Condition Monitoring to „protect“ the machine

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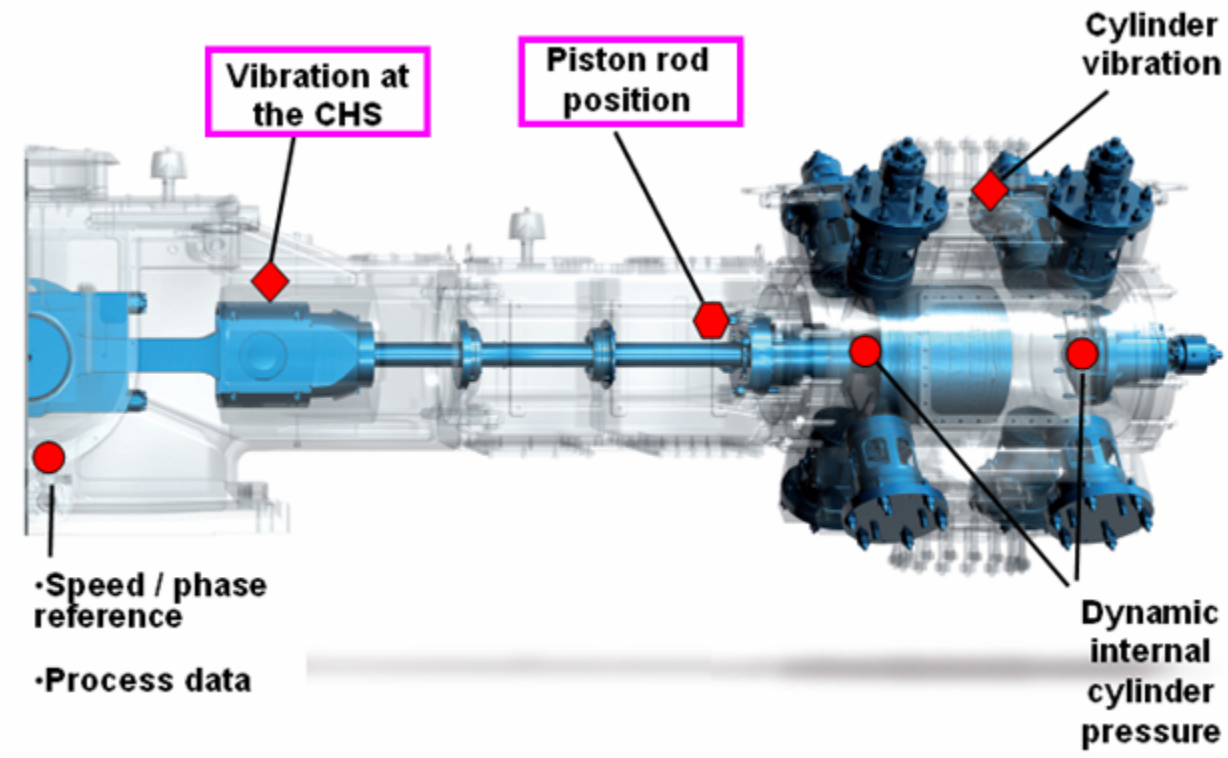
Explanation:

How to successfully manage challenging conditions?

- Continuously data stream
  (Comparative measurement)
- All-over data during event
  (Ring buffer)
- Event controlled safety setting and analysis
  (Segmentation)
- Use of specific measuring points and analysis
  (Crosshead and piston rod)

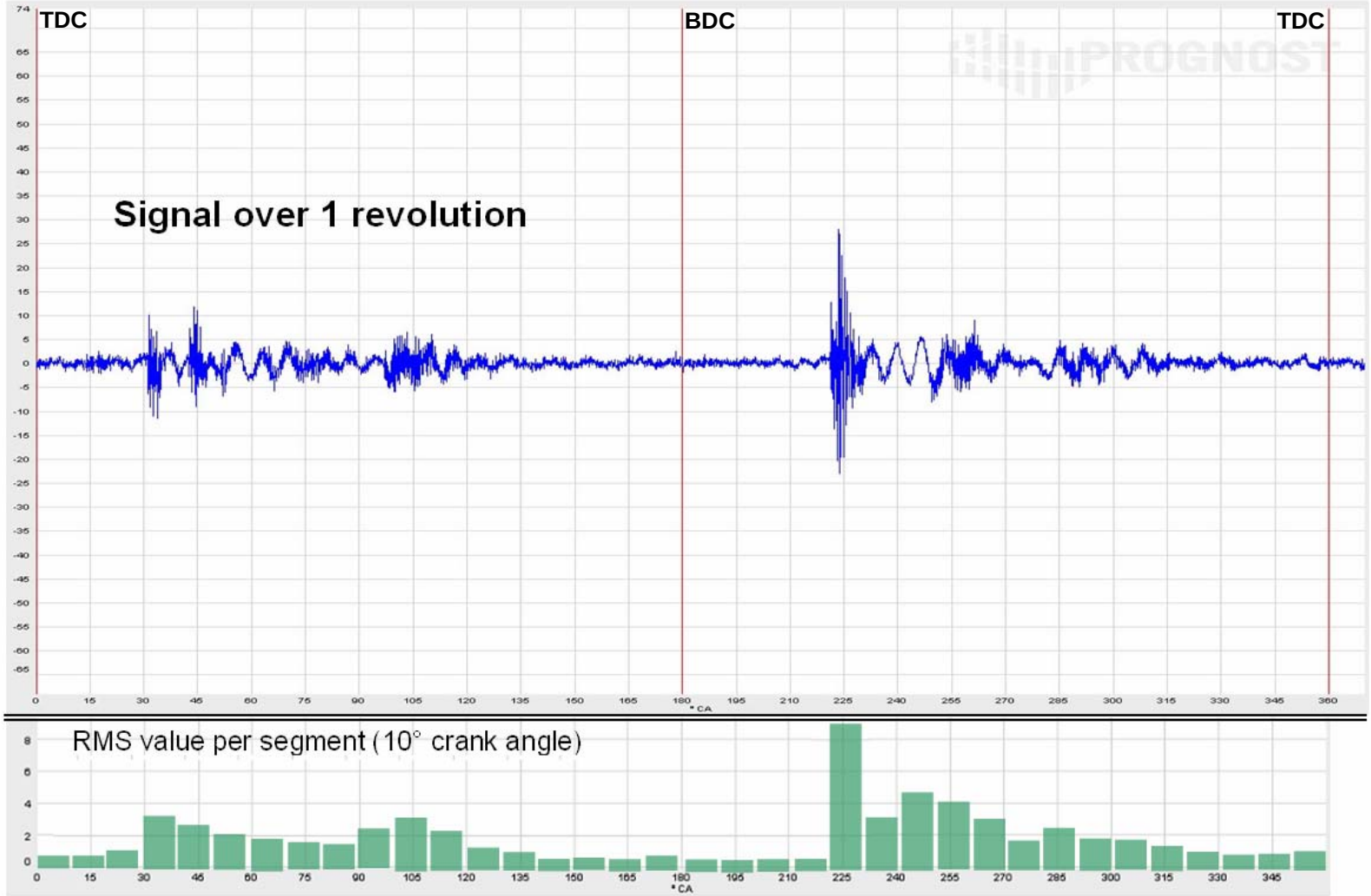
Explanation: Safety measuring points



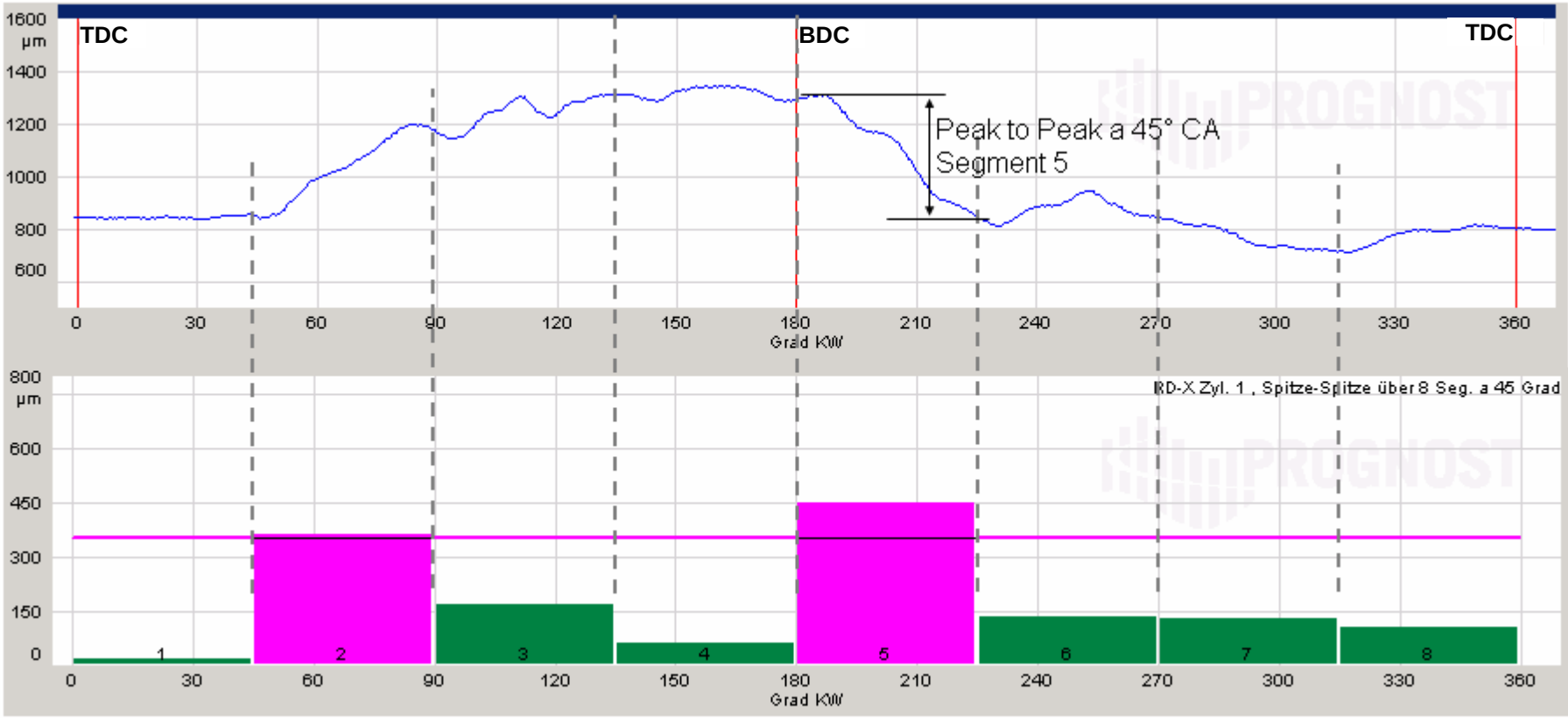
Sensors on Safety:

- Crosshead slide (CHS)
- Piston rod

Explanation: Safety analysis *CHS 36 Seg. RMS*



Explanation: Safety analysis *RP 8 Seg. PTP*



Explanation: Reliable shutdown algorithm

Input signals

Plausibility Check

Monitored parameters:
- Cross head slide acceleration
- Piston rod / Plunger position

Every crank rotation

Incl. segmentation

Alarm Conditions

Safety Limit Violation

... within how many rotations

.....within which segments?

... within how many segments?

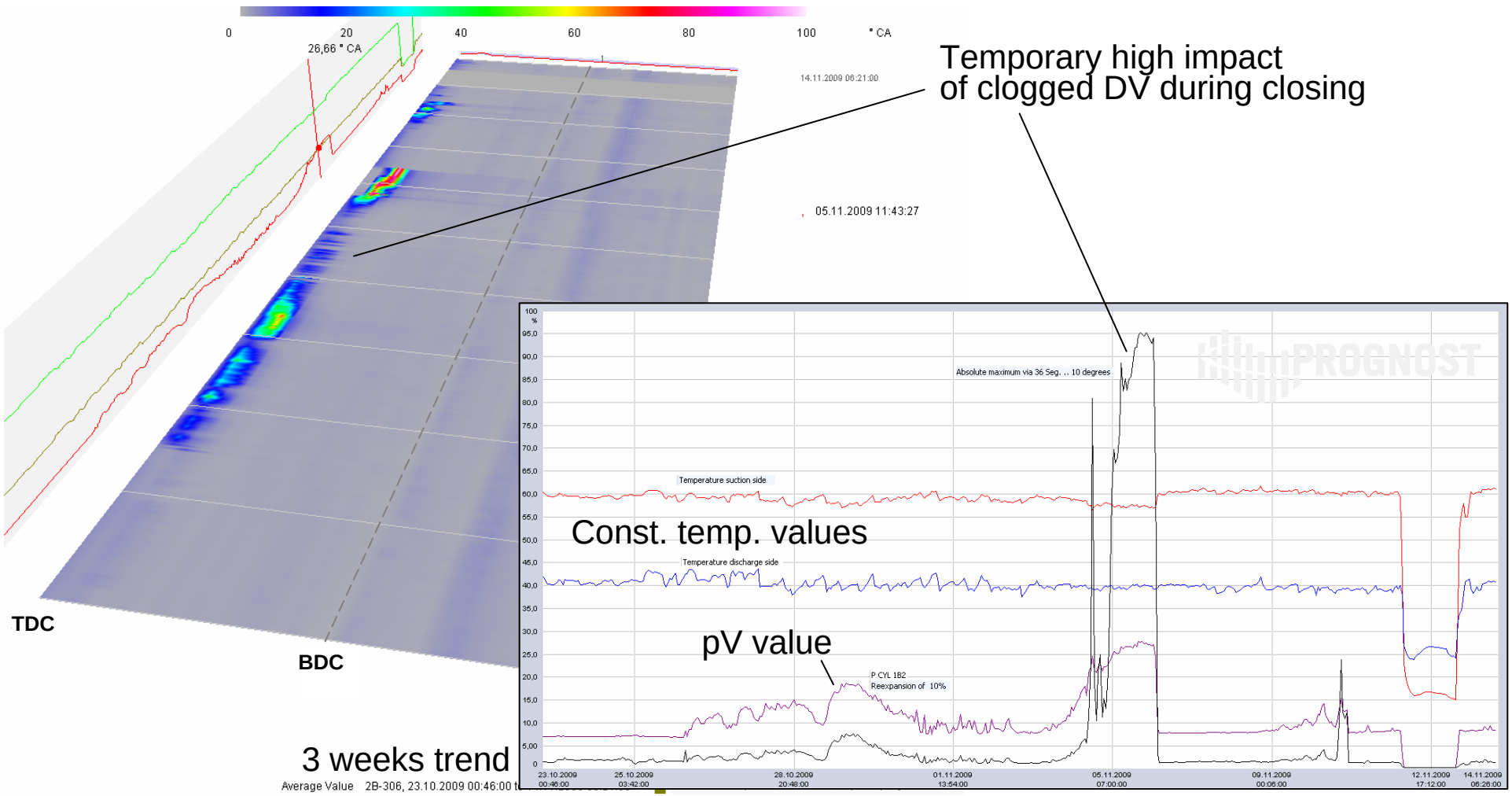
OR

AND

ALERT or SHUTDOWN

All-over data recording (10 minutes)
of all online time signals for each revolution

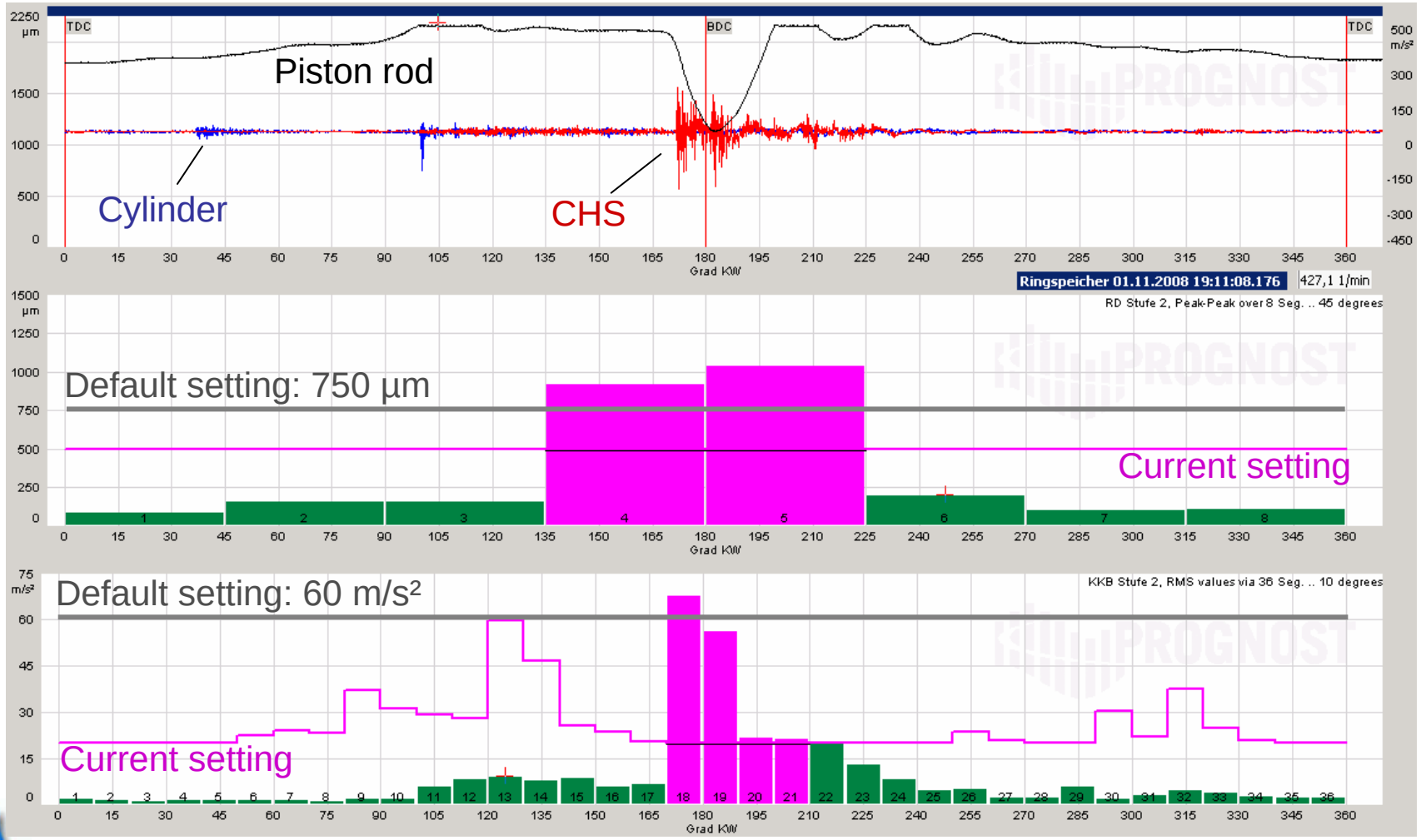
Explanation: Trend - Continuously data



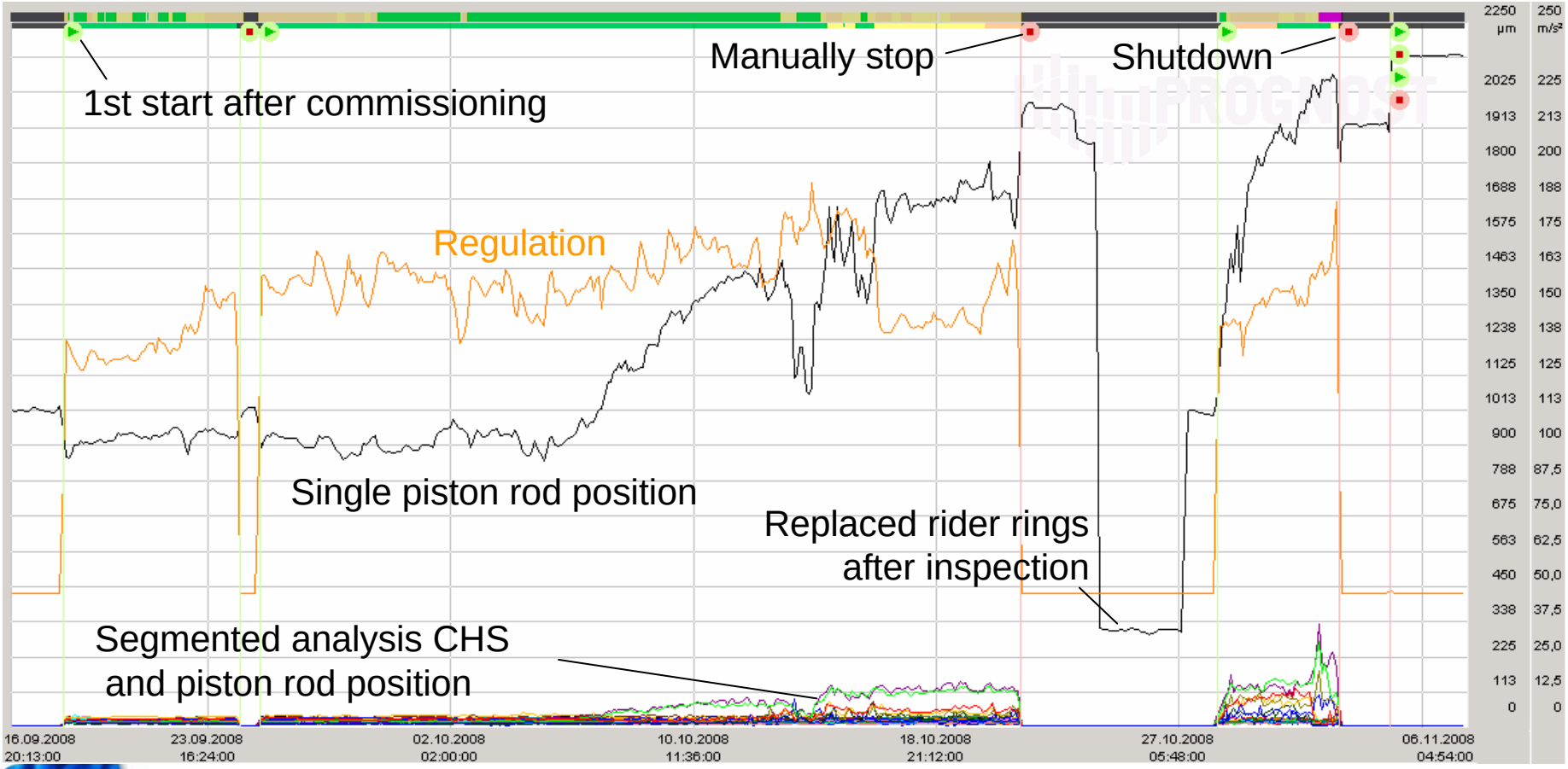
Case 1: Excessive rider ring wear

- Horizontal 545 kW 2-throw / H2 service
- Trip criteria: Piston rod position 8 Seg. PTP over 20 consecutive revolutions (by default setting)
- Rider ring wear and crumbled piston rings because of extremely wet gas
- No consequential damage
- Unknown gas specification upfront
- Problem solved by adding of a separator

Safety analysis

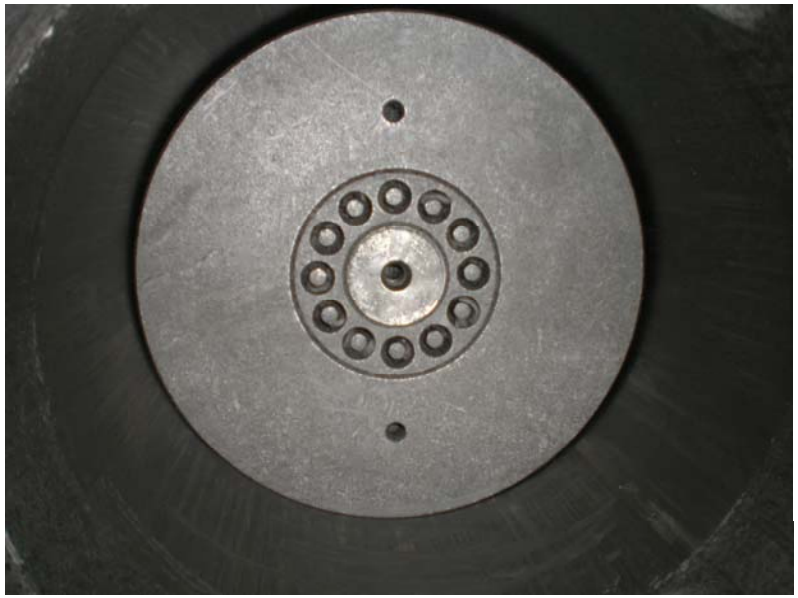


Development of event



- 3 weeks minute trend -

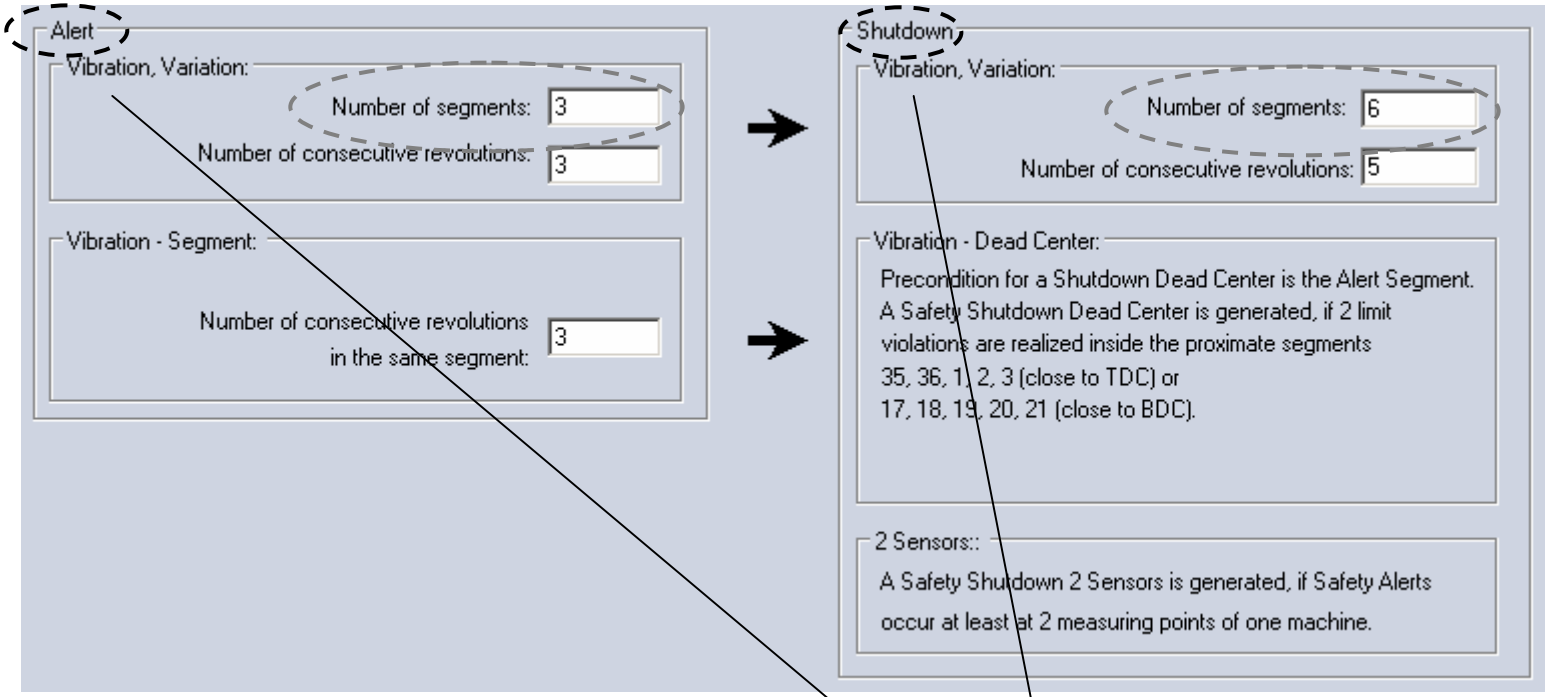
Findings



Case 2: Broken piston

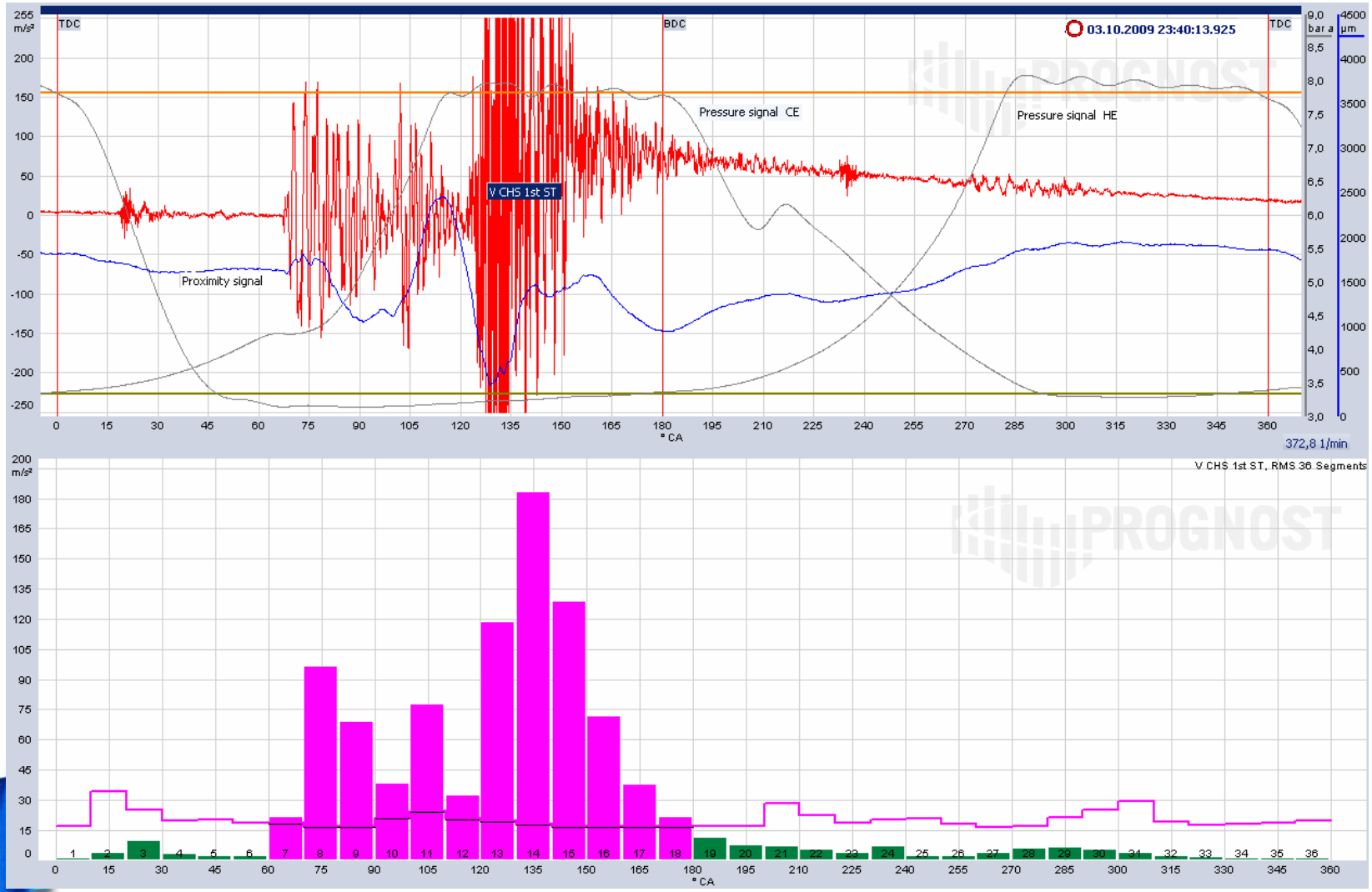
- Vertical 1400 kW 2-throw / H2 service
- Trip criteria: Acceleration CHS RMS
  36 segments over 5 consecutive revolutions
- Abrupt event
- No consequential damage

Shutdown definition



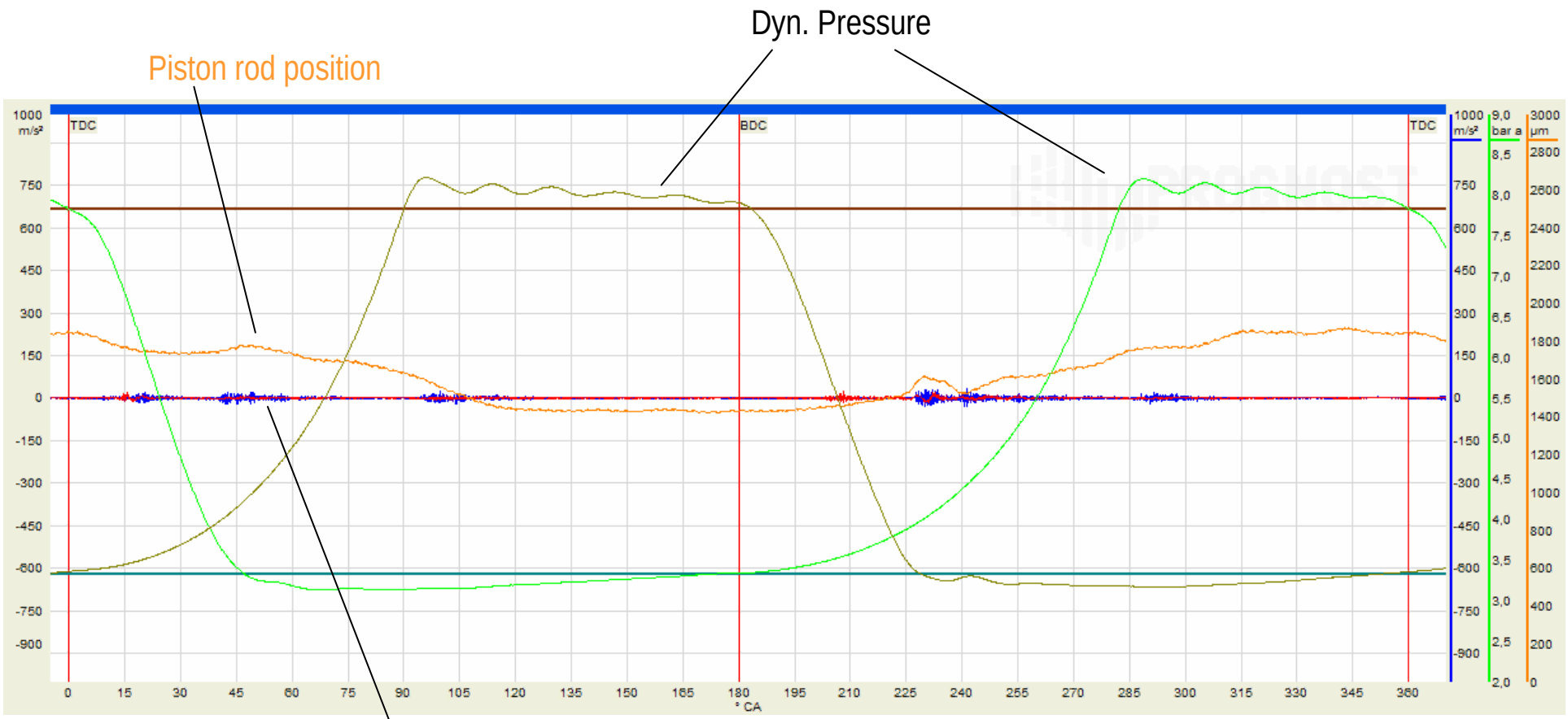
IMPORTANT	03.10.2009 23:40:17	V CHS 1st ST	Safety Alarm: Safety limit violated in at least 6 segments
IMPORTANT	03.10.2009 23:40:15	V CHS 1st ST	Safety Alert: Safety limit violated in at least 3 segments

Safety analysis



Finding

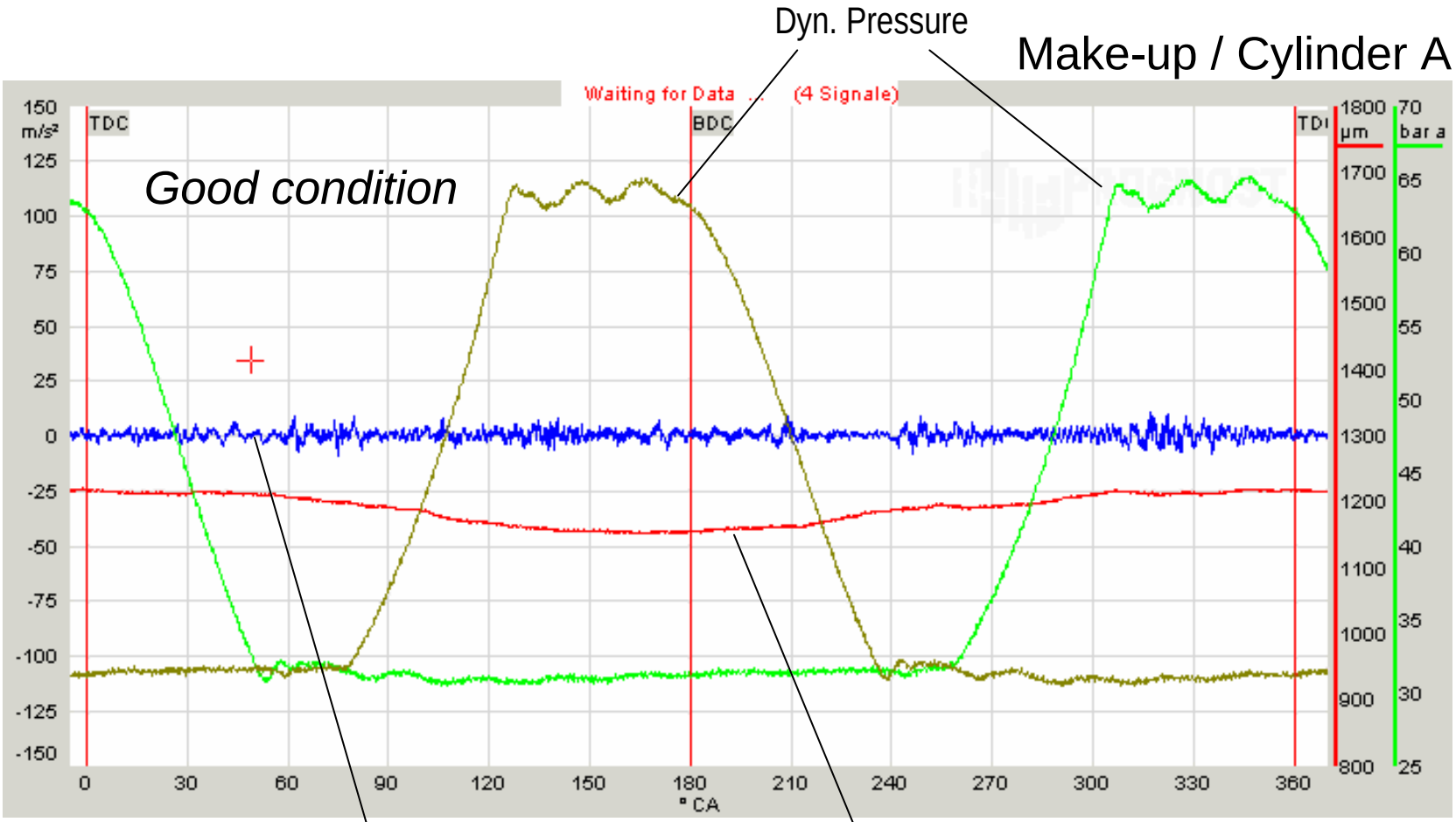
Ring buffer movie



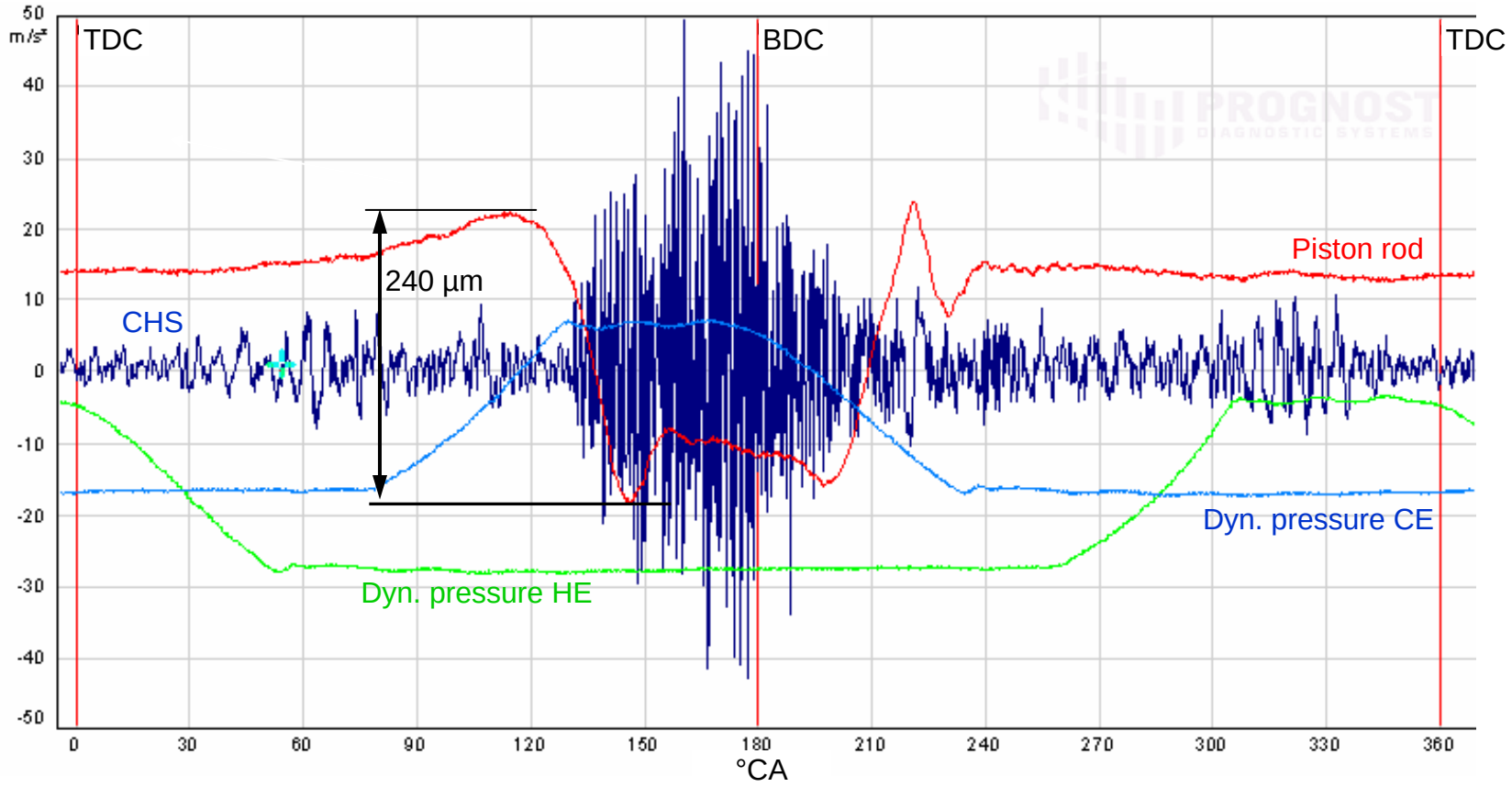
Case 3: Liquid Carry-over

- Vertical 1150 kW 4-throw / H2 service
- Ring buffer trigger: Acceleration CHS RMS
  36 segments over 5 consecutive revolutions
- HCOM control
- Sporadic event
- No damage

Ring buffer movie



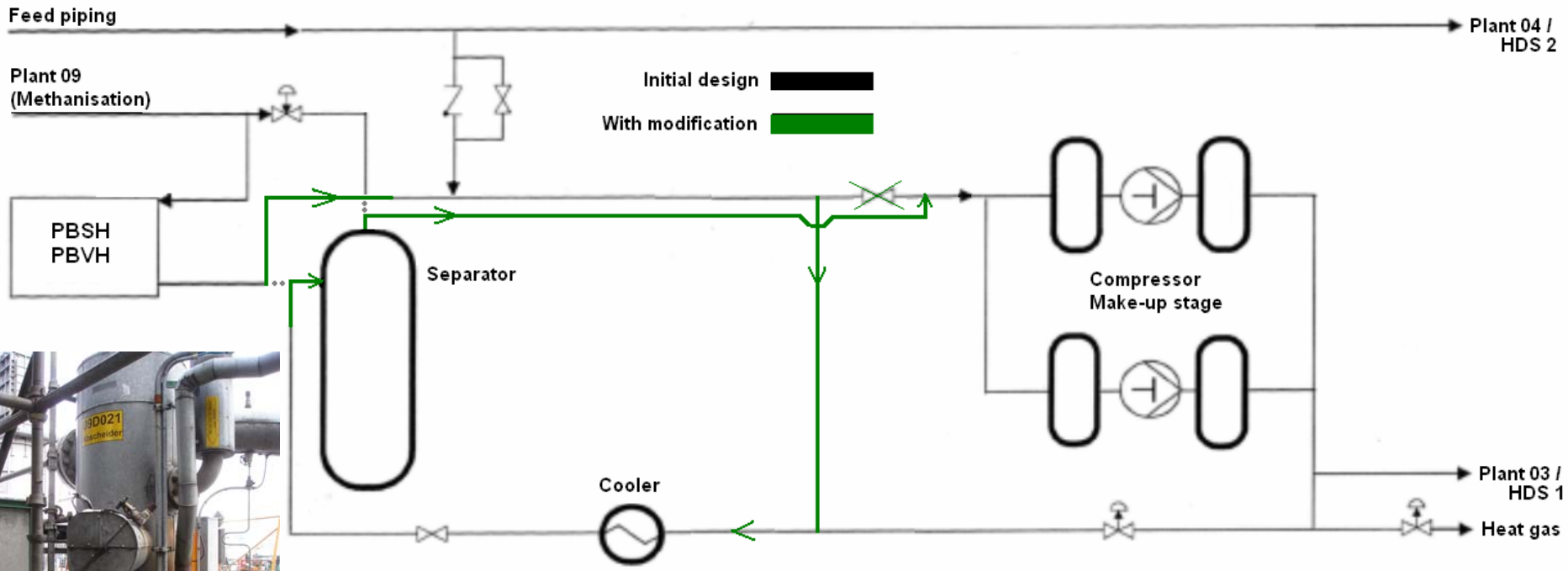
Ringbuffer data: Bad condition



During 11 revolutions at bottom dead center (BDC):

- High CHS acceleration
- Large piston rod displacement

H2 flow chart with modification



- Root cause:
  Failed elec. Heater
  External H2 supply with to low temperature / no separator

Summary

- Safety protection and condition monitoring
  has to be based on the same measurement value
- Root cause analysis based on stored data
  (Ring buffer and long-term trend)
- Early detection is possible -> No consequential damages

$\Rightarrow$ Highly effective tool for Safety Protection
and Condition Monitoring