

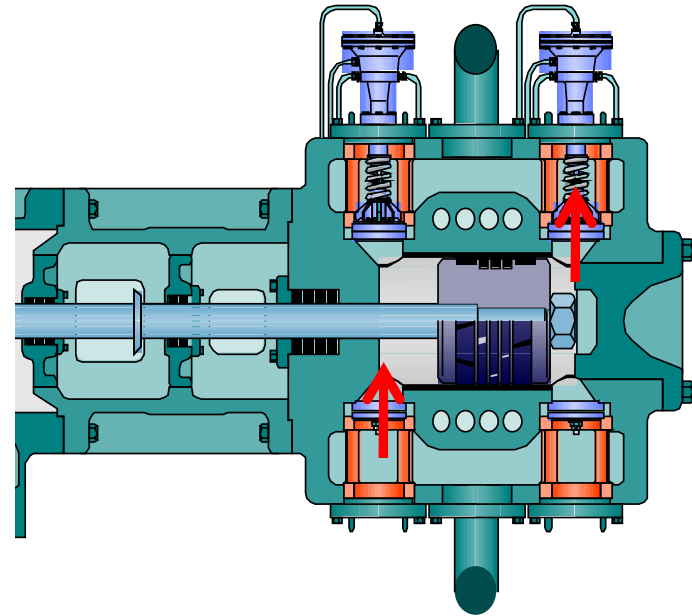
GMRC 2011 Analyzer Workshop

Diagnosing Leaking Valves and Rings - Basic and Complex

Warren Laible
Windrock, Inc



Valve Leakage



Suction or discharge valve leakage occurs when gas passes by the closed sealing elements or the seat gasket while there is a differential pressure across the valve.

The cylinder capacity is reduced and, in some cases, the required compression work load may remain the same or increase.

Measurable **Suction** Valve or Seat Leakage Characteristics:

Suction Cavity Temperature Increase

- As the gas is compressed in the cylinder end it is heated. This heated gas will leak into the suction cavity through the closed valve and raise the temperature in the suction cavity.
- The valve cap closest to the leaking valve may be the hottest.
- This heated gas is also made available to the other cylinder end that may be healthy.

Measureable **Suction** Valve or Seat Leakage Characteristics:

Discharge Temperature Increase

- Since the inlet gas to the cylinder is heated due to recycling across the leaking suction valve, the discharge temperature will also increase.
- Both ends of the cylinder will have an increase in discharge temperature.
- The cylinder end with the valve leakage will generally increase more.
- The temperature at the discharge nozzle is a blend of both cylinder ends.

Measurable **Suction** Valve or Seat Leakage Characteristics:

Discharge Delta Temperature Increase

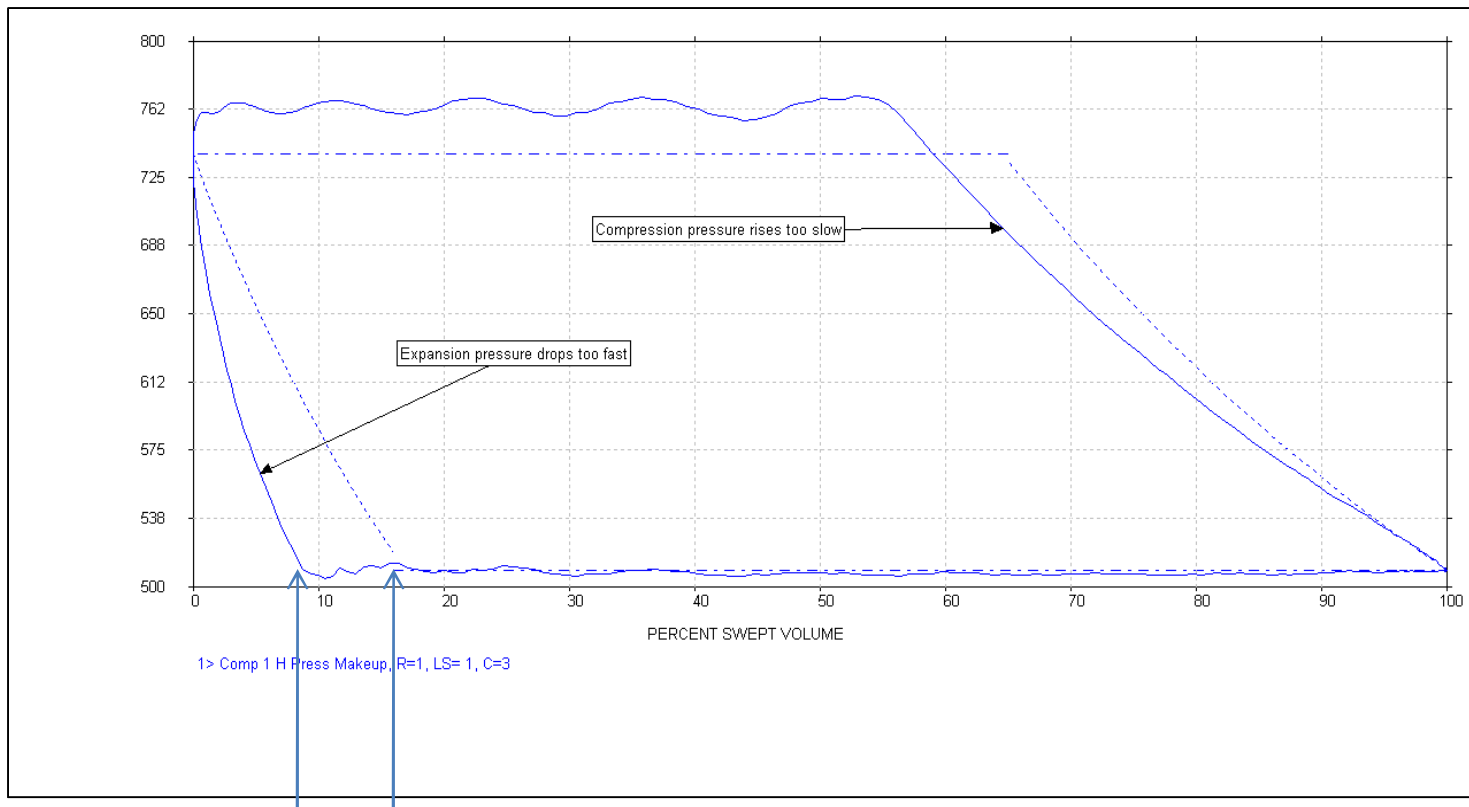
- Discharge delta temperature is measured discharge temperature - theoretical discharge temperature.
- This delta temperature will generally increase as the suction leakage progresses.

Measurable **Suction** Valve or Seat Leakage Characteristics:

Indicated Suction Volumetric Efficiency Increase

- For a fixed pressure ratio, the measured suction volumetric efficiency will increase.
- Since high pressure gas is leaking out of the cylinder during the expansion event, the internal cylinder pressure will drop faster than normal and will reach suction pressure earlier in the stroke.
- The **calculated** suction flow rate will increase.

Indicated **Suction** Volumetric Efficiency Increase

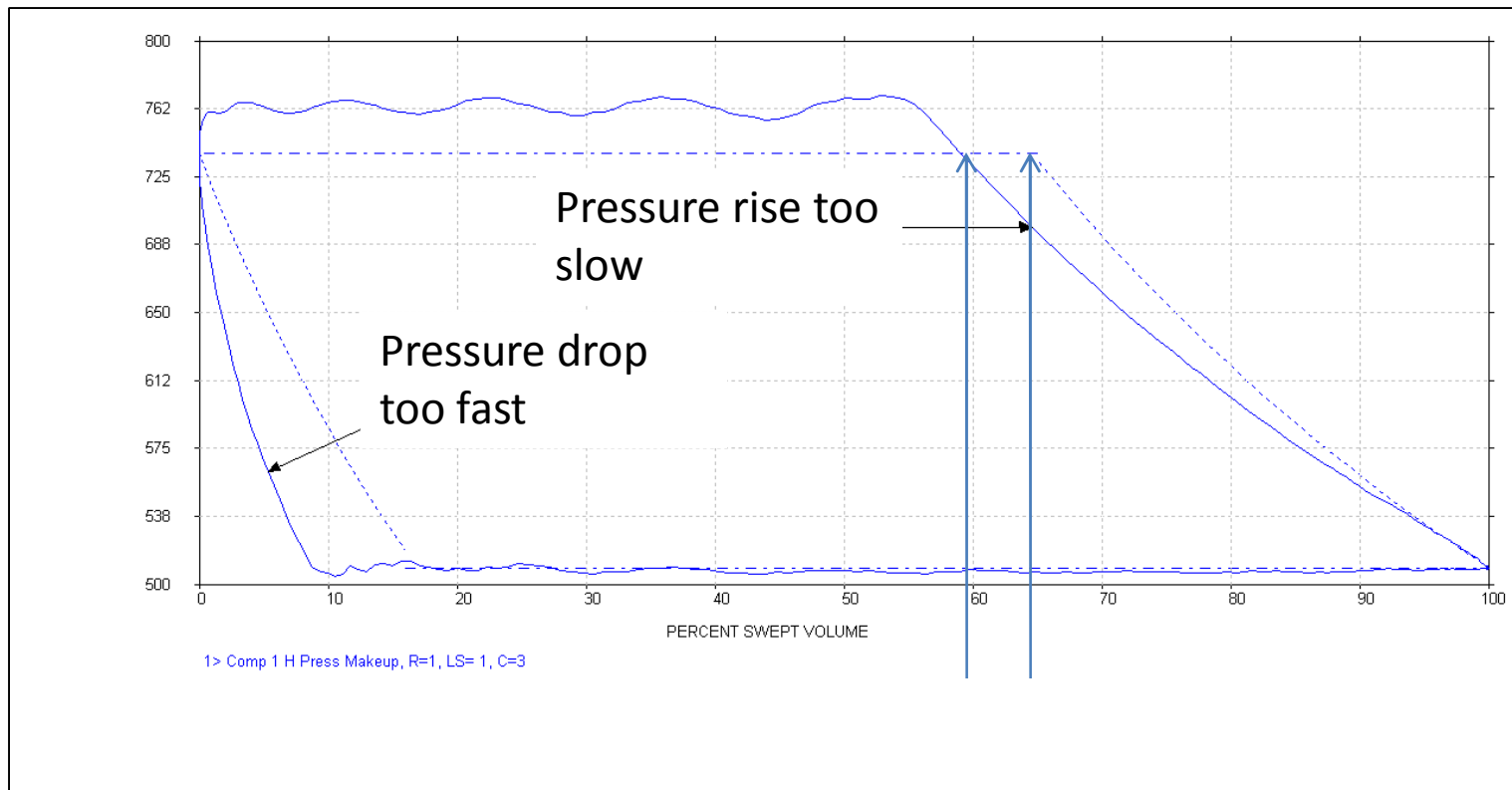


Measureable **Suction** Valve or Seat Leakage Characteristics:

Indicated Discharge Volumetric Efficiency Decrease

- For a fixed pressure ratio, the measured discharge volumetric efficiency will decrease.
- Since high pressure gas is leaking out of the cylinder during the compression event, the internal cylinder pressure will remain below discharge pressure for a longer percentage of the stroke.
- The **calculated** discharge flow rate will decrease.

Indicated **Discharge** Volumetric Efficiency Decrease with Suction Leakage



Measurable **Suction** Valve or Seat Leakage Characteristics:

Calculated Flow Balance is Greater than 1.0

Flow balance is the **calculated** suction flow rate divided by the **calculated** discharge flow rate. The average calculated flow rate may not appear to change much in the performance report; however, the externally **measured** flow rate may be significantly reduced.

Measurable **Suction** Valve or Seat Leakage Characteristics:

Reduction in the **Calculated** Clearance Volume From the Expansion Line

If you are calculating cylinder clearance volume from the expansion line and suction volumetric efficiency, the clearance will **appear** less than when the cylinder was healthy.

Measurable **Suction** Valve or Seat Leakage Characteristics:

Increase in the **Calculated** Clearance Volume From the Compression Line

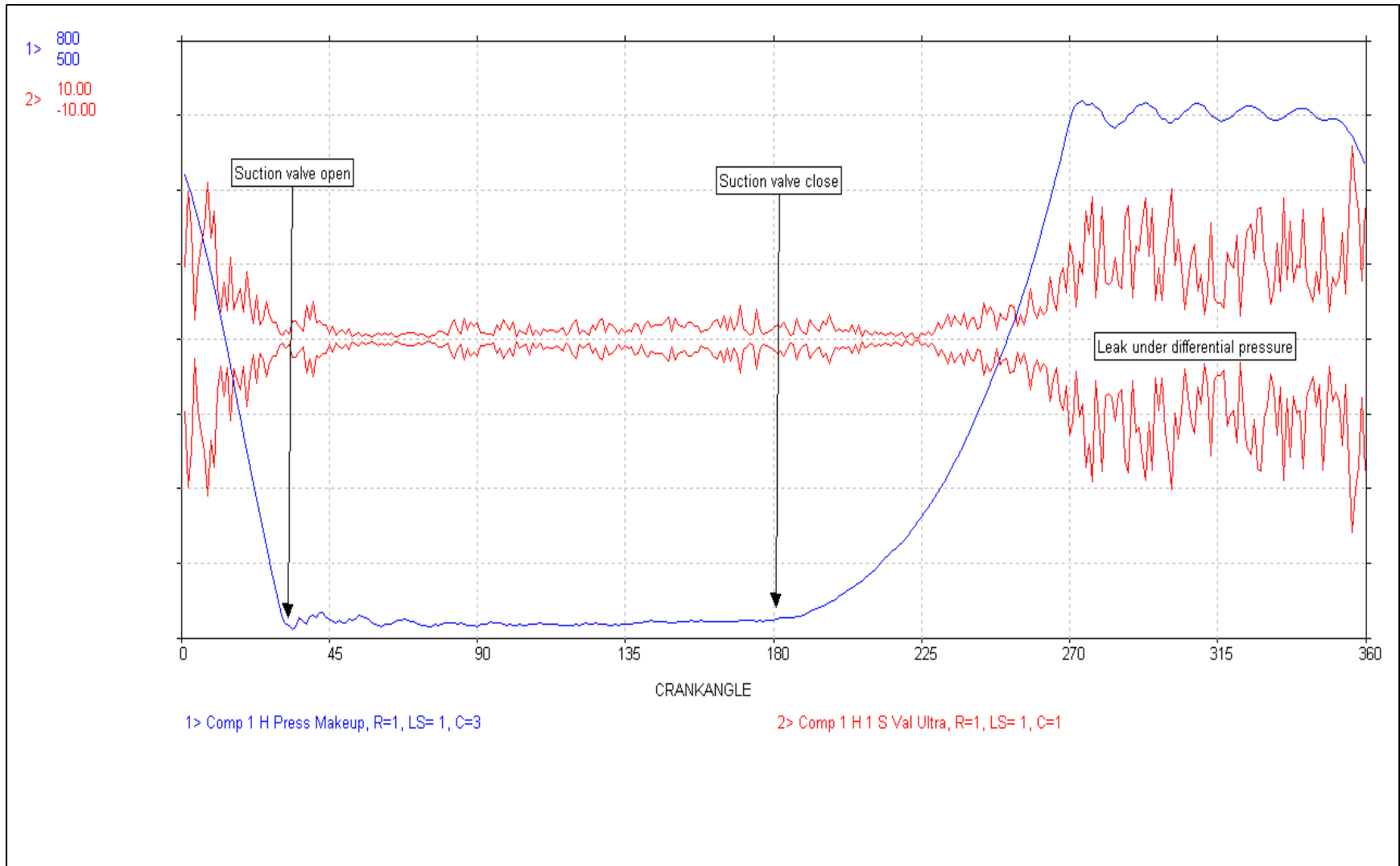
If you are calculating cylinder clearance volume from the compression line and discharge volumetric efficiency, the clearance will appear greater than when the cylinder was healthy.

Measurable **Suction** Valve or Seat Leakage Characteristics:

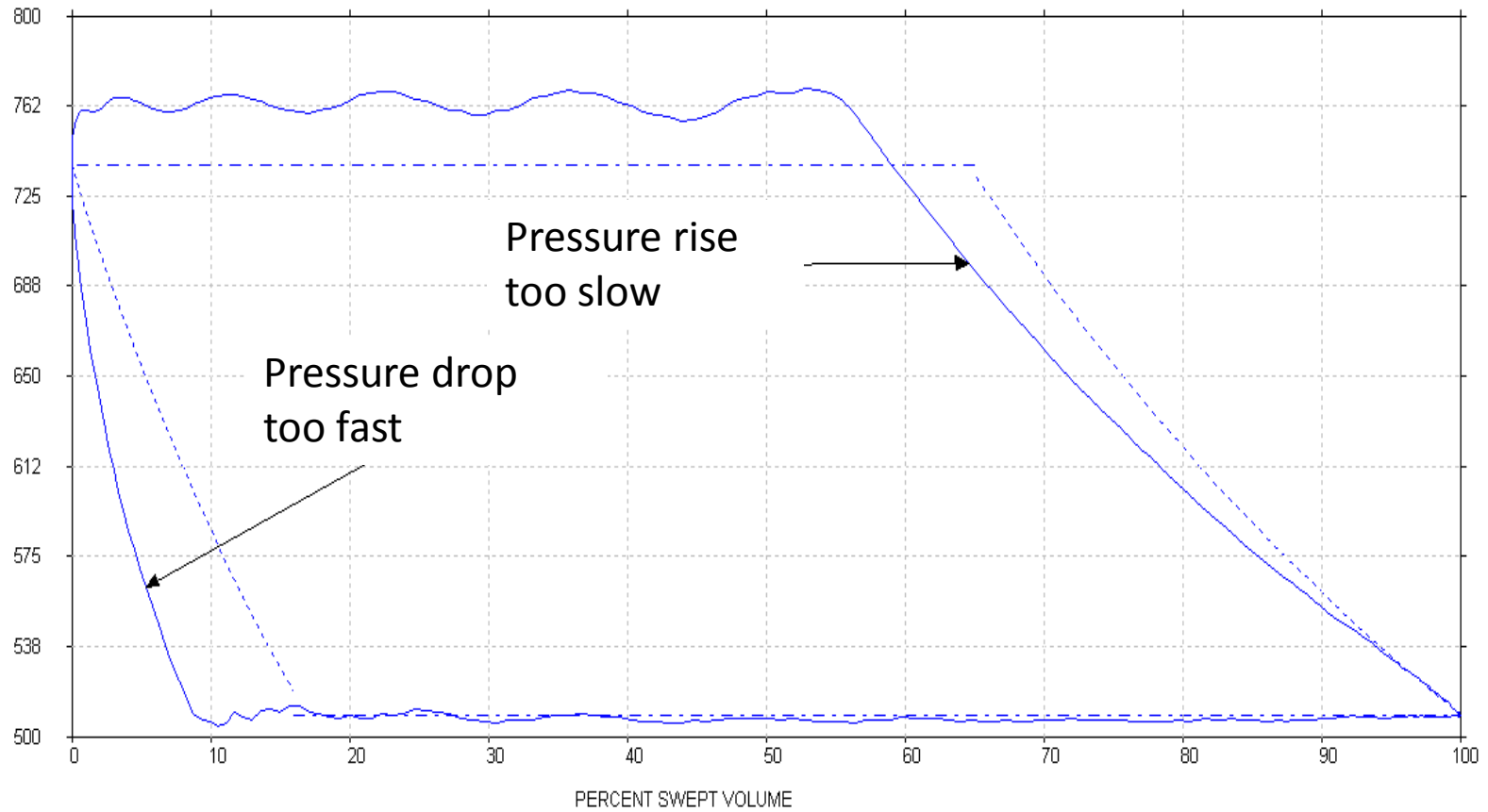
A defective valve leaks when it is closed; therefore, the ultrasonic traces will indicate leakage after the normal valve closure and will indicate greater leakage activity as the differential pressure increases.

The leakage will stop when the valve re-opens.

Head-End Pressure & Ultrasonic Vs. Crank-Angle

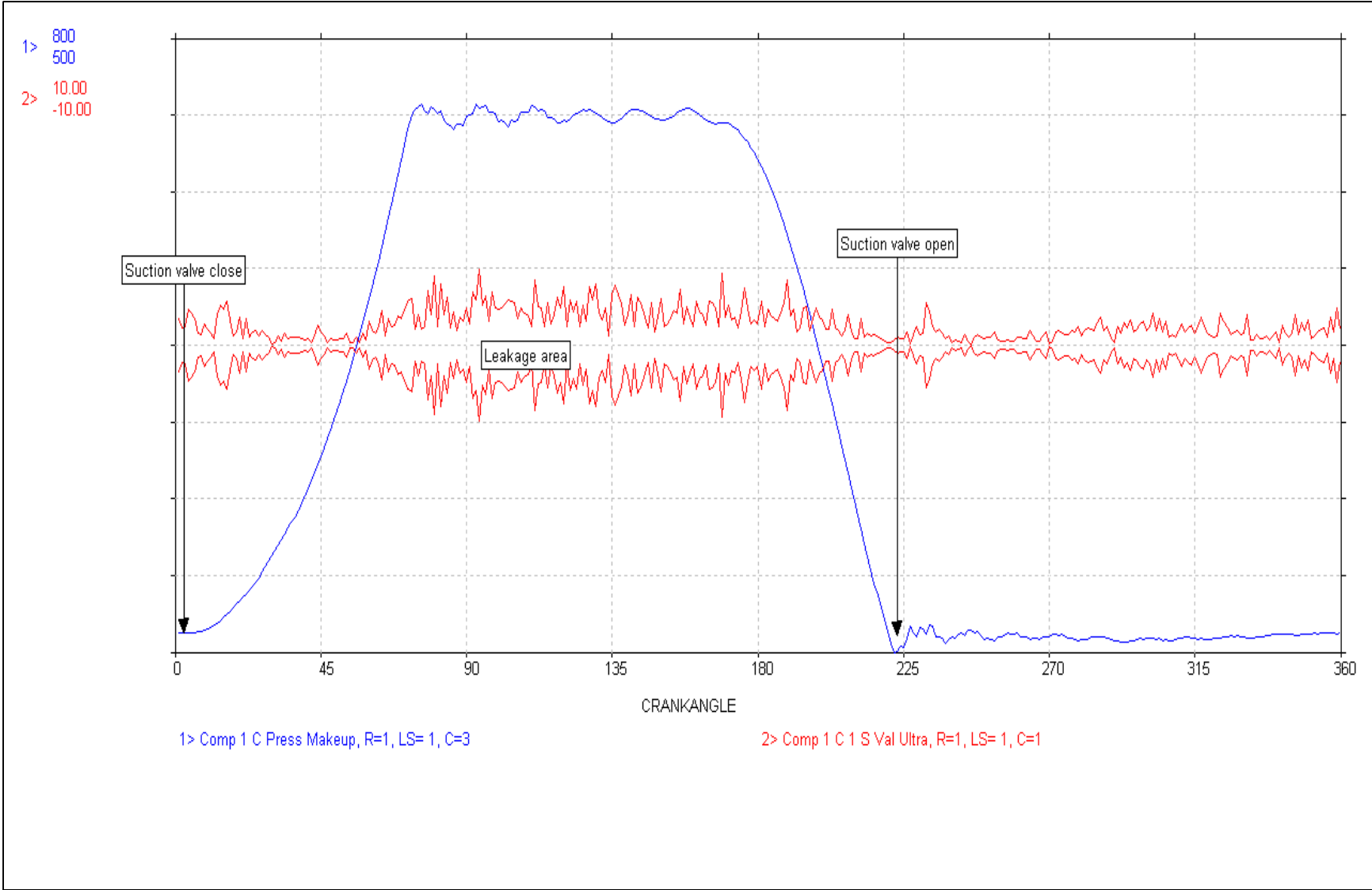


Head-End Pressure Vs. Displaced Volume with Suction Valve Leakage

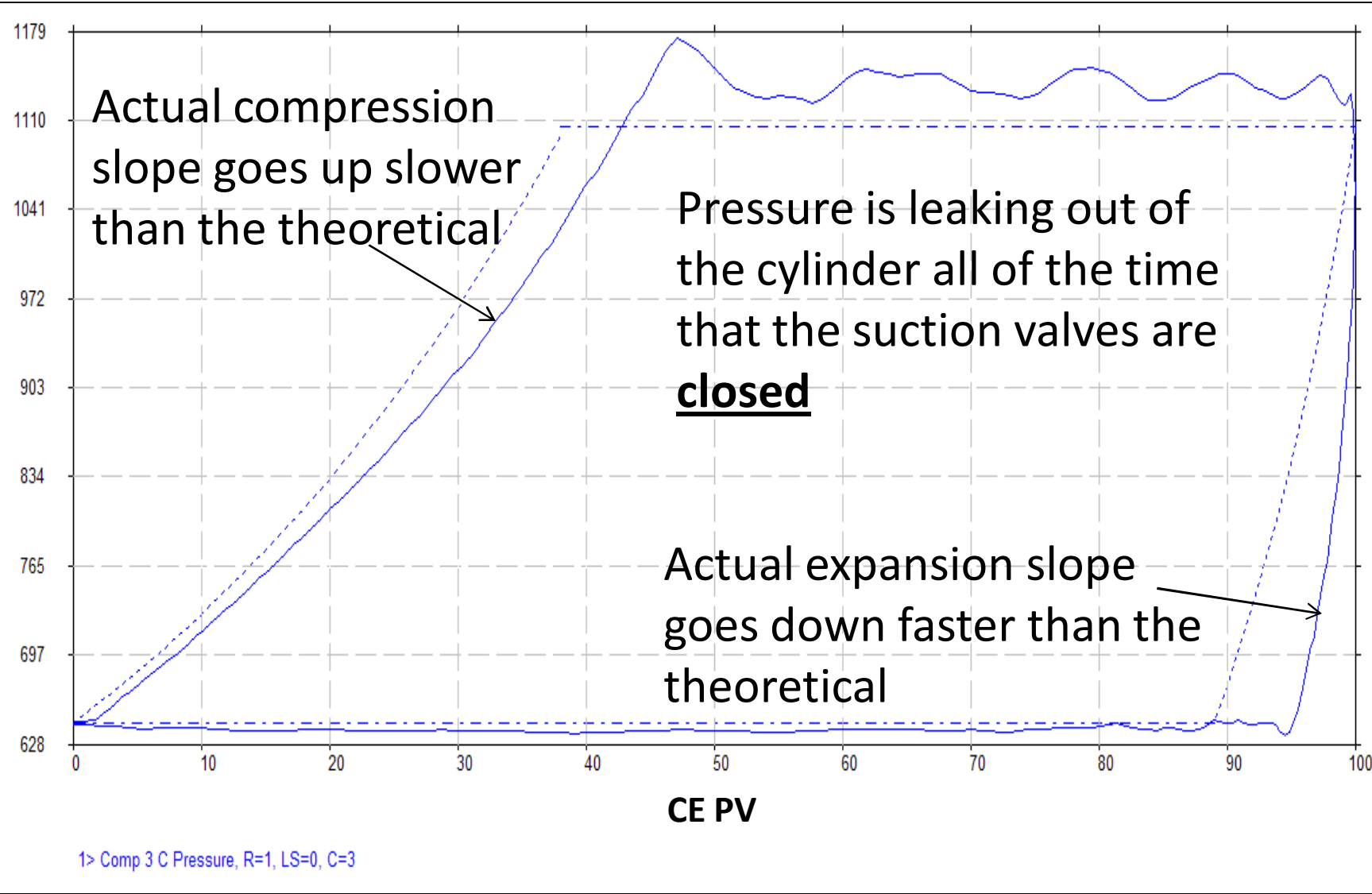


1> Comp 1 H Press Makeup, R=1, LS= 1, C=3

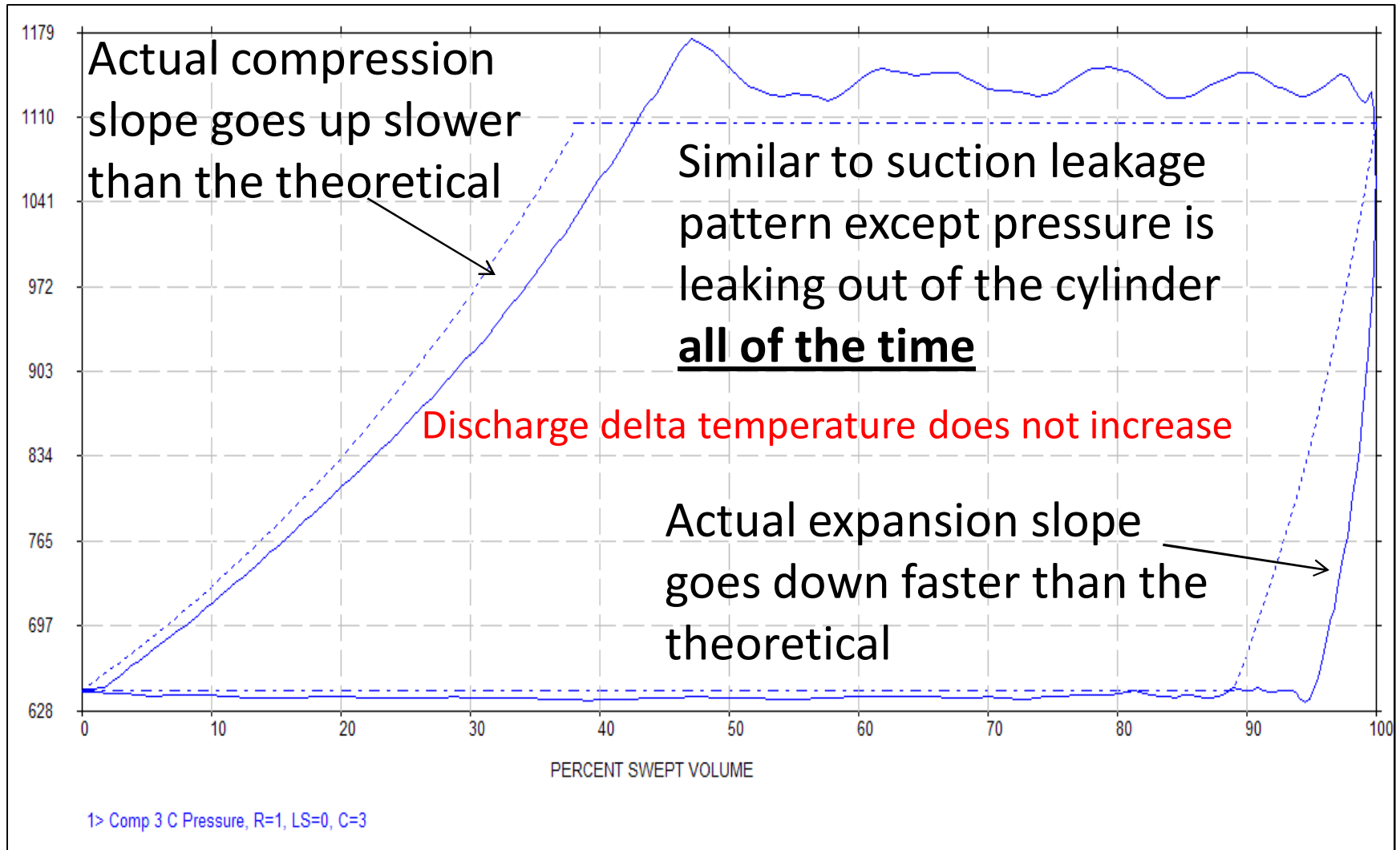
Crank-End Pressure Vs. Crank-Angle With Suction Valve Leakage



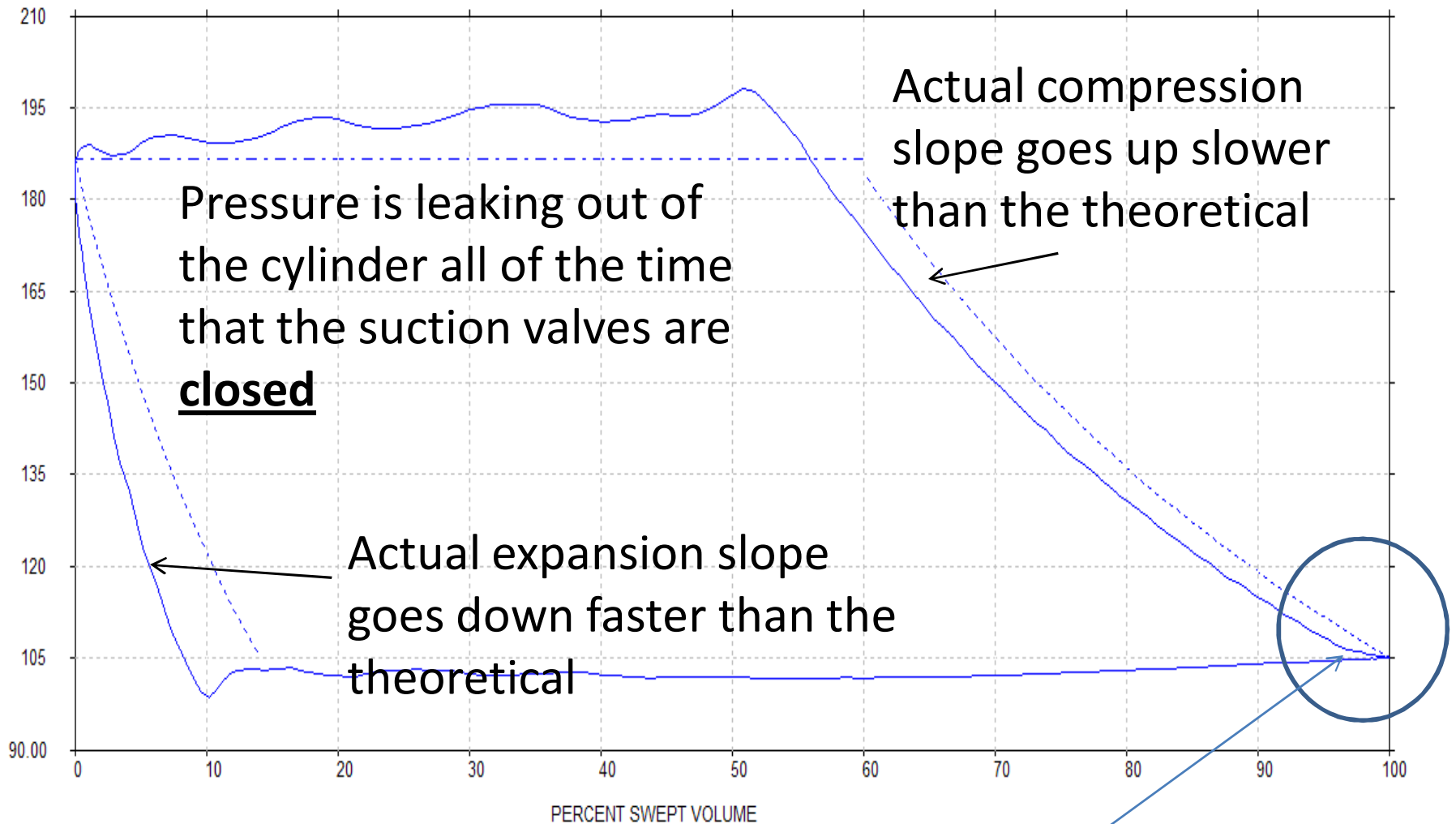
Crank-End PV With Suction Valve Leakage



Crank-End Cylinder Pressure With **Packing** Leakage



Head-End Suction **Un-loader** Leakage (Finger Type)



1> Comp 1 H Pressure, R=1, LS=0, C=3

Un-loader fingers resting on valve plates

Suction Valve Leakage Summary

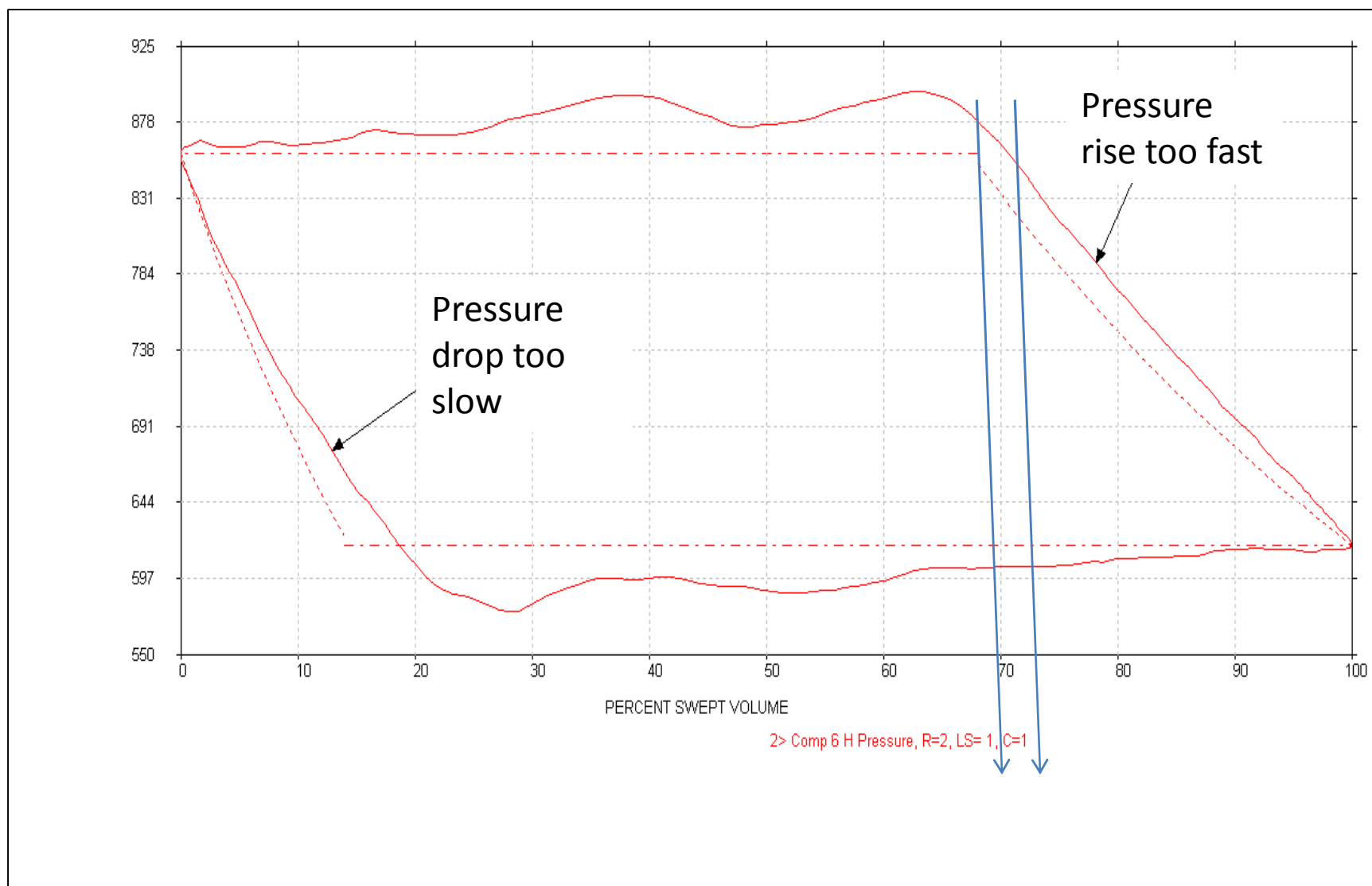
- Flow balance greater than 1.00
- Suction cavity temperature increase
- Discharge temperature increase
- Measured suction volumetric efficiency increase
- Measured discharge volumetric efficiency decrease
- Discharge delta temperature increase
- Decrease in calculated clearance volume from the expansion event
- Increase in calculated clearance volume from the compression event
- N-ratio greater than 1.00

Measurable **Discharge** Valve or Seat Leakage Characteristics

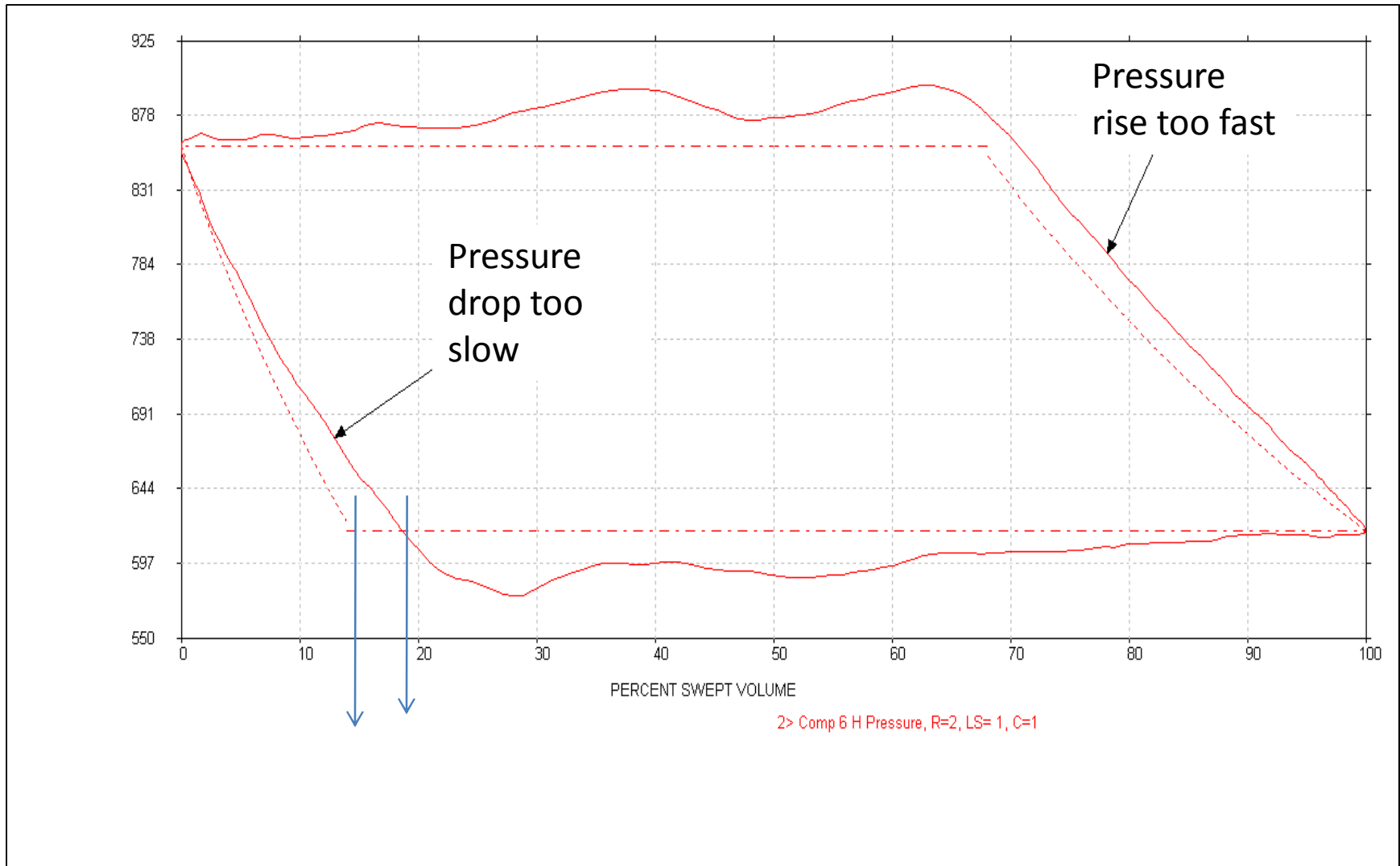
Indicated Discharge Volumetric Efficiency Increase

- For a fixed pressure ratio, the **measured** discharge volumetric efficiency will increase.
- Since high pressure gas is leaking into the cylinder during the compression event, the internal cylinder pressure will increase at a faster rate and the compression event will end earlier in the stroke.
- The **calculated** discharge flow rate will increase.

Indicated **Discharge** Volumetric Efficiency Increase



Indicated **Suction** Volumetric Efficiency Decrease



Measurable Discharge Valve or Seat Leakage Characteristics

Calculated Flow Balance is Less Than 1.0

Flow balance is the calculated suction flow rate divided by the calculated discharge flow rate. The average calculated flow rate may not appear to change much in the performance report; however, the externally measured flow rate can be significantly reduced.

Measurable Discharge Valve or Seat Leakage Characteristics

Reduction in the Calculated Clearance Volume from the Compression Line

- If you are calculating cylinder clearance volume from the compression line and discharge volumetric efficiency, the clearance will appear less than when the cylinder was healthy.
- Excessive discharge valve leakage can cause a **negative** clearance volume calculation

Measurable **Discharge** Valve or Seat Leakage Characteristics

Increase in the Calculated Clearance Volume From the Expansion Line

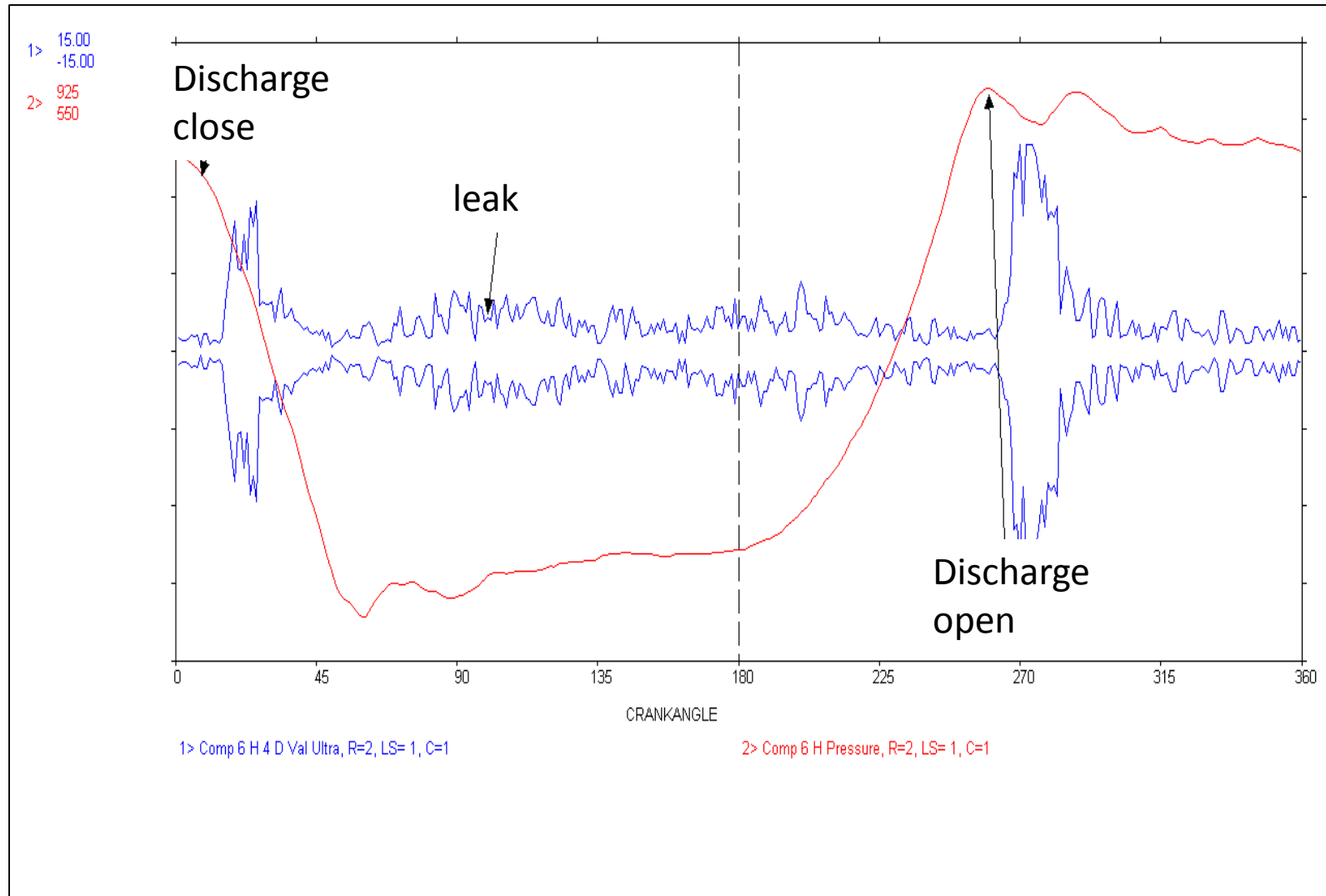
If you are calculating cylinder clearance volume from the expansion line and suction volumetric efficiency, the clearance will appear greater than when the cylinder was healthy.

Measurable Discharge Valve or Seat Leakage Characteristics

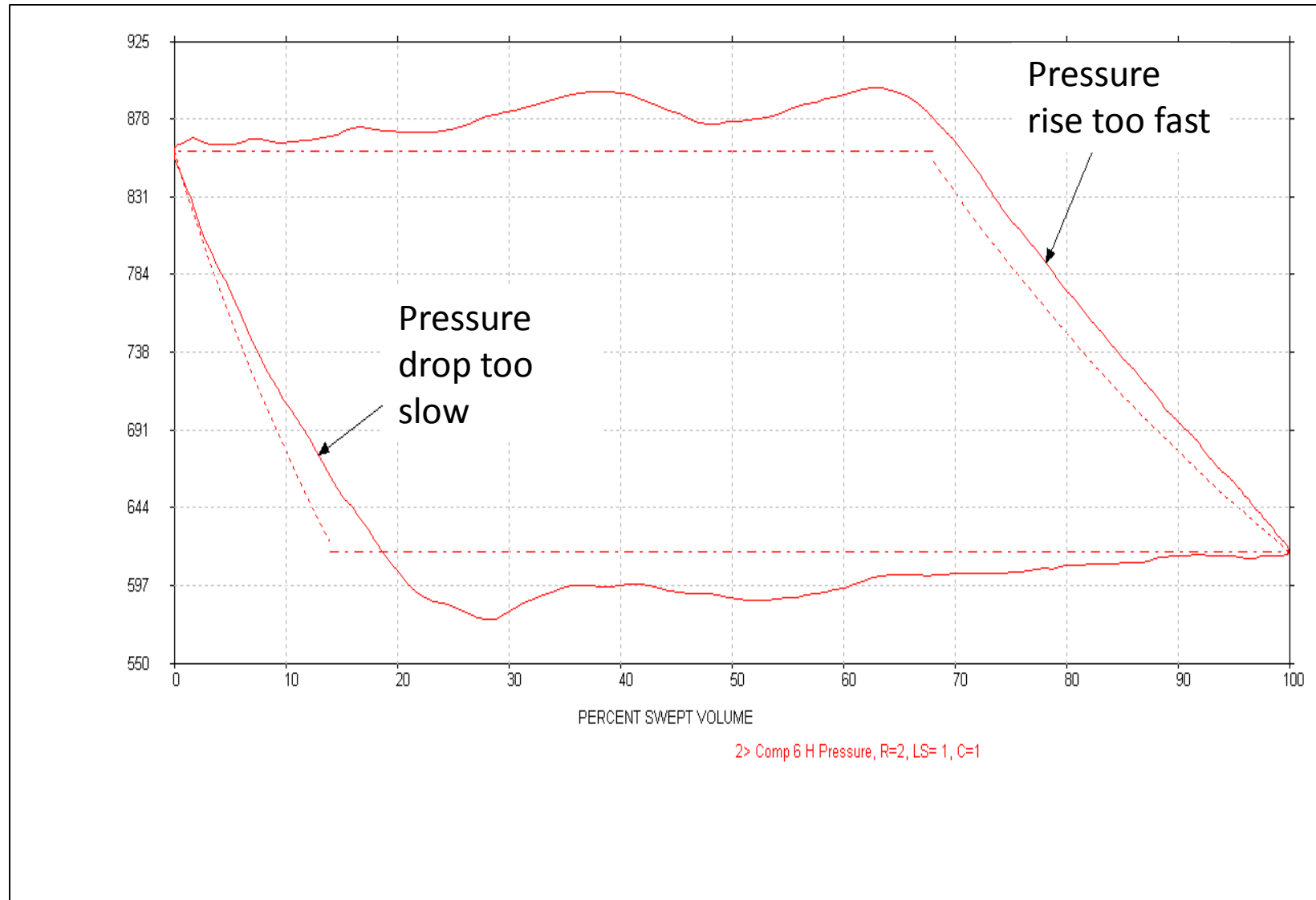
A defective valve leaks when it is closed; therefore, the ultrasonic traces will indicate leakage after the normal valve closure and will indicate greater leakage activity as the differential pressure increases.

The leakage will stop when the valve re-opens.

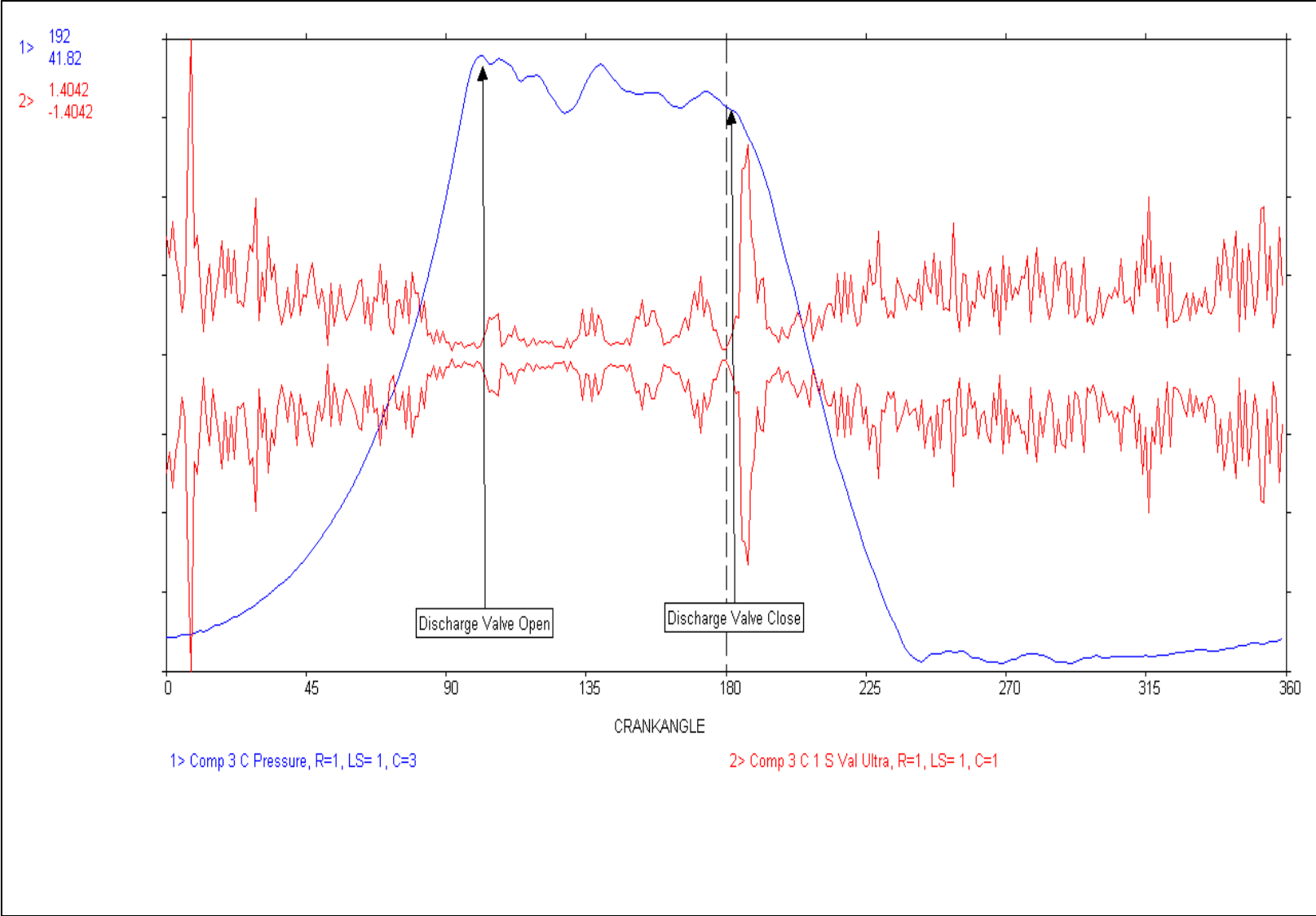
Head-End Pressure & Ultrasonic Vs. Crank-Angle With Leaking Discharge Valve



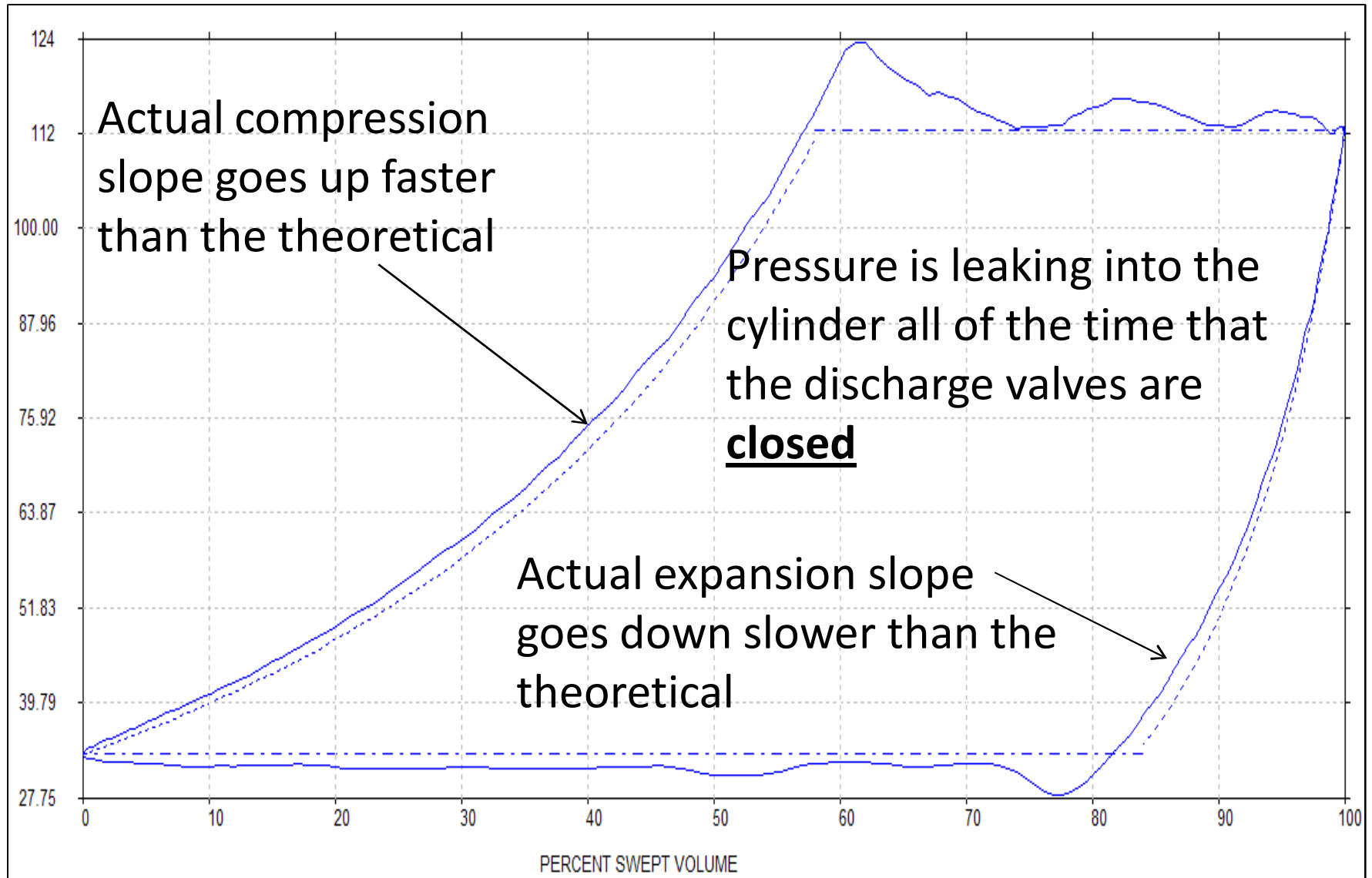
Head-End Pressure Vs. Displace Volume With Leaking Discharge Valve



Crank-End Pressure Vs. Crank-Angle With Leaking Discharge Valve



Crank-End PV With Slight Discharge Valve Leakage



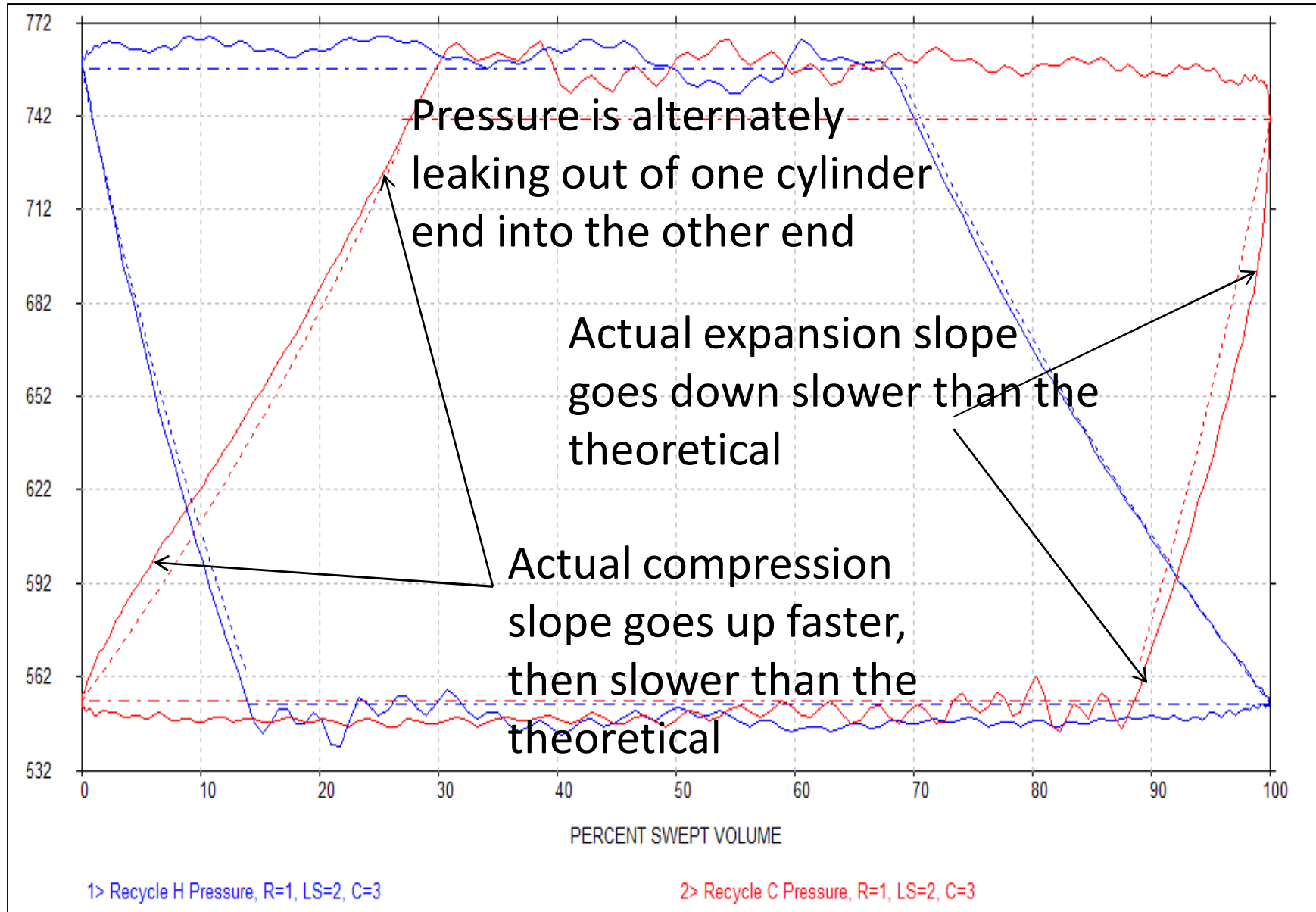
Discharge Valve Leakage Summary

- Flow balance less than 1.00
- Discharge temperature increase
- Calculated suction volumetric efficiency decrease
- Calculated discharge volumetric efficiency increase
- Discharge delta temperature increase
- Increase in **calculated** clearance volume from the expansion event
- Decrease in **calculated** clearance volume from the compression event (may go negative)
- N-ratio below 1.00

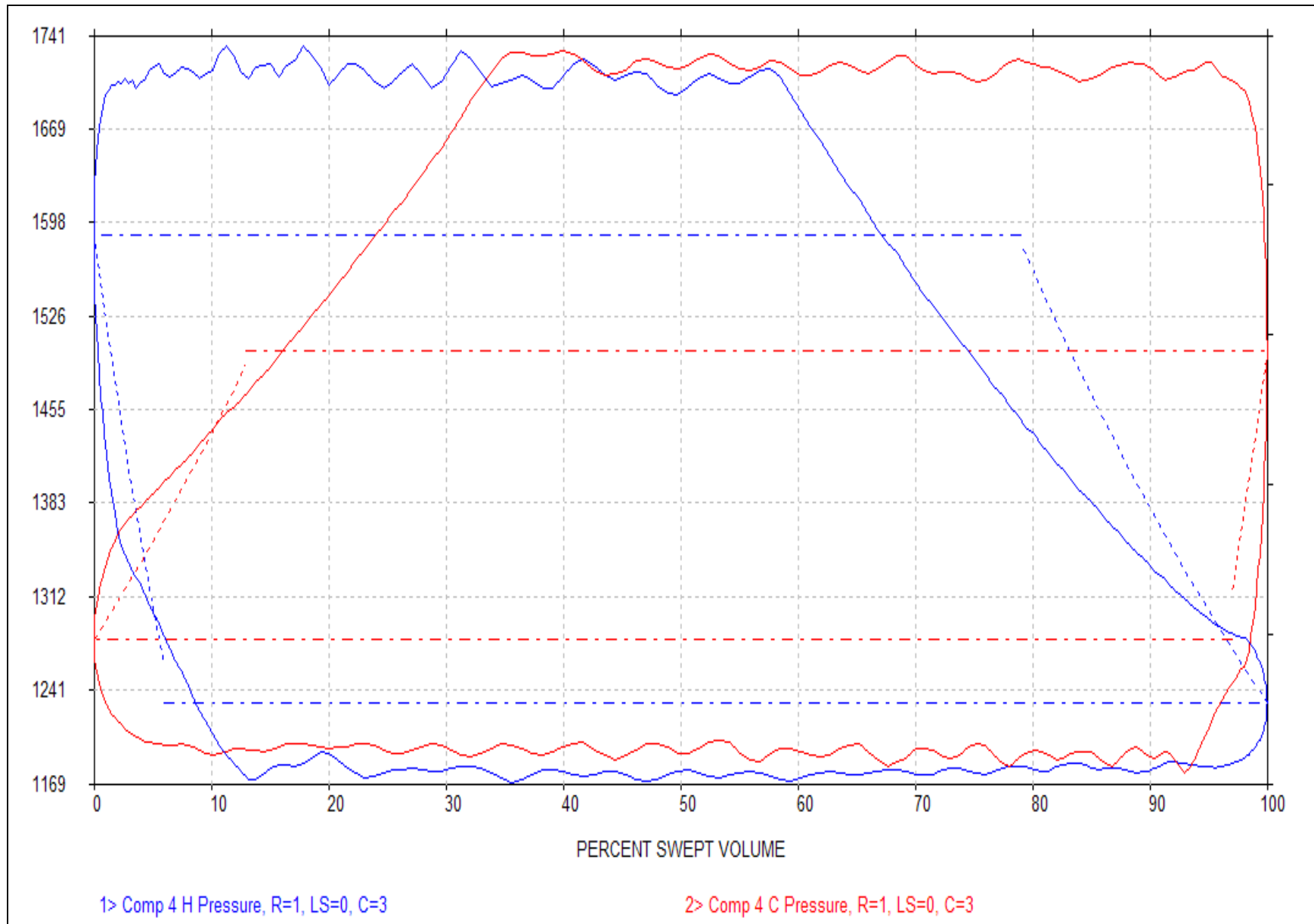
Ring Leakage

- Flow balance greater than 1 unless discharge leakage is also present
- Discharge temperature increase
- VEs generally increases
- VEd generally decreases but may remain fairly stable or even increase
- Discharge delta temp increase
- Calculated clearance from expansion may increase or decrease
- Calculated clearance from compression may increase or decrease
- N-ratio above 1

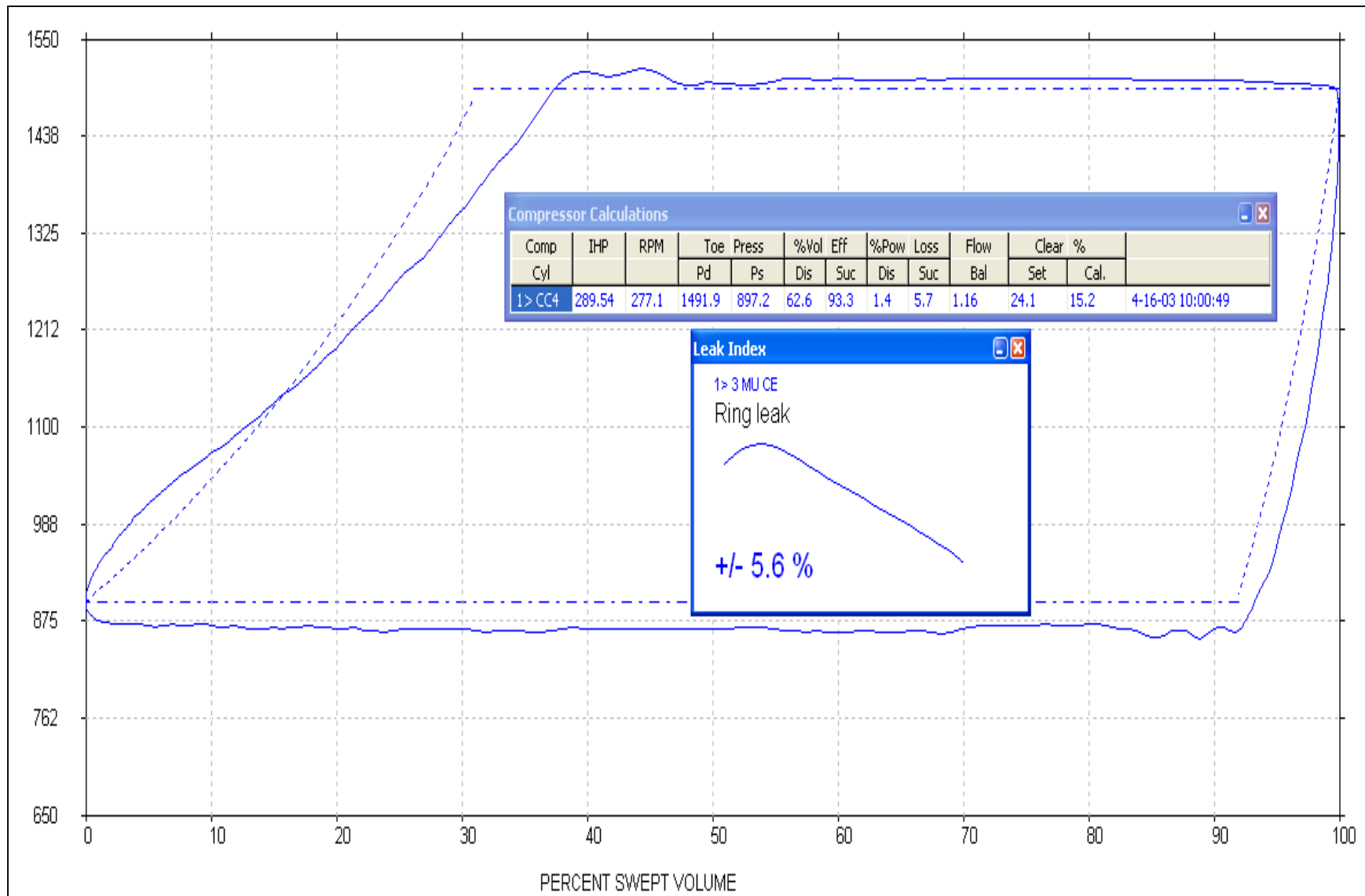
Slight Ring Leakage



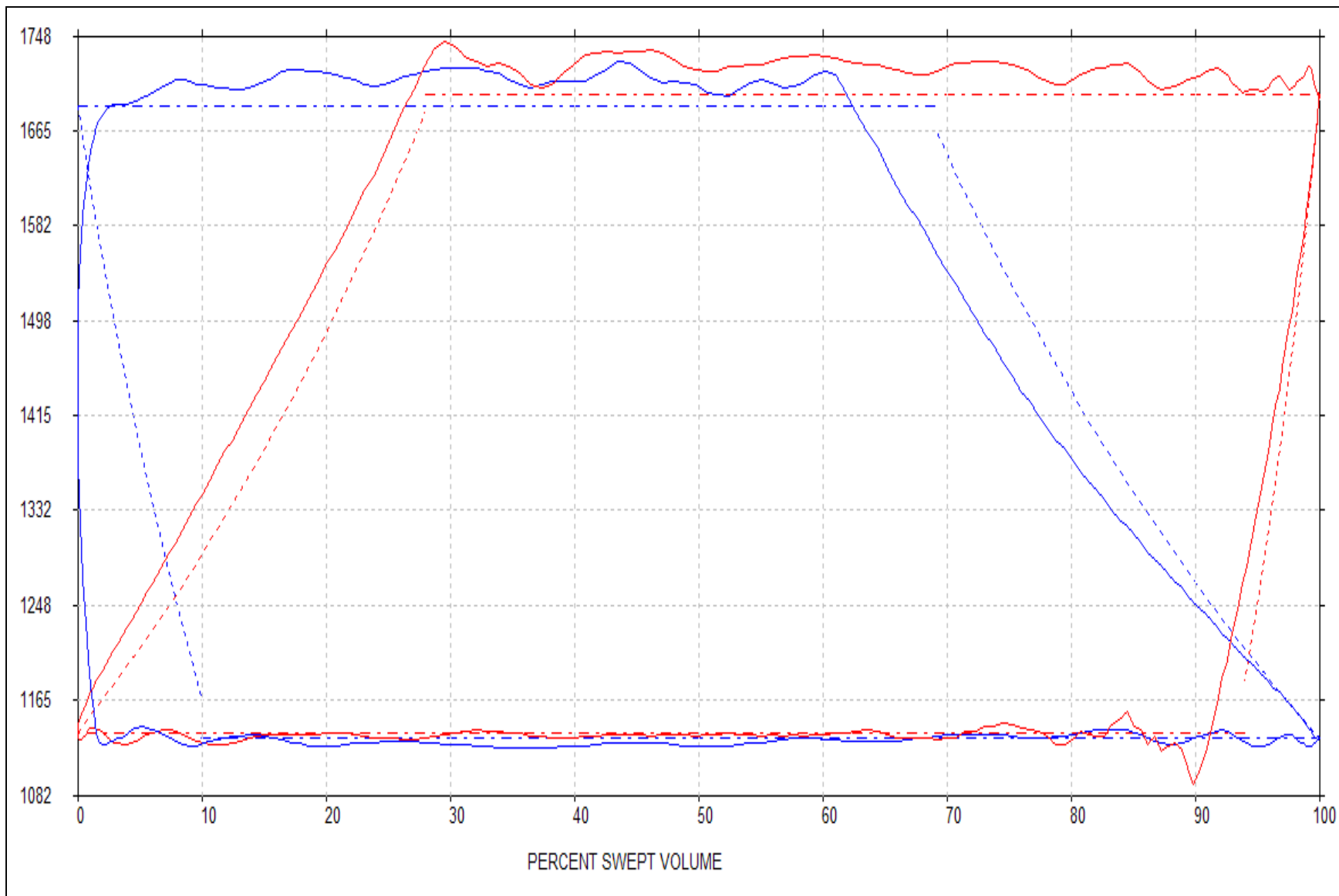
Severe Ring Leakage



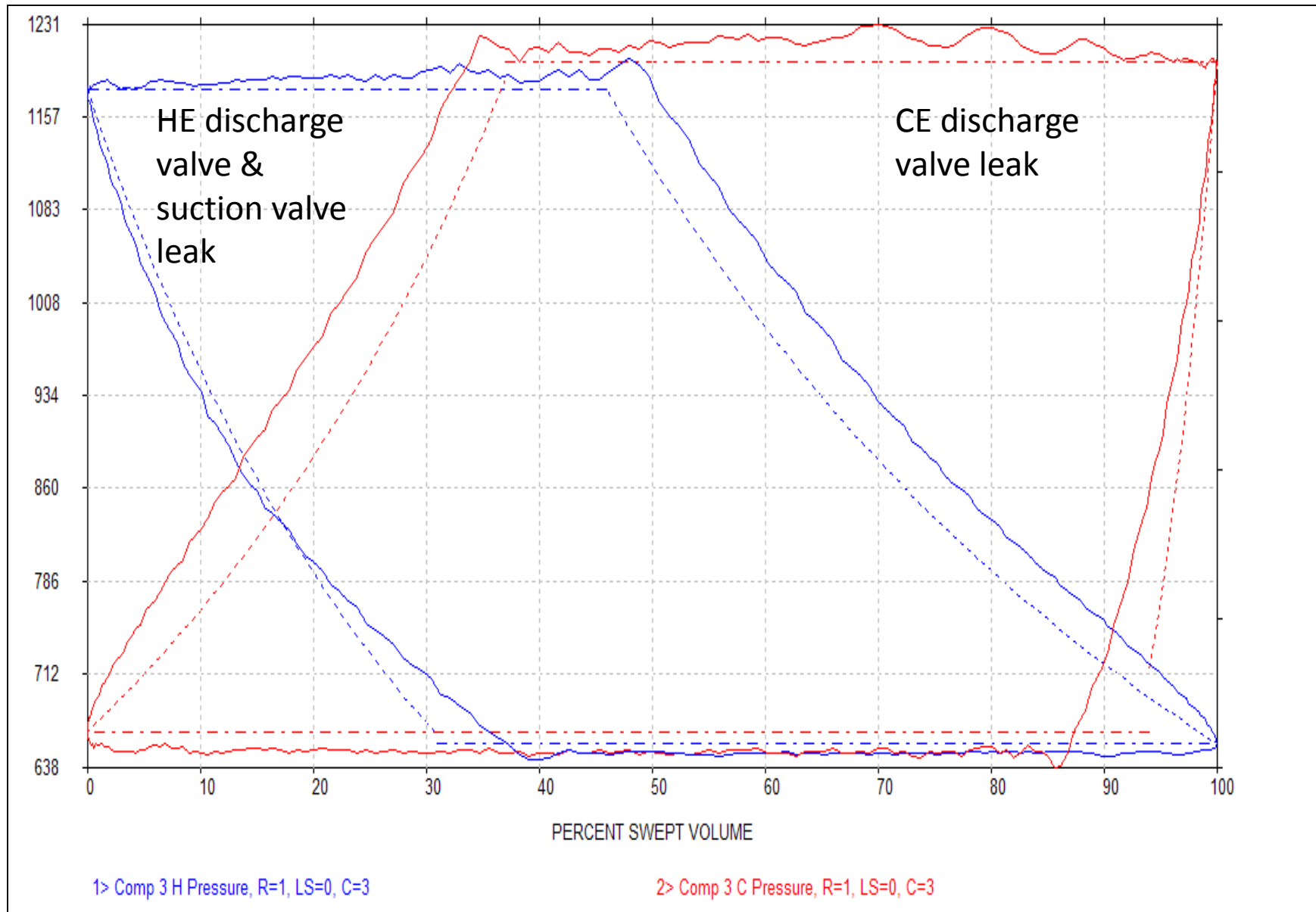
Leak Index and Ring Leakage



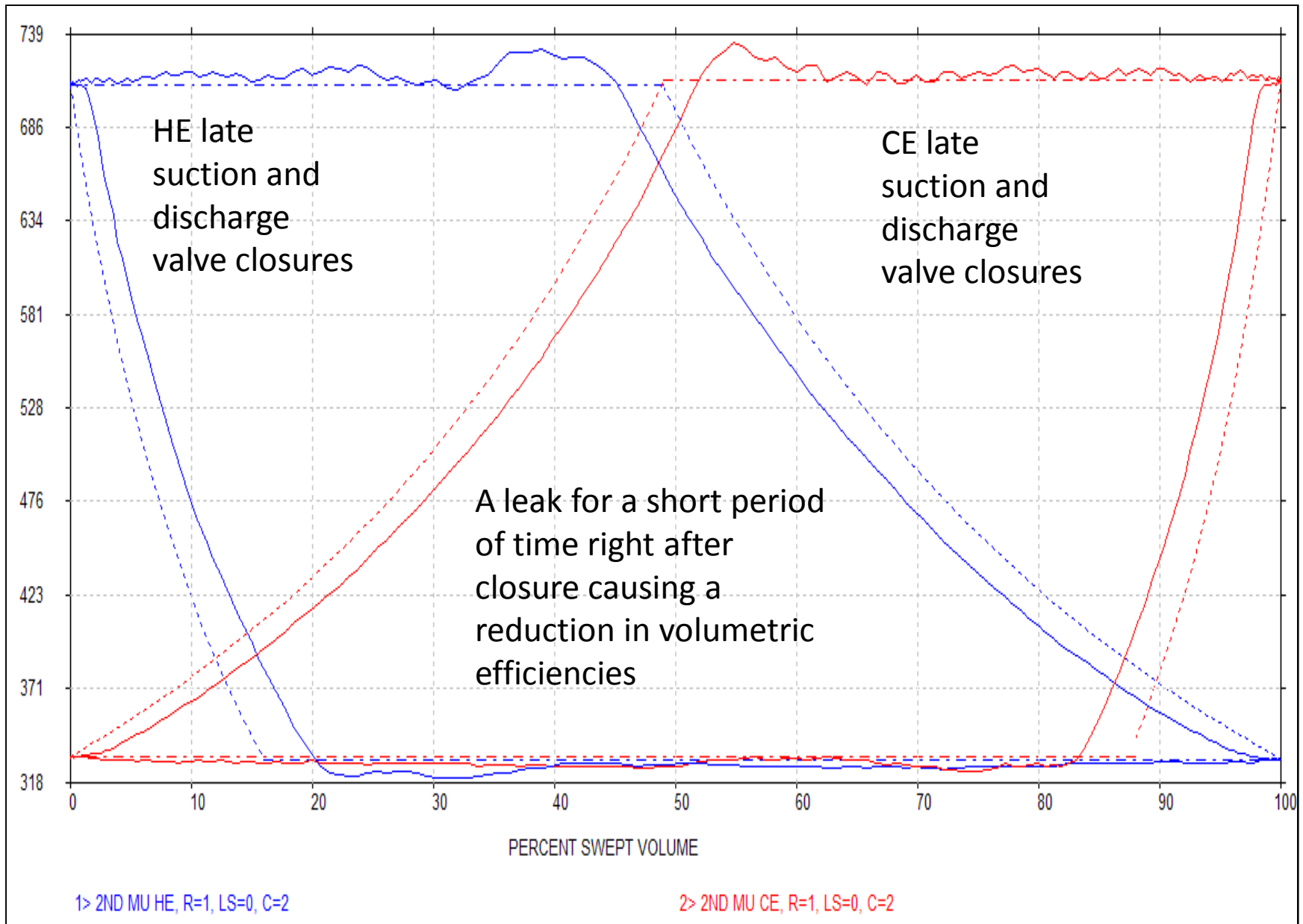
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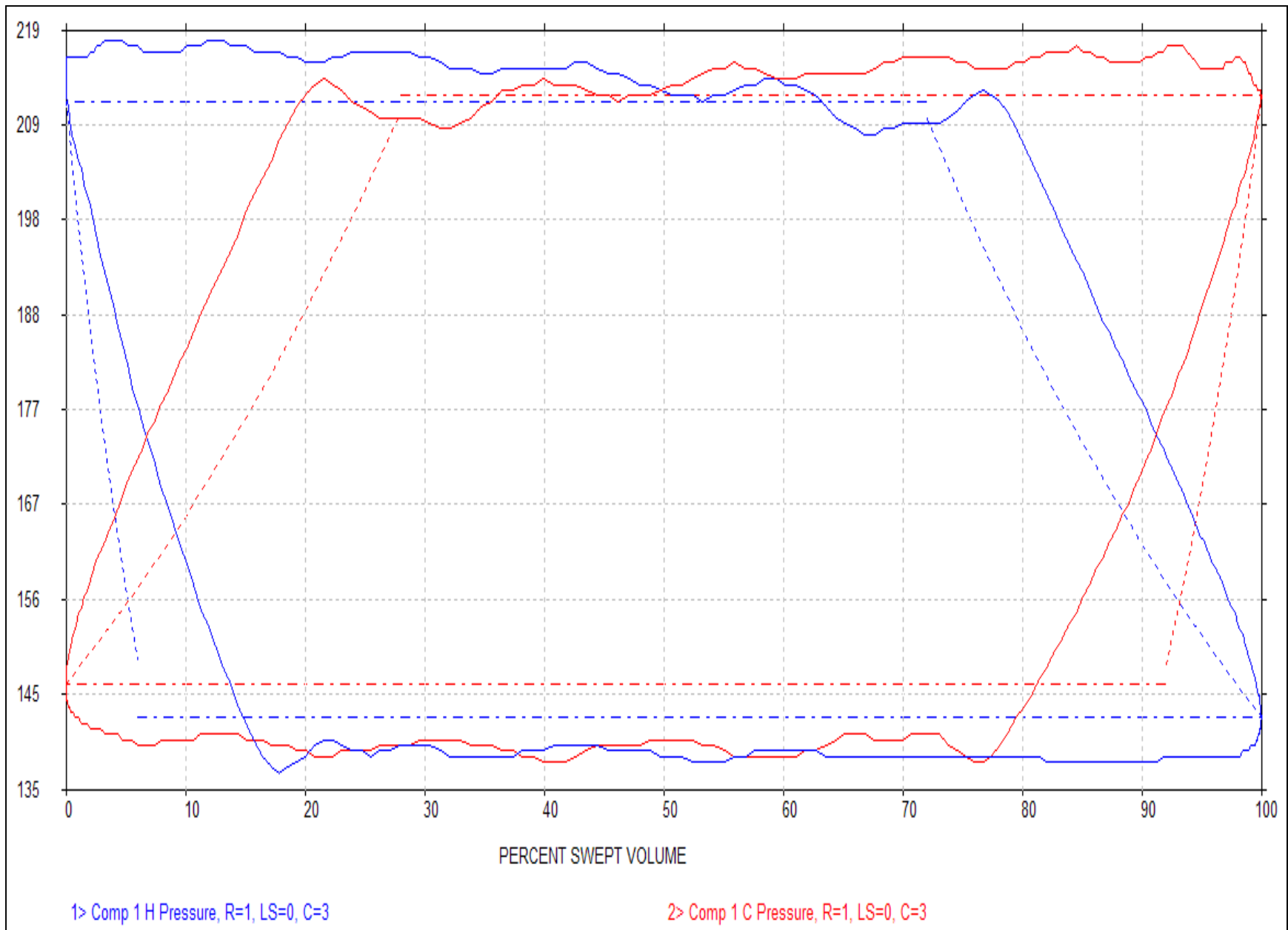
Multiple Leakages



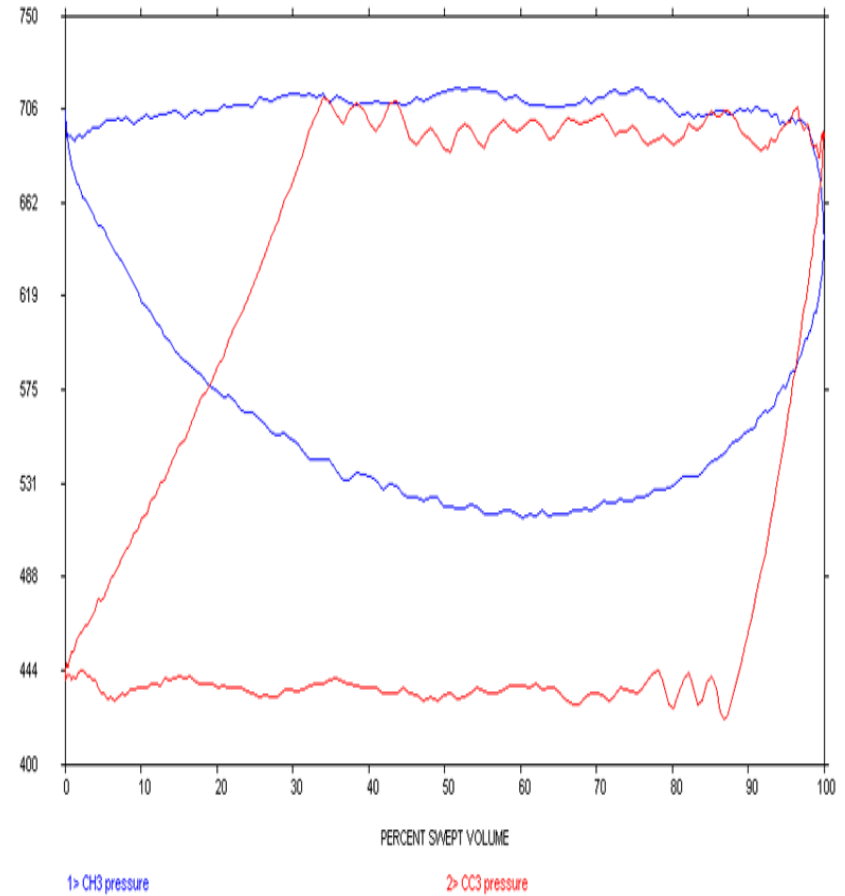
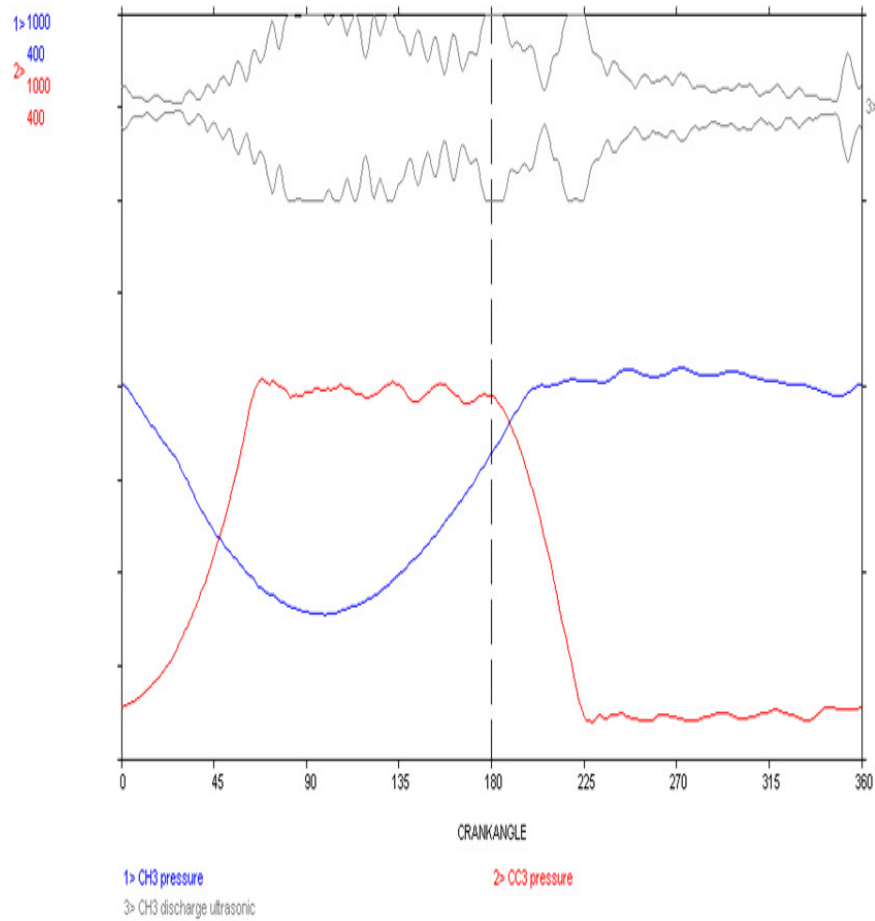
Late Closures



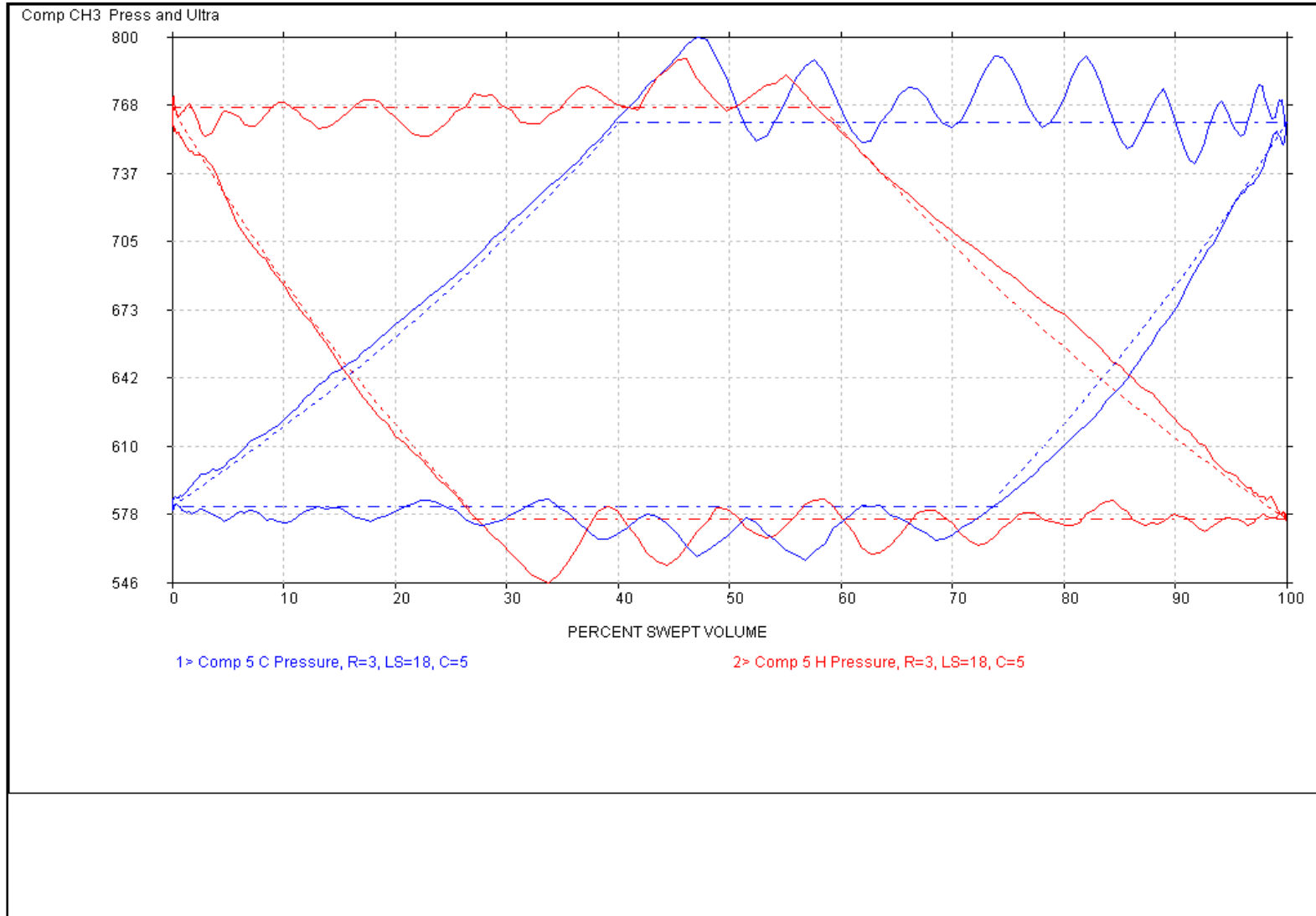
Ring Leakage or Discharge Valves?



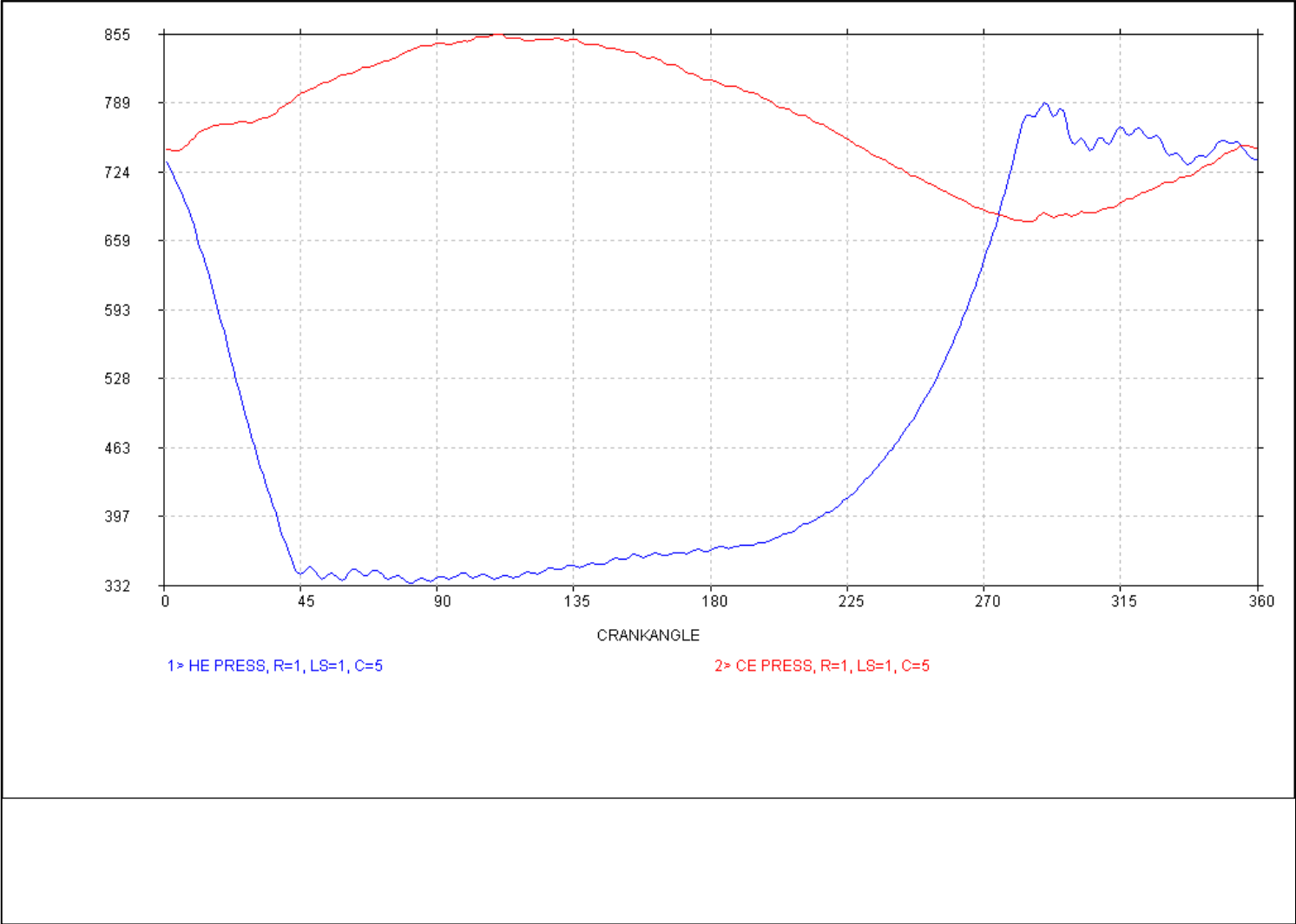
Severe Discharge Valve Leakage



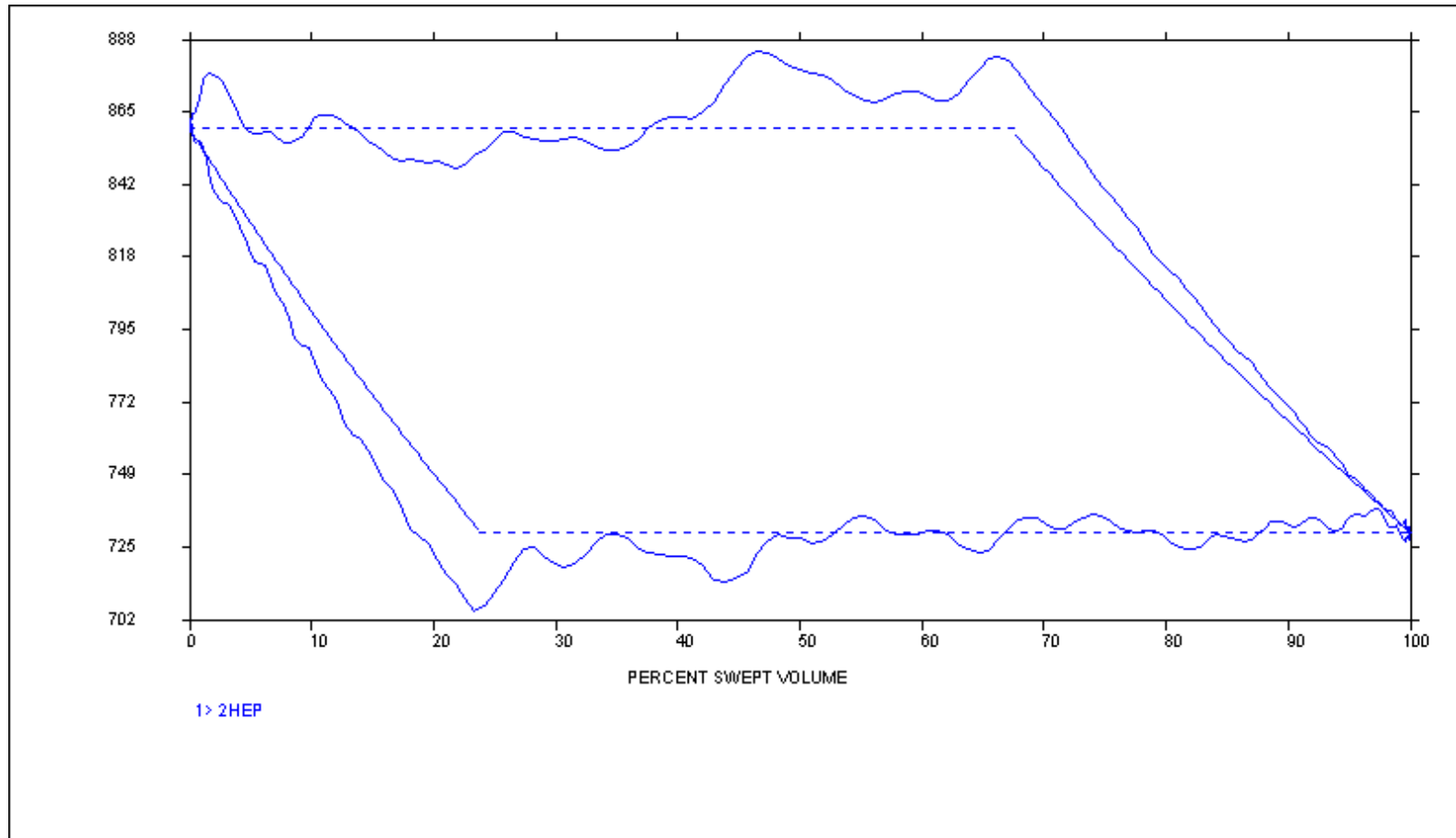
Is There a Leakage Problem?



Suction or Discharge Valve Problem?



What Would You Call?



Questions?