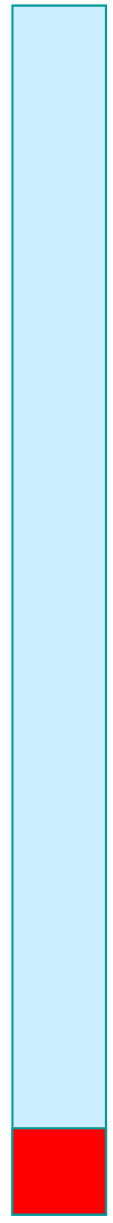
# Flow



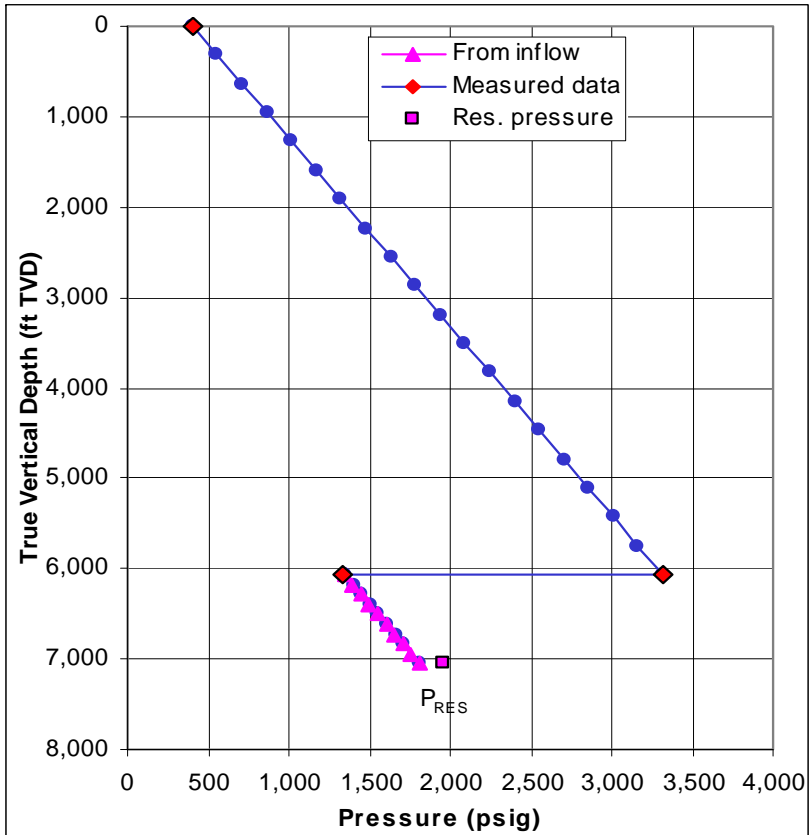
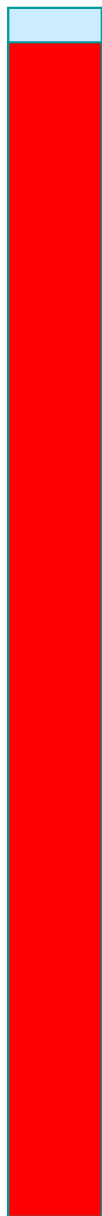
# WCut



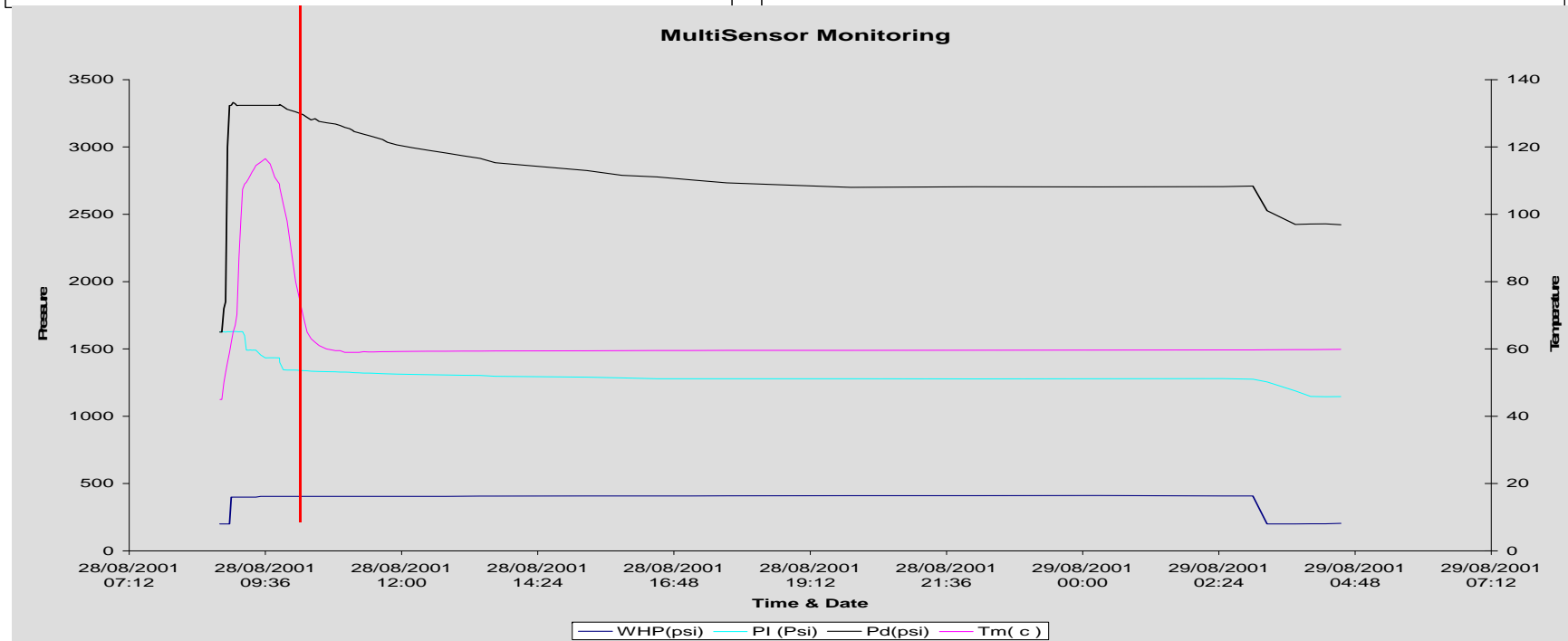
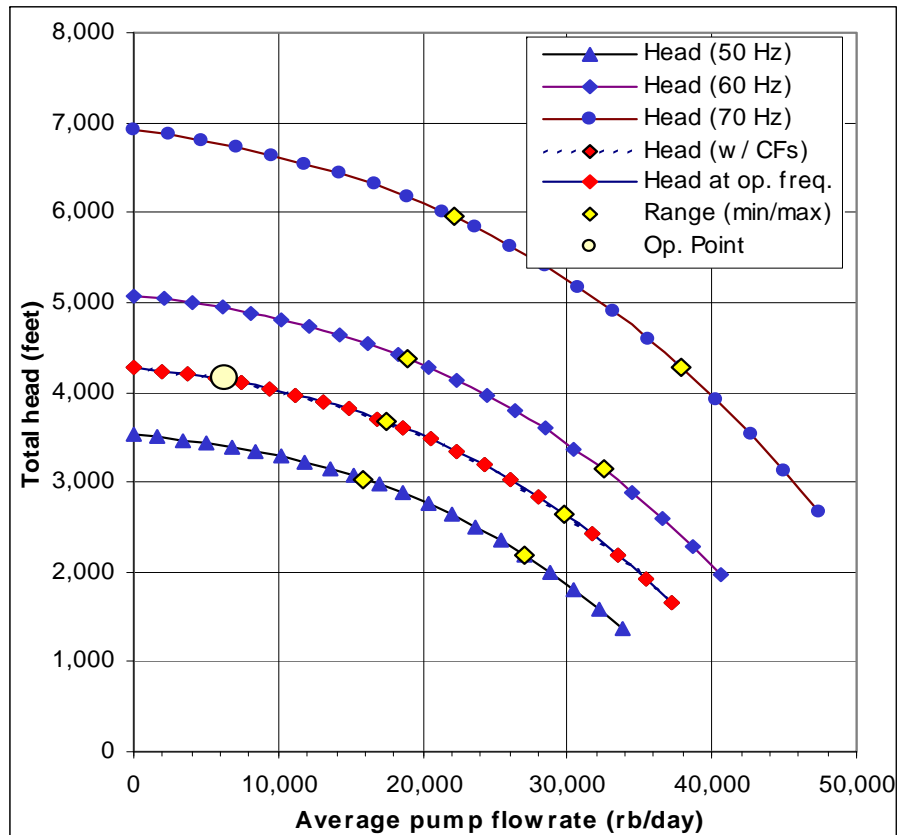
# Flow



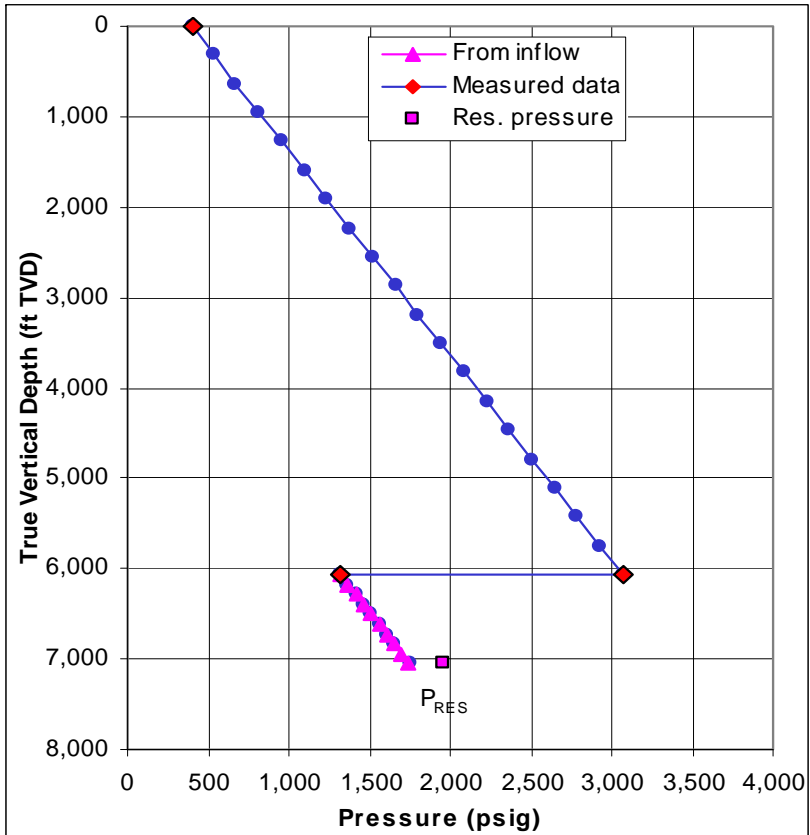
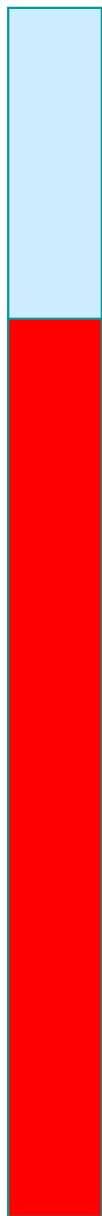
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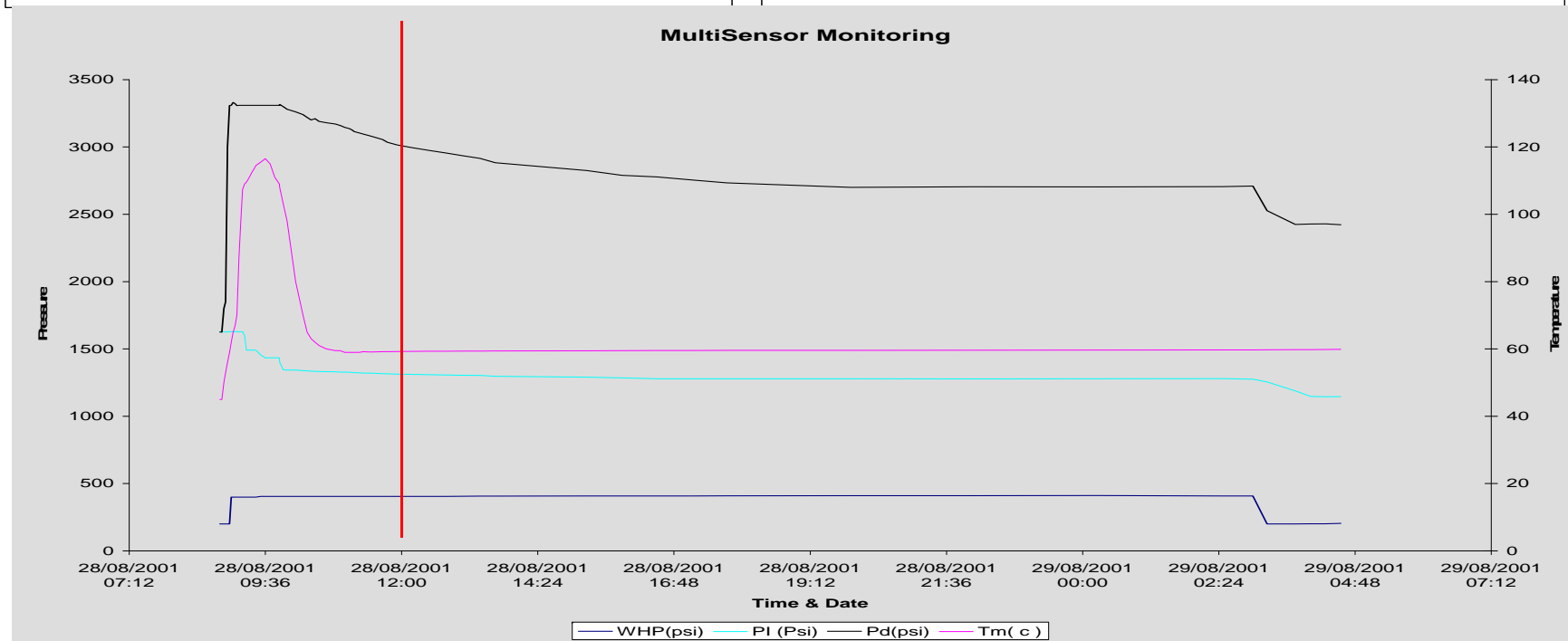
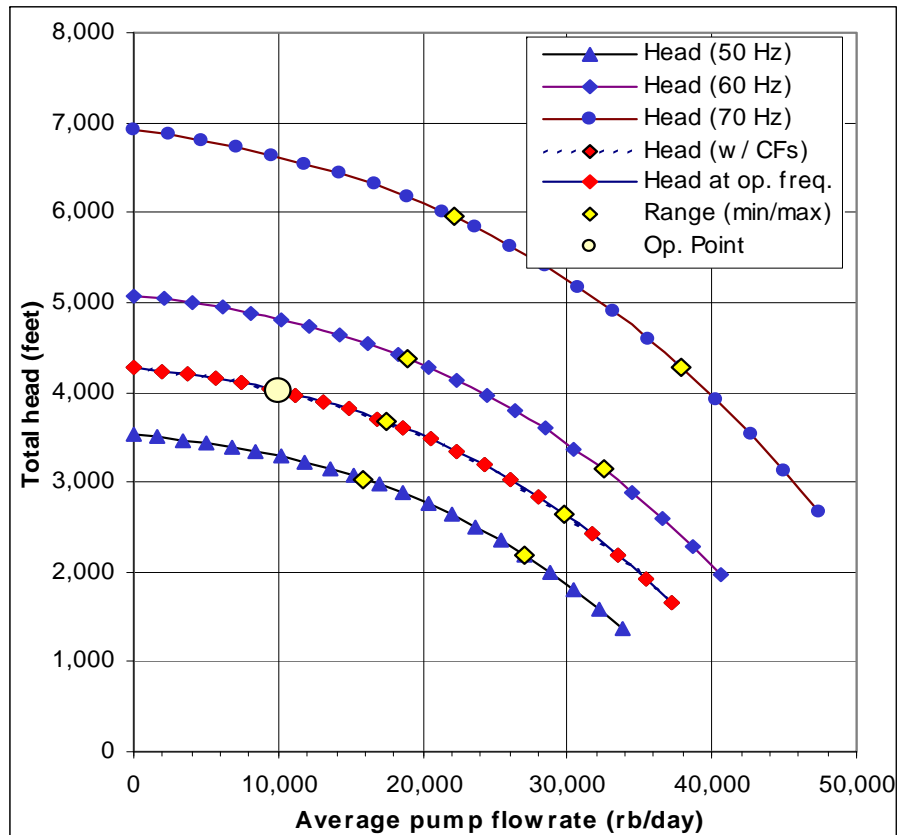
# Flow



WCut



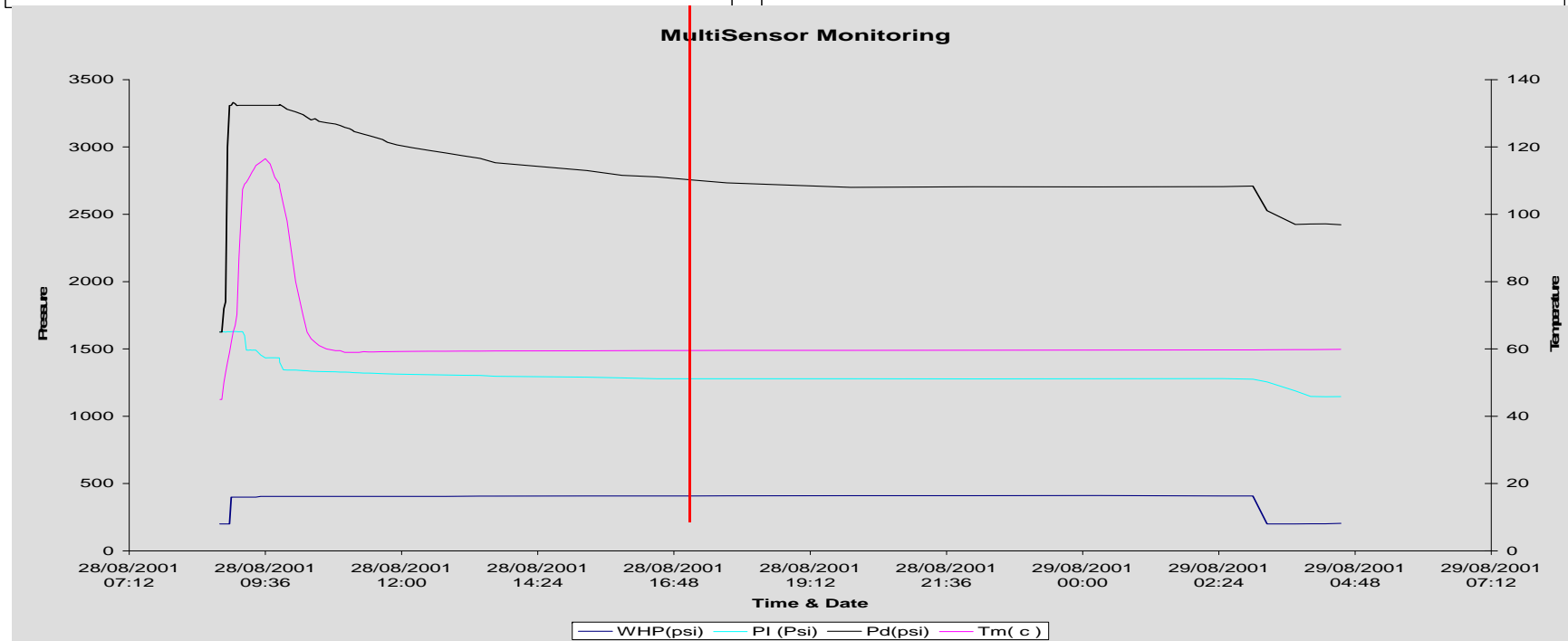
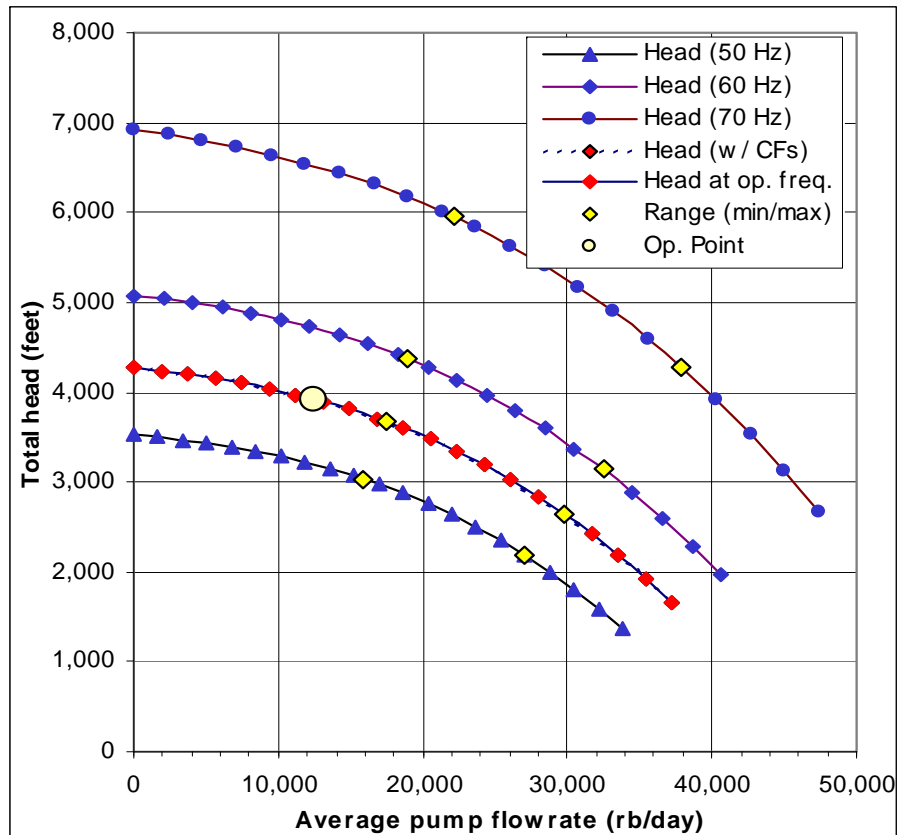
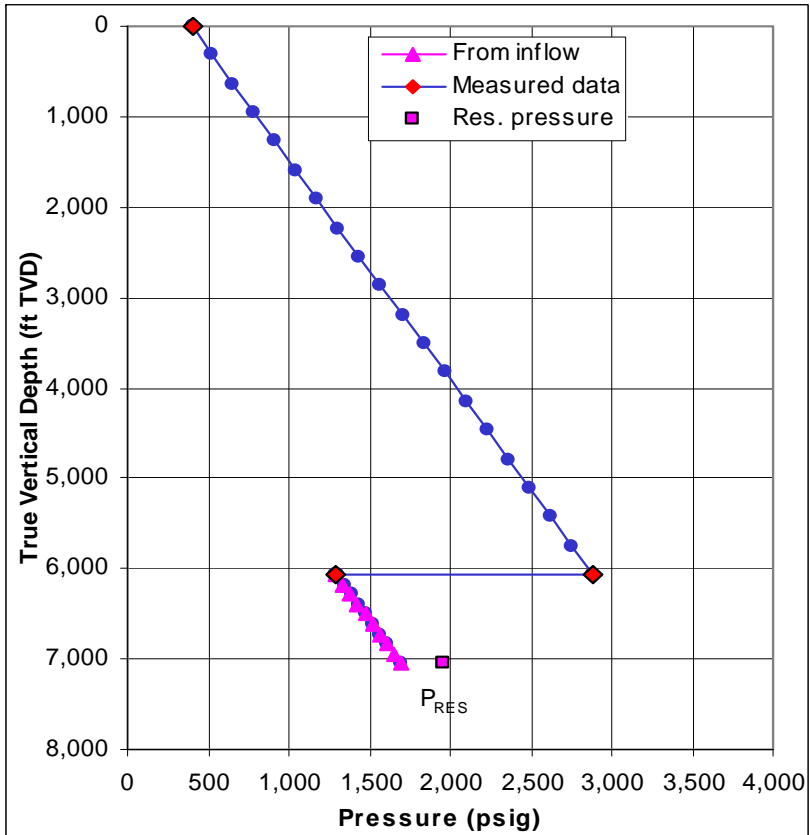
Flow



# WCut



# Flow

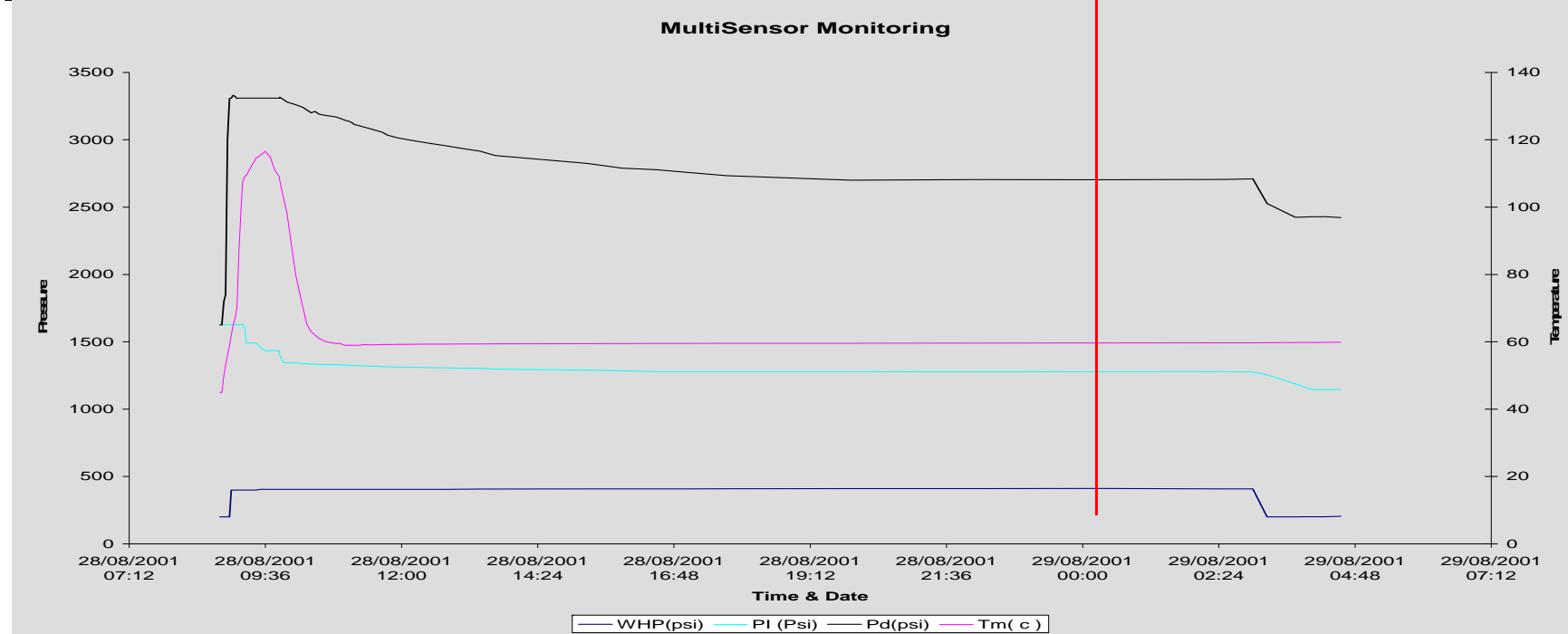
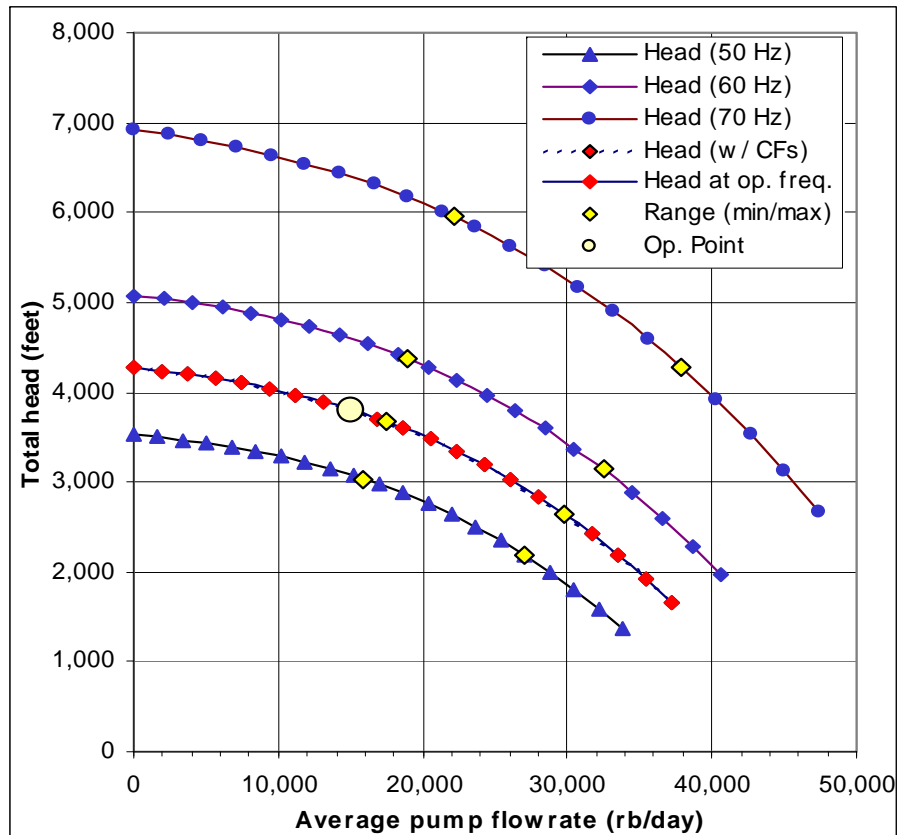
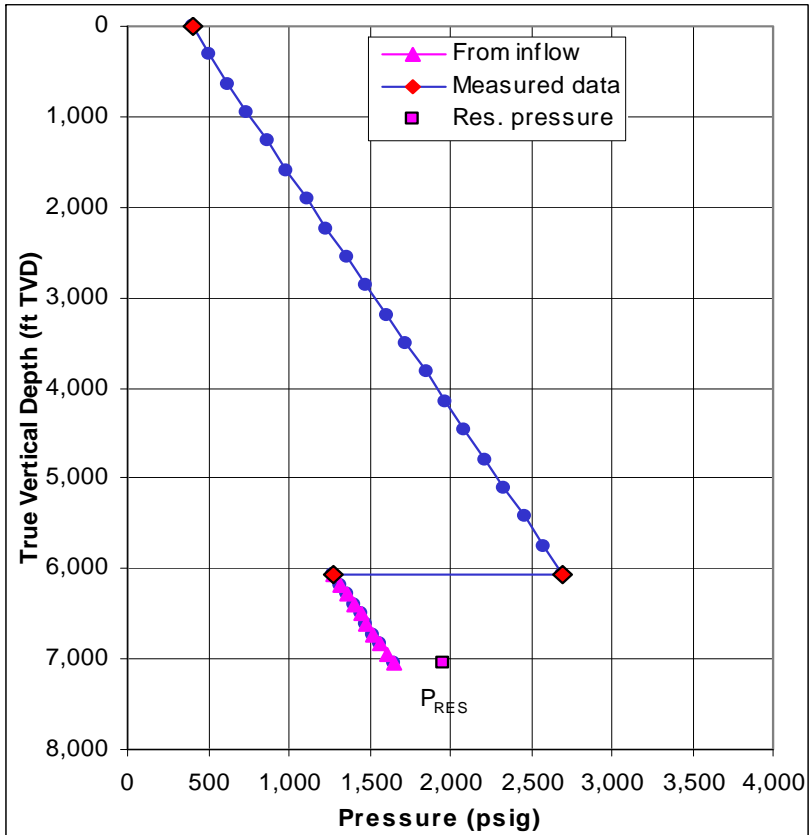
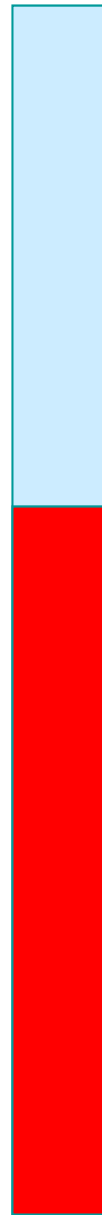




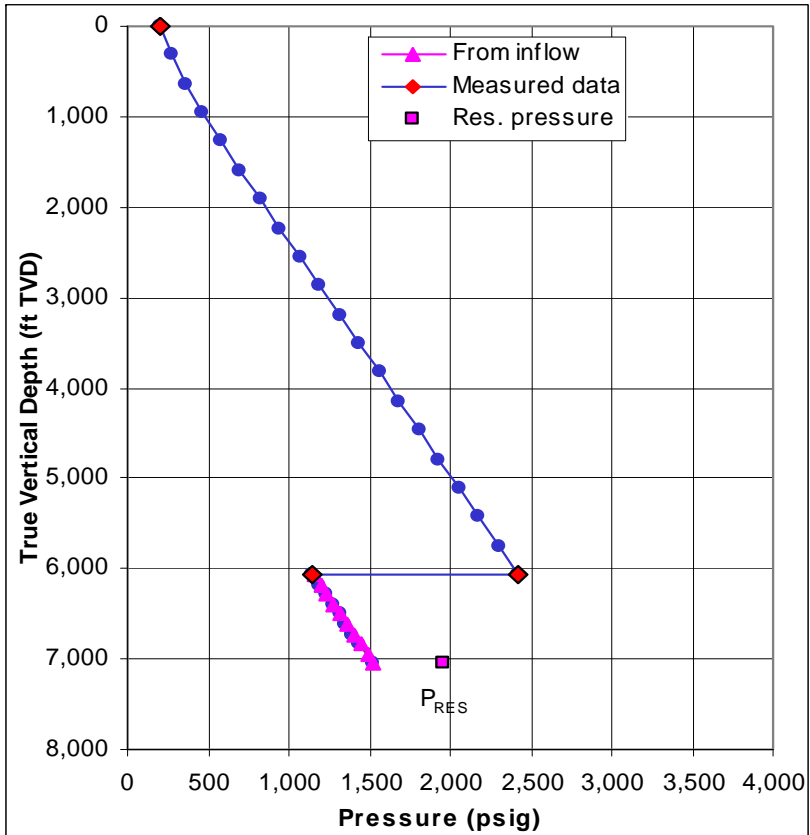
# WCut



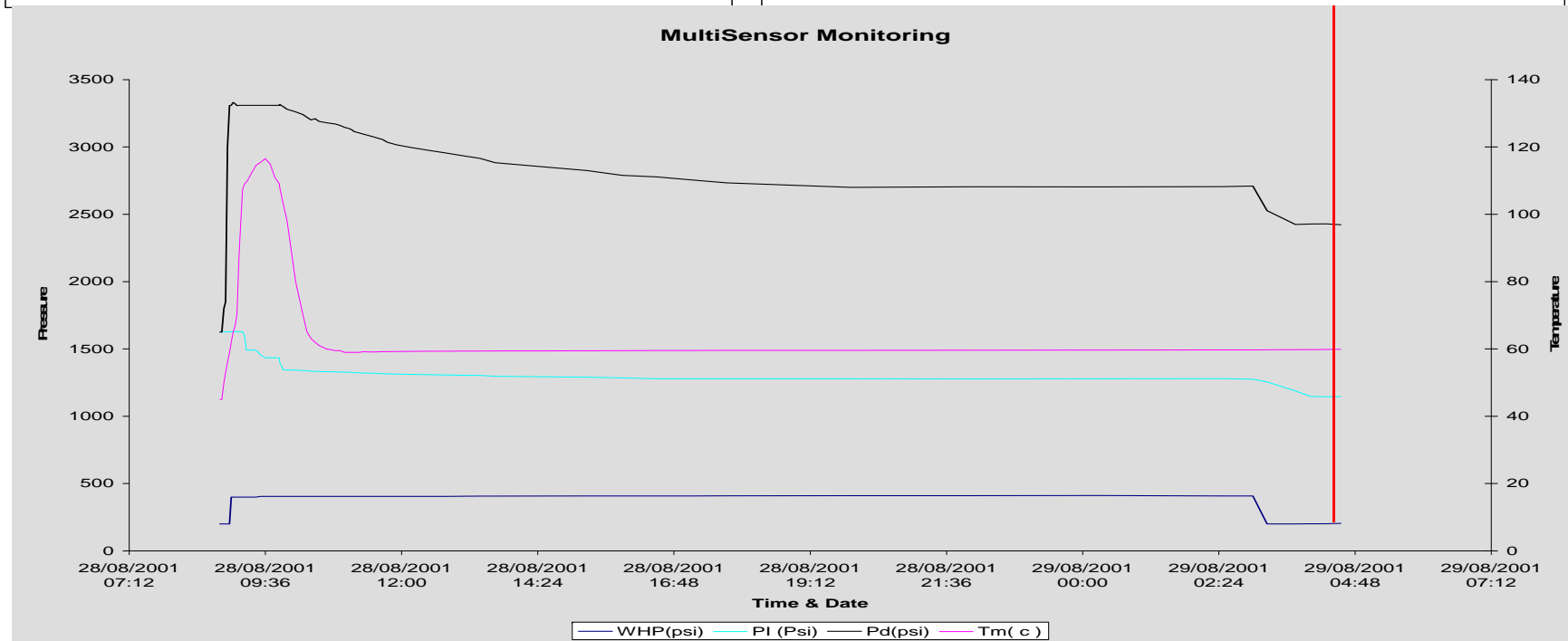
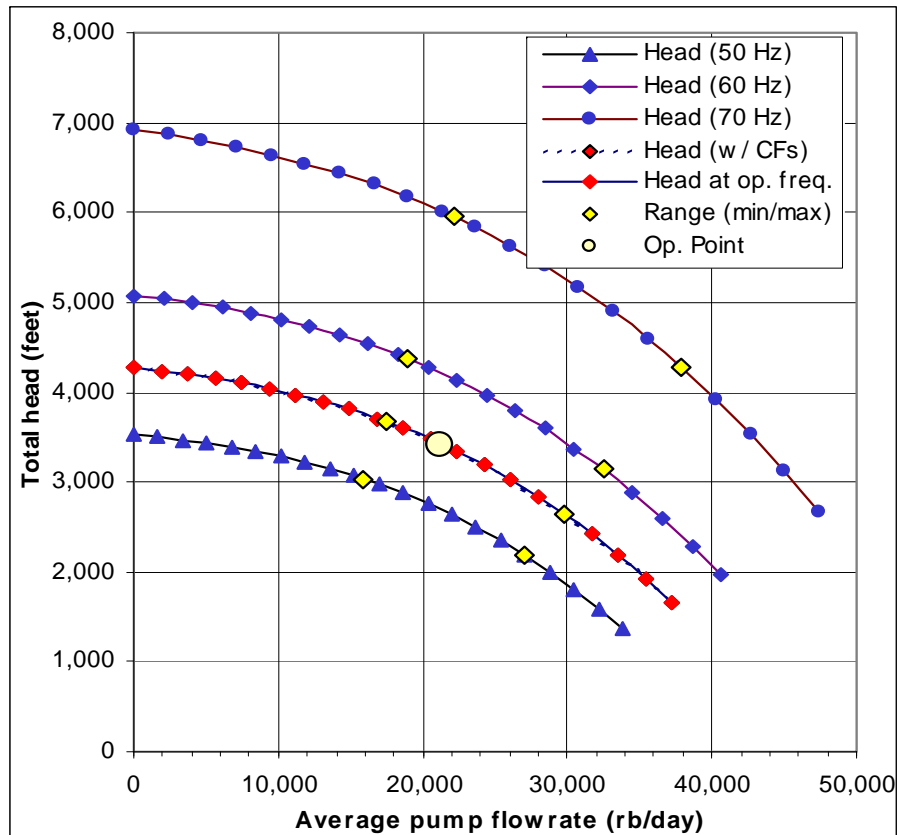
# Flow



# WCut

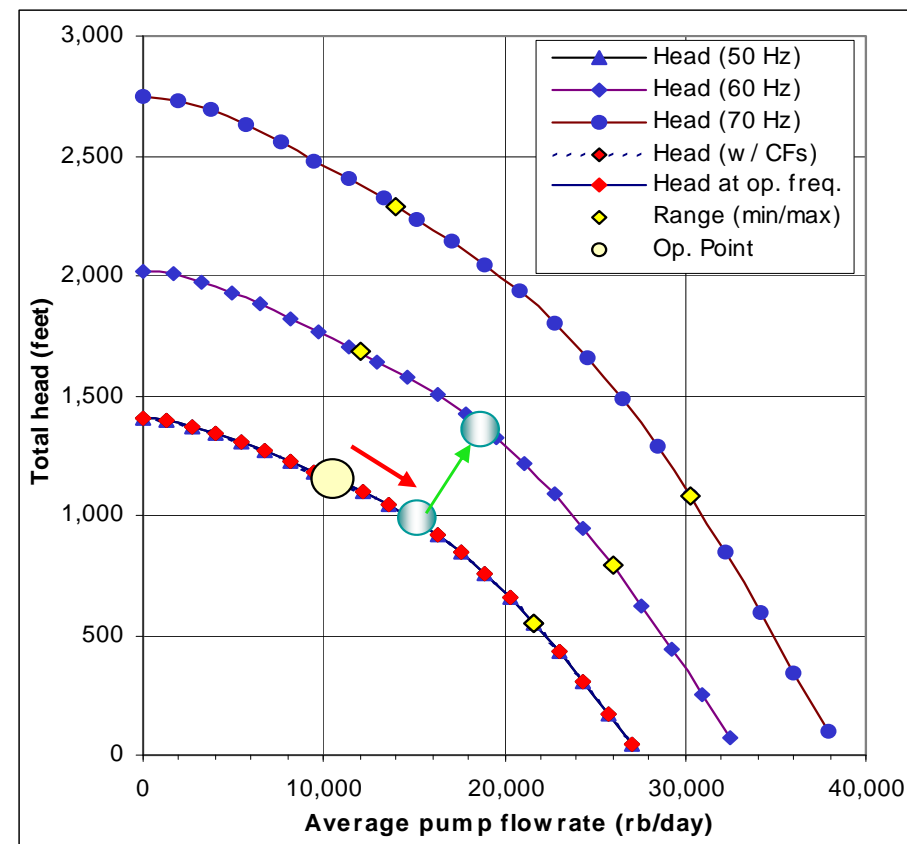
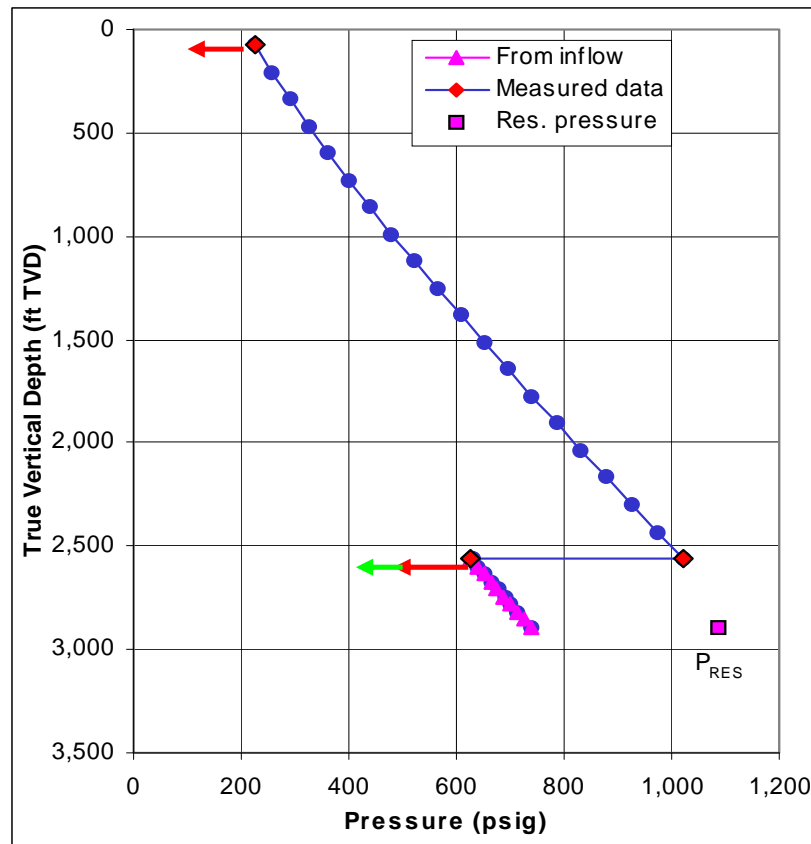


# Flow



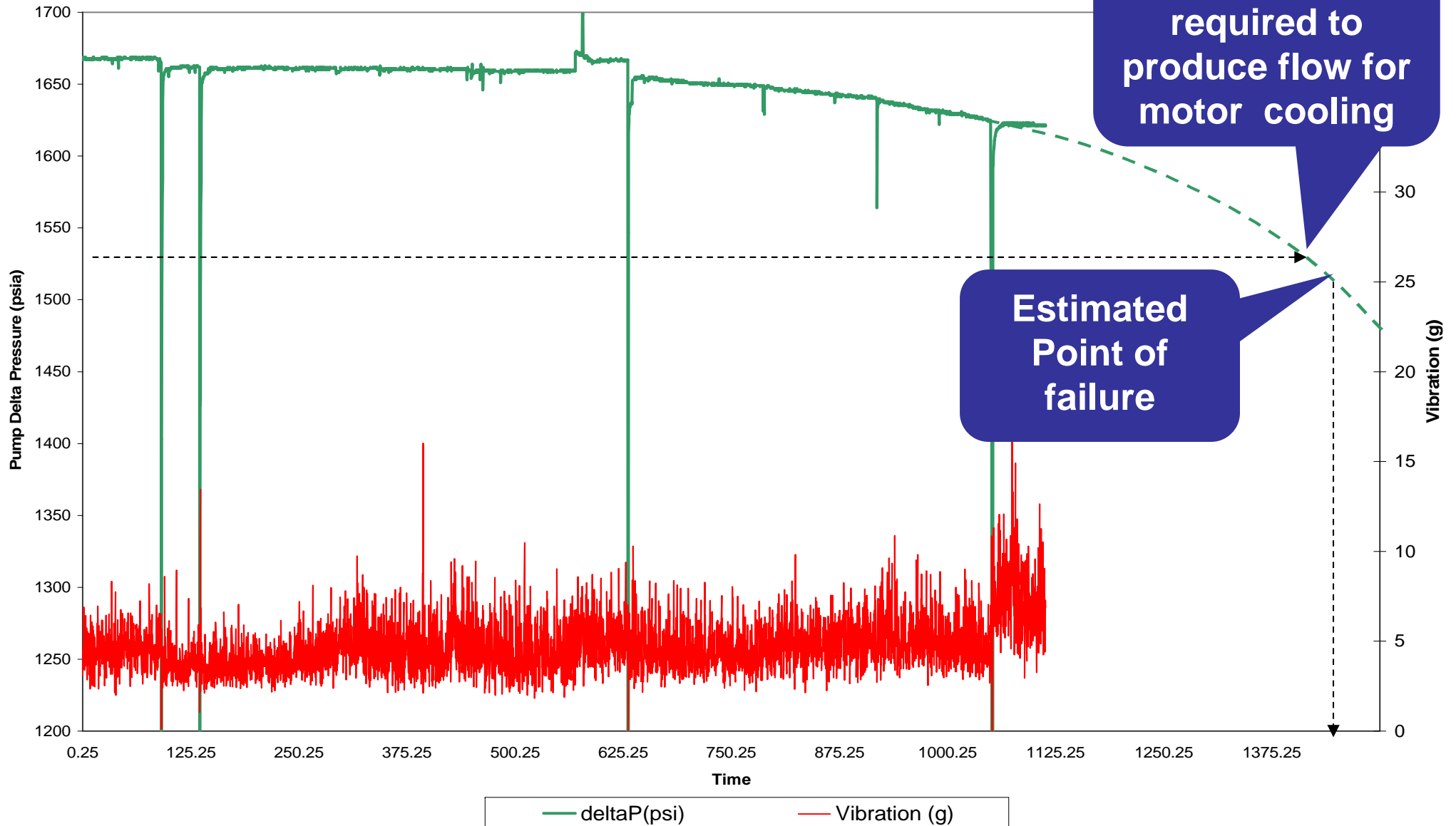
# ESP Optimisation

- Process of validation with measured downhole data.
- Increased production through advanced diagnosis.
- More efficient operating point, better use of power resources.
- Better understanding of well performance for subsequent pump design



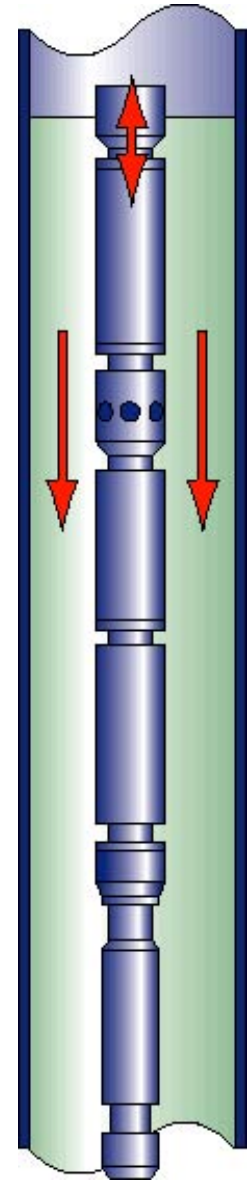
# Proactive Analysis Example

## Proactive Analysis



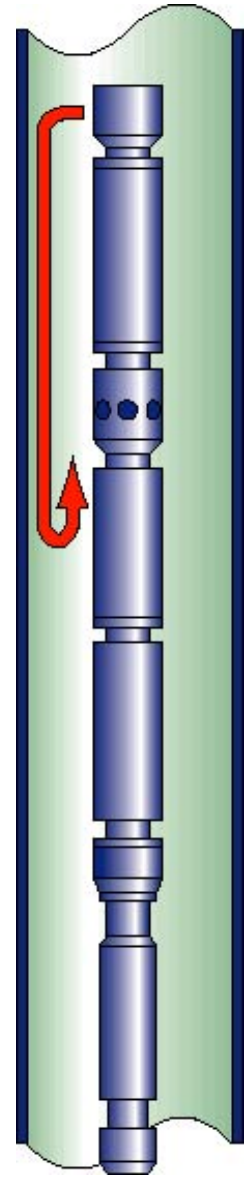
# Pressure Protection

- Intake Pressure
  - Low Trip – protect against Pump Off
    - Low Fluid Level
    - Gas Breakout
- Discharge Pressure
  - High Trip – protect against Shut In
    - Closed Valves
    - Heavy Fluid Slugs
- Delta Pressure
  - Low / High Trip – Upthrust / Downthrust
    - High Flow Conditions
    - Low Flow Conditions



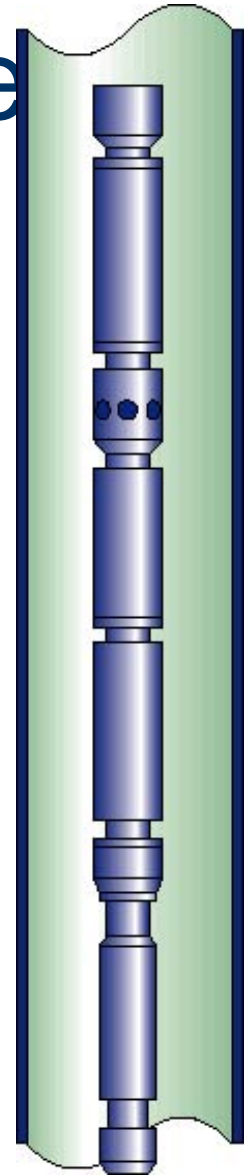
# Temperature Protection

- Intake Temperature
  - High Trip – protect excessive Intake Temp
    - Recirculation
- Motor Winding Temperature
  - High Trip – protect excessive Motor Temp
    - Low Flow
    - High Load
    - Anything that will cause the motor to heat



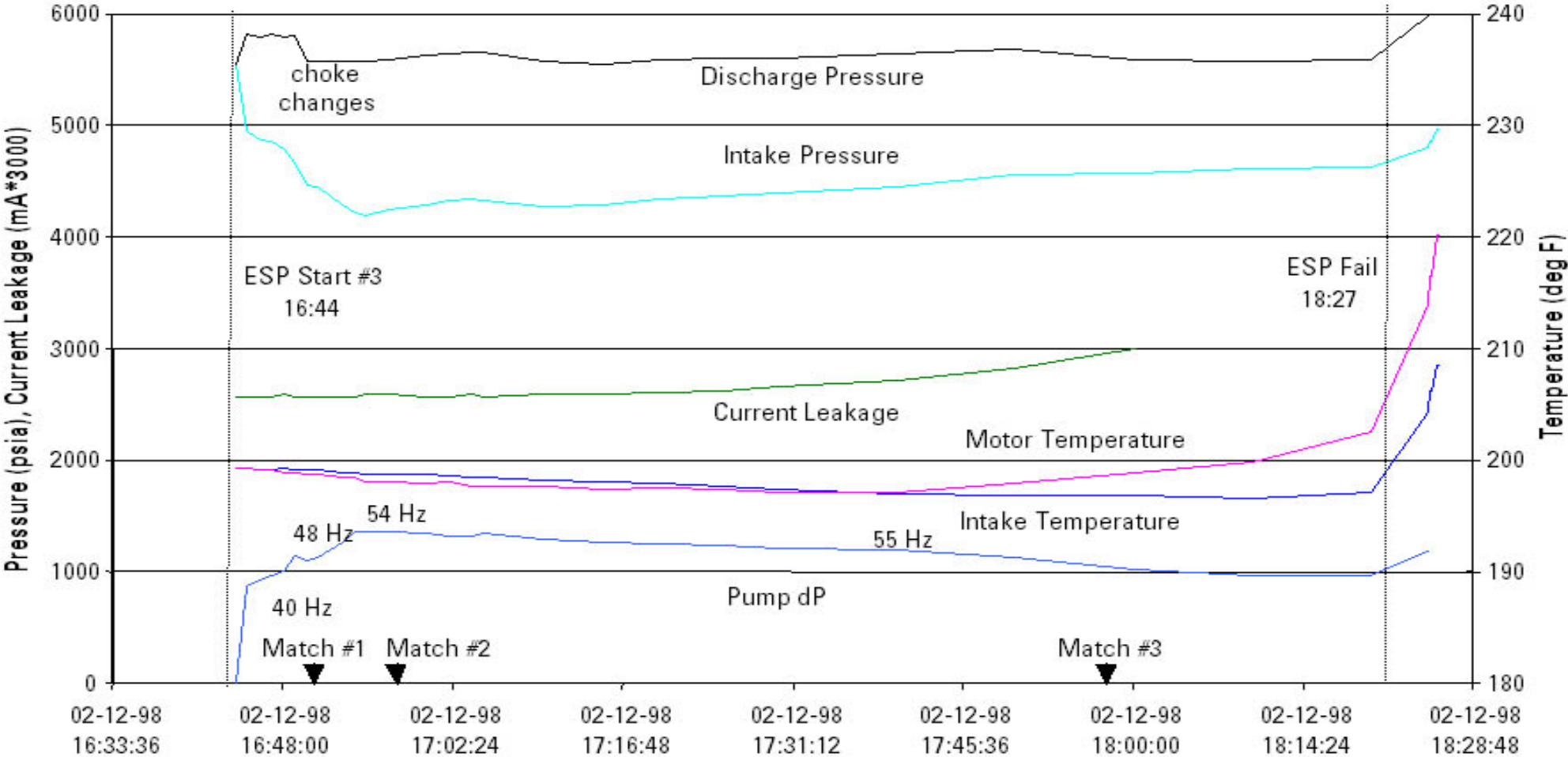
# Vibration & Current Leakage

- Vibration
  - High Alarm – Submersible Pump Mechanical Damage
    - High Solids Production
    - Warning of Mechanical Wear
    - Resonance ‘Frequency Fine Tuning’
- Current Leakage
  - High Alarm – Electrical System Deterioration
    - High Pump Heat (MLE)
    - Resistance Breakdown
    - Phase to Ground Warning



# Getting it Wrong

... and avoidable!





# Process of diagnosis

