FLOATING SEAL RING ACTING AS A THIRD BEARING

Case History

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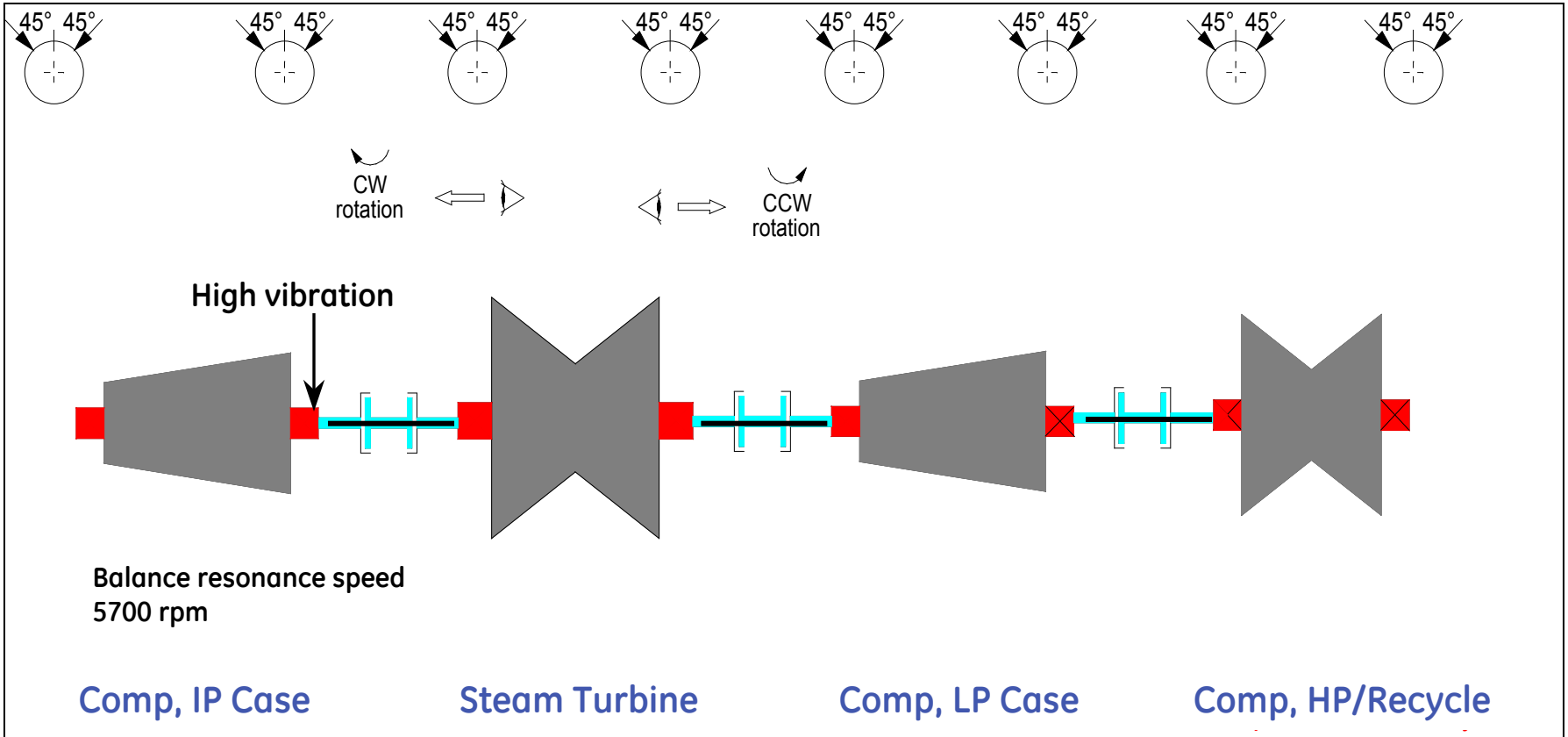
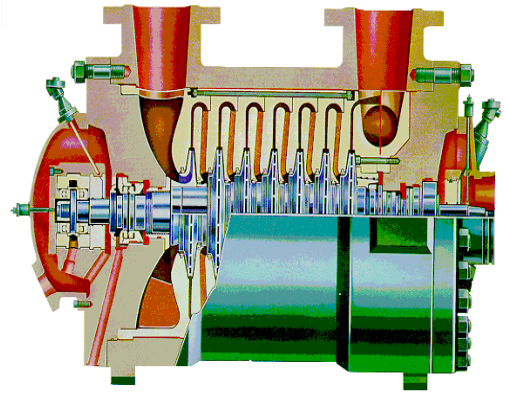
Background

- The synthesis Gas Compressor was recently overhauled.
- Replaced the IP Compressor rotor, interstage seals and floating seal rings.
- Replaced the Inboard radial & thrust bearings of IP Compressor.
- When the machine started, high vibration was experienced on the Inboard bearing while Outboard bearing indicated low vibration levels.

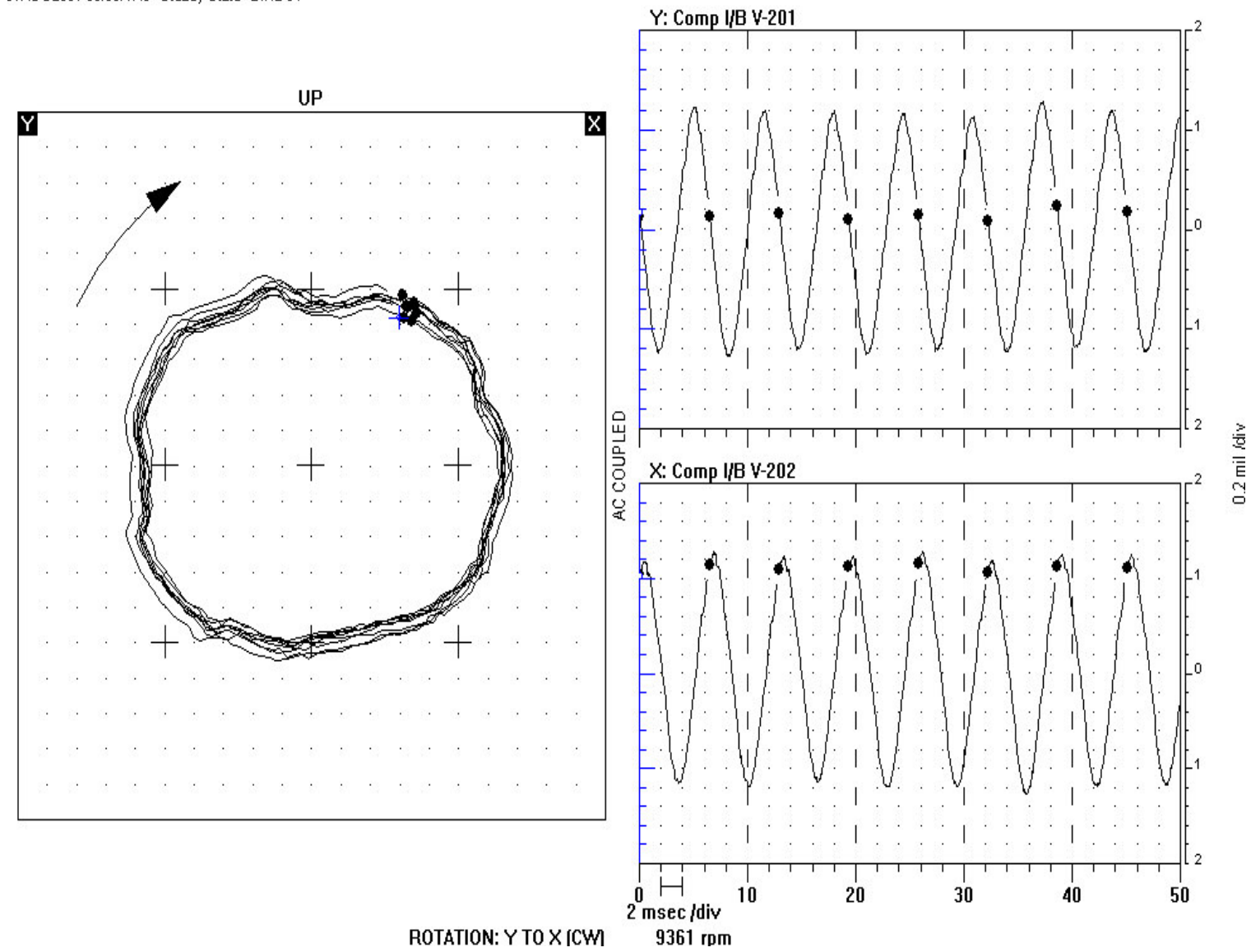


Machine Train Diagram

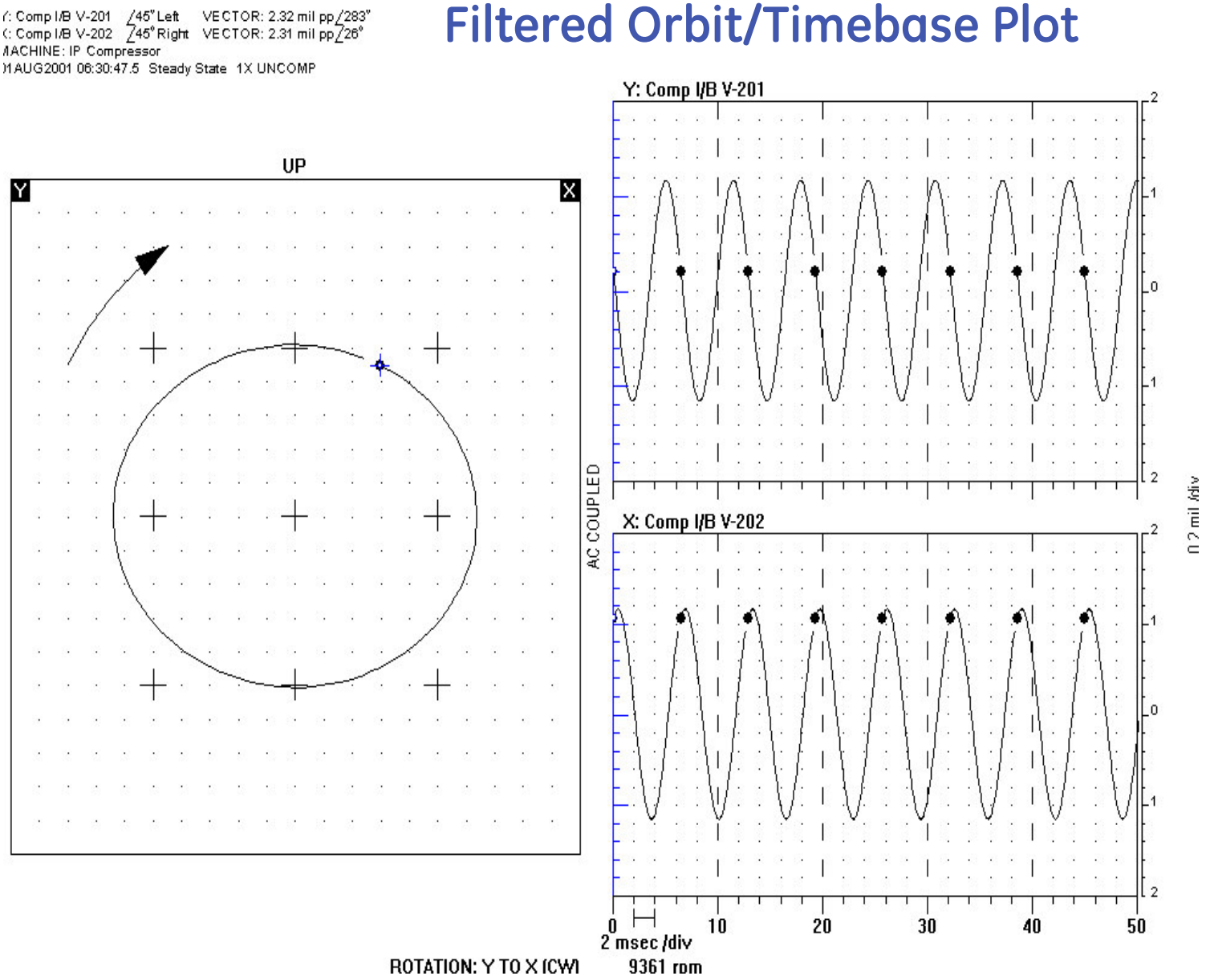
Data collected during steady state



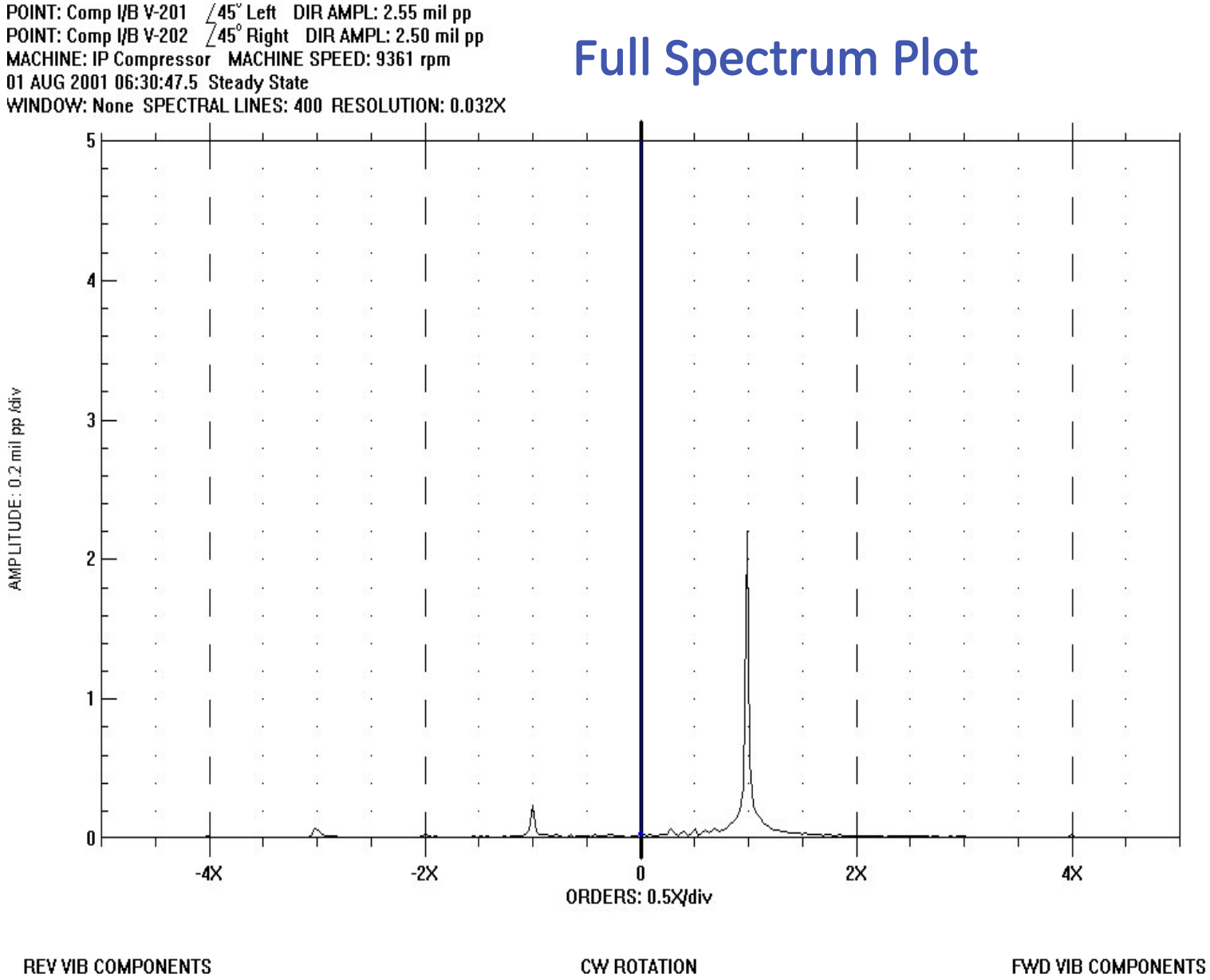
Direct Orbit/Timebase Plot



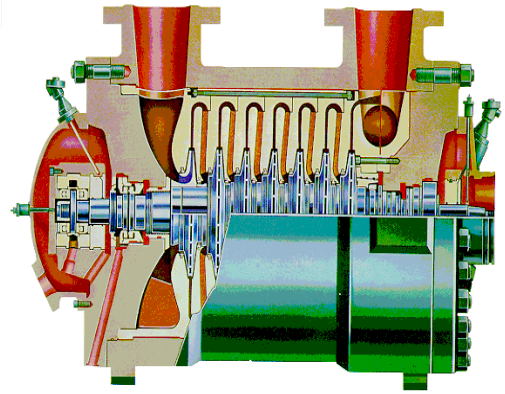
Filtered Orbit/Timebase Plot



Full Spectrum Plot

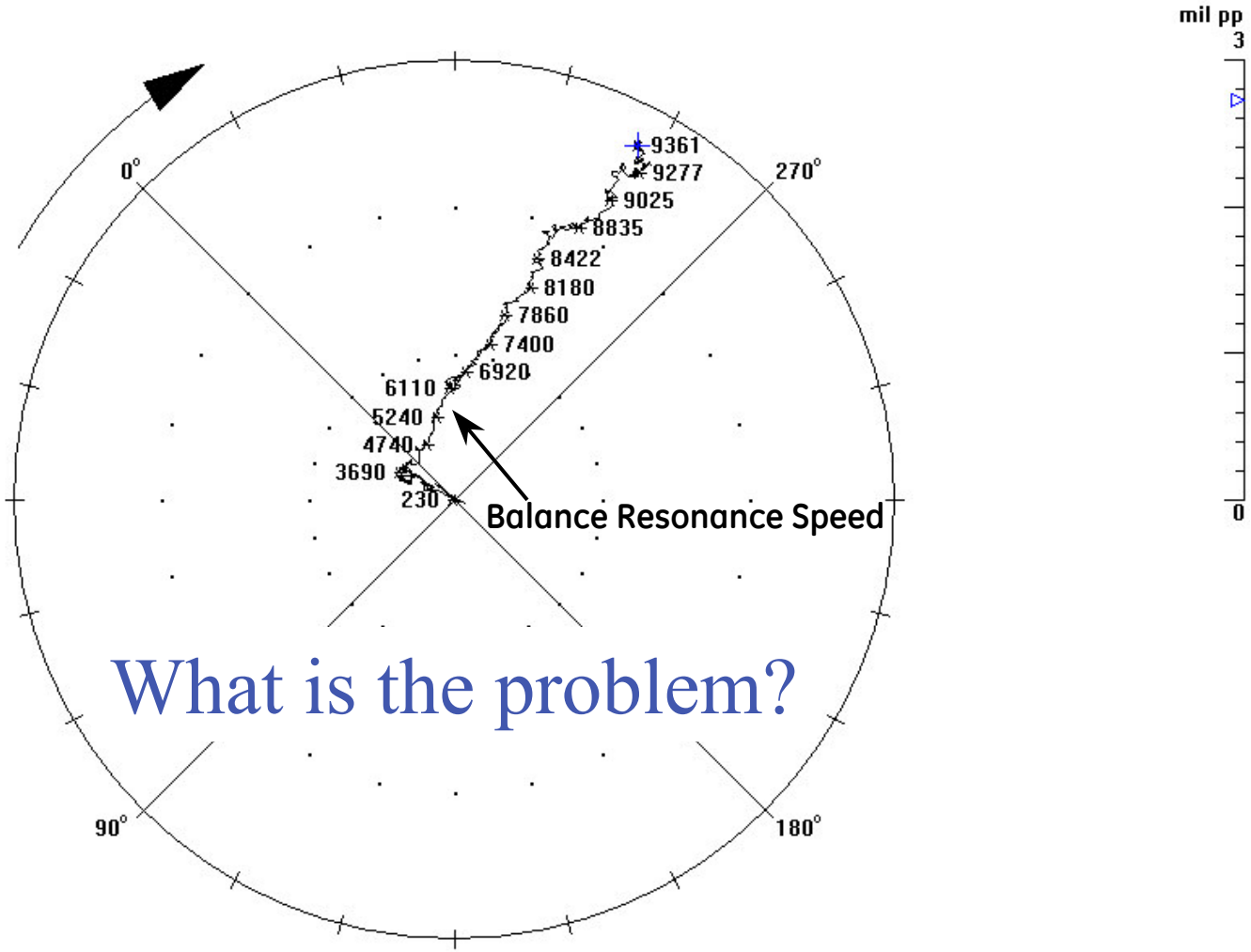


Data collected during shutdown



Shutdown Polar Plot

POINT: Comp I/B V-201 ∠45° Left 1X COMP SR: 0.437∠131° 2.72∠288° @9361 rpm
MACHINE: IP Compressor
From 01AUG2001 06:30:47.5 To 01AUG2001 08:00:03.6 Shutdown

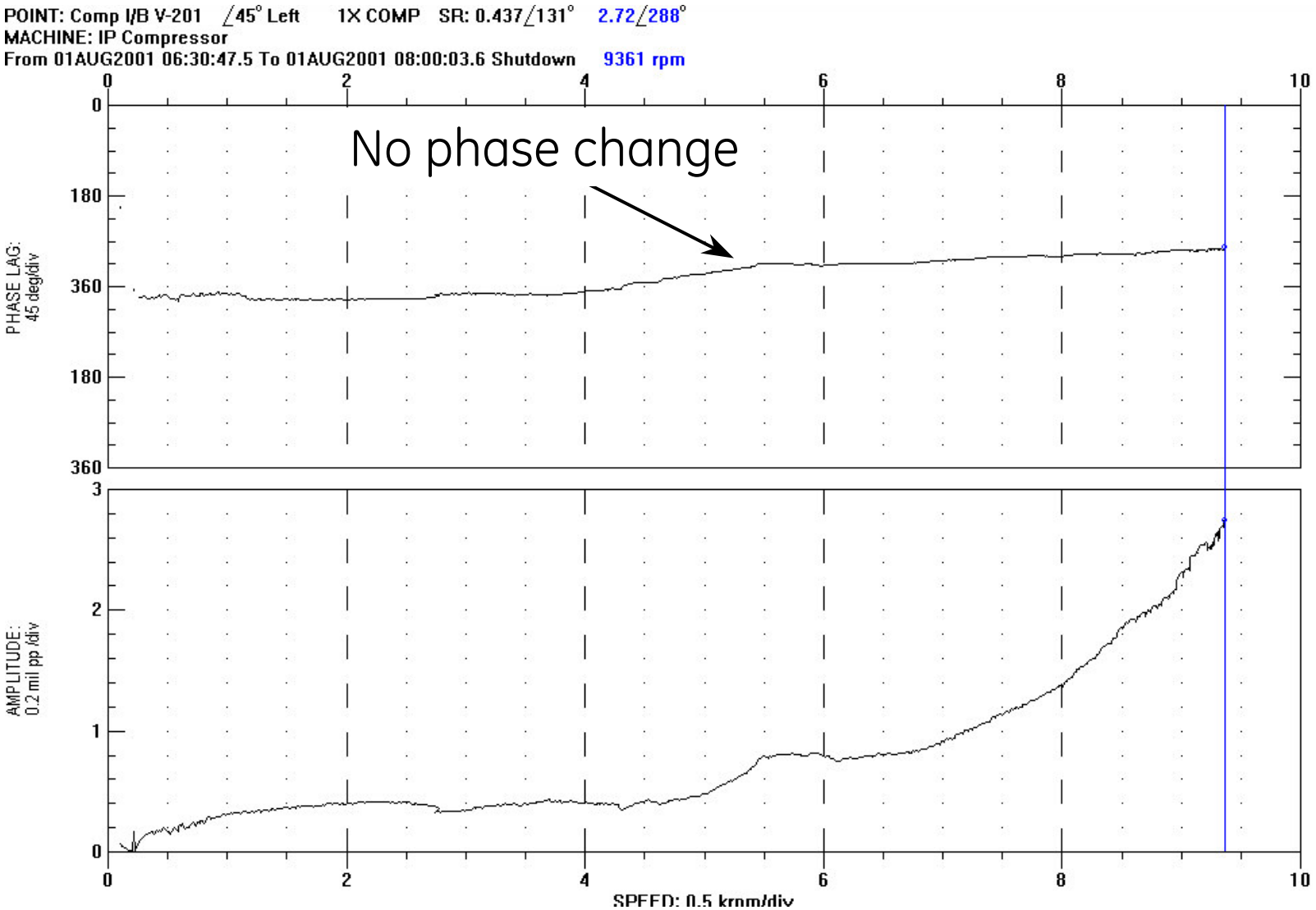


What is the problem?

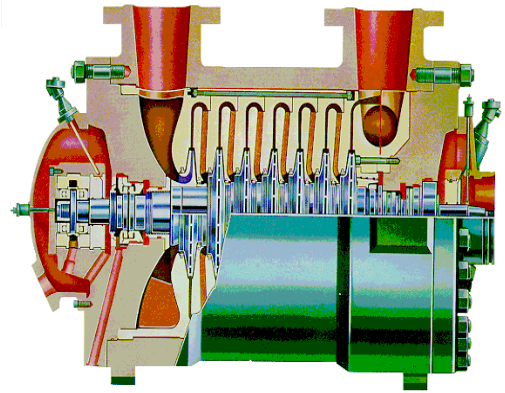
3 mil pp FULL SCALE

CW ROTATION

Shutdown Bode Plot

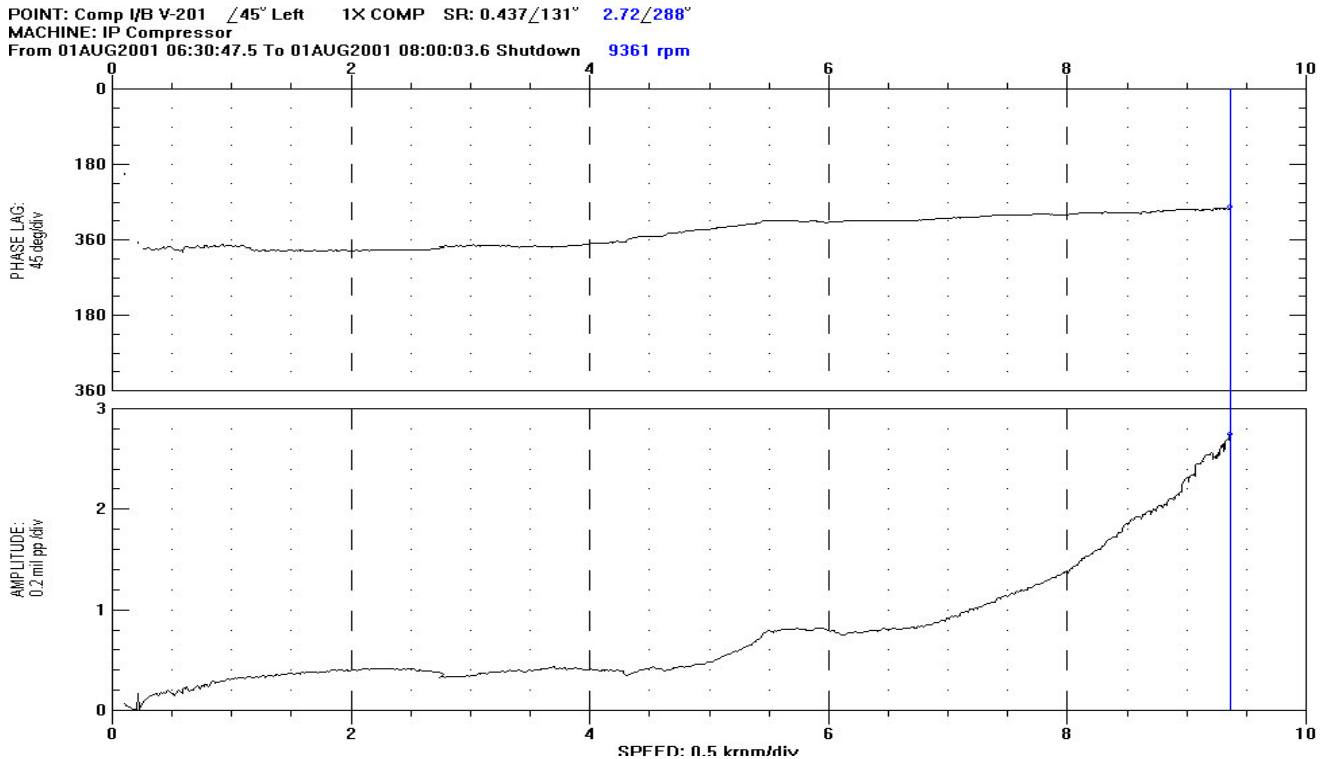


Symptoms of the Problem



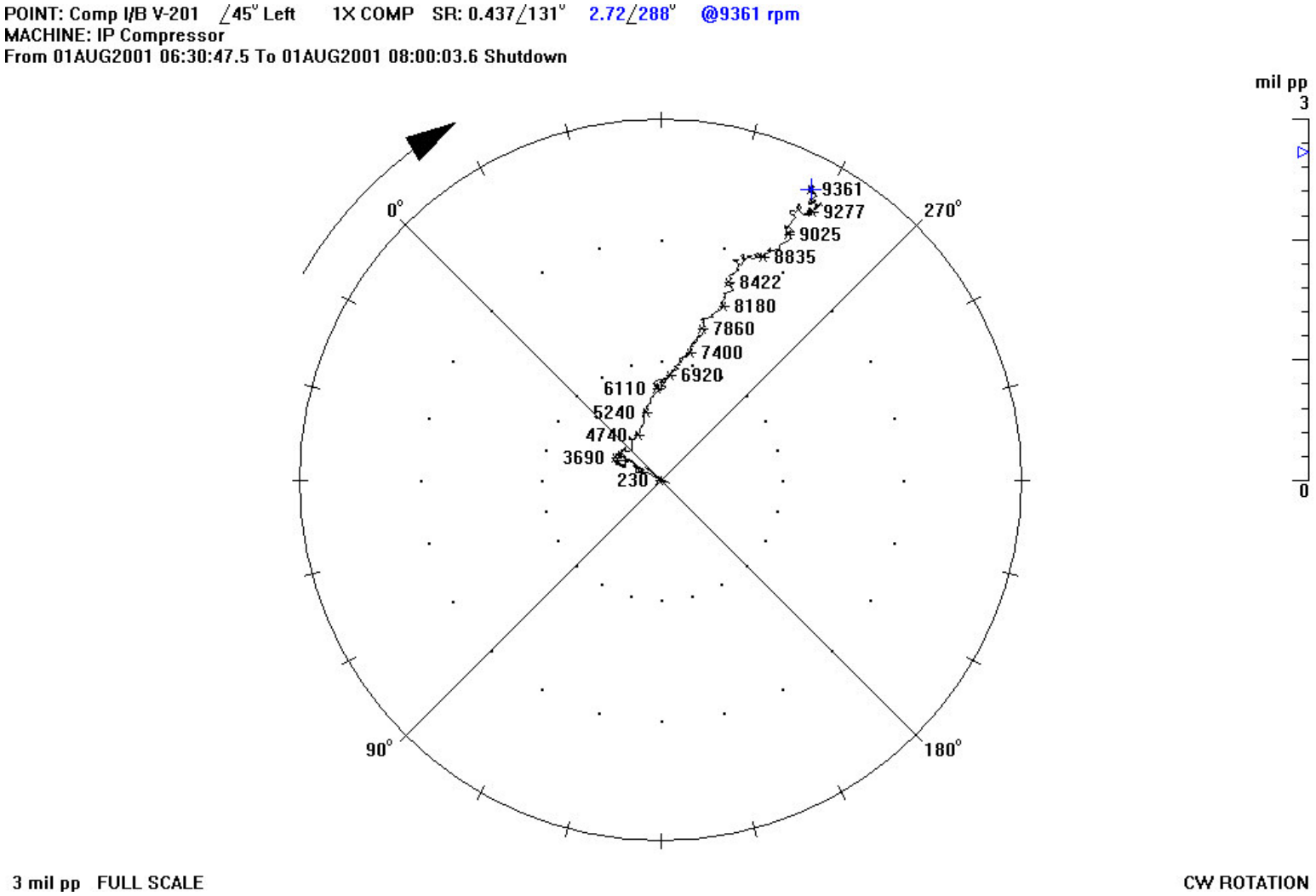
Symptoms:

- Vibration amplitude did not peak at the designed balance resonance speed of 5700 rpm
- The amplitude kept changing as the square of the speed changed from 5000 rpm to 9200 rpm.



Symptoms:

- The phase angle also did not change while passing the designed balance resonance speed



All these symptoms prove that the balance resonance speed has increased to beyond operating speed.

Analysis

- In general, the rotor's balance resonance speed is a function of the rotor mass and spring stiffness.
- It will remain unchanged unless the rotor mass or spring stiffness changes. A simple formula that describes this relationship is:

$$\omega_{res} = \sqrt{\frac{K}{M}}$$

Where:

ω = rotor natural resonance frequency

K = system spring stiffness

M = rotor mass

The rotor mass probably did not change.

It is now obvious that the system spring stiffness had increased.

What could have increased the spring stiffness?

~~Severe Misalignment~~!

- The coupling is flexible type
- The orbit shape doesn't suggest misalignment

Rub!

What can cause Rub?

~~Interstage seal rub~~!

- Shaft will bow
- Vibration will increase on I/B and O/B bearings
- Machine can trip in few minutes

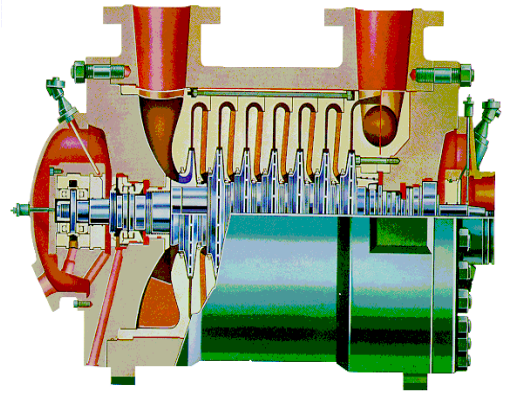
~~Bearing rub!~~

- Tilt Pad Bearing
- Normal bearing temperatures
- Bearing clearance is usually bigger than the seal ring clearances. So, it will rub in the seal area before a bearing rub can occur.
- *Lubricated seal rub is suspected*

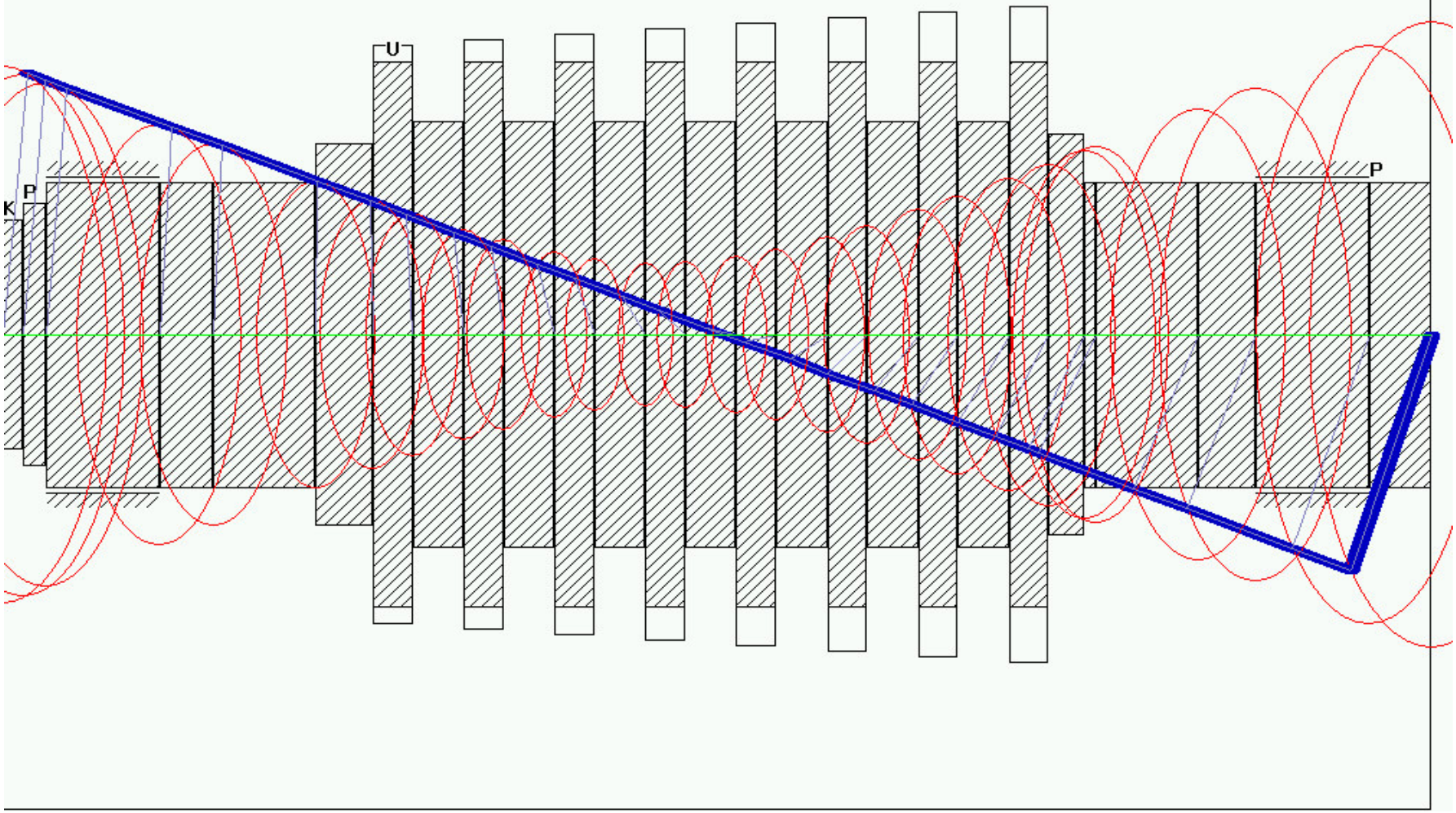
CONCLUSION:

Locked-up seal ring acting as an additional bearing

Verification of the Problem

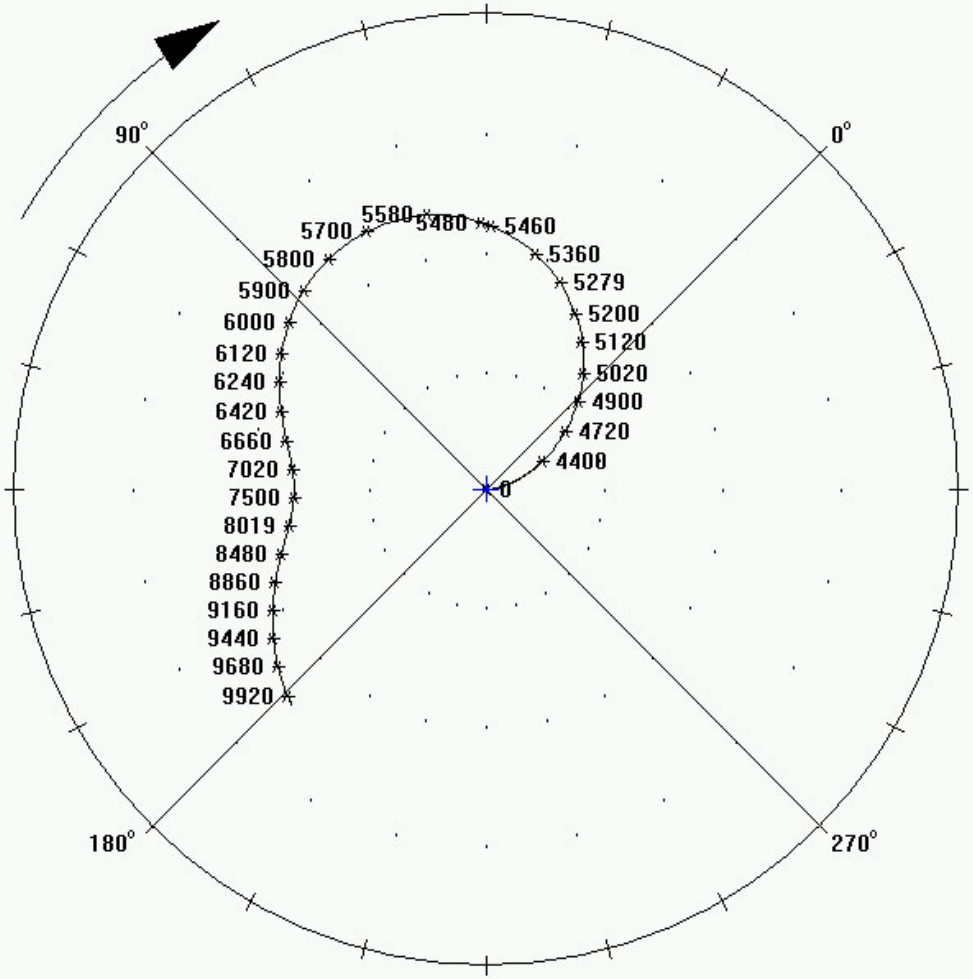


Modal Analysis



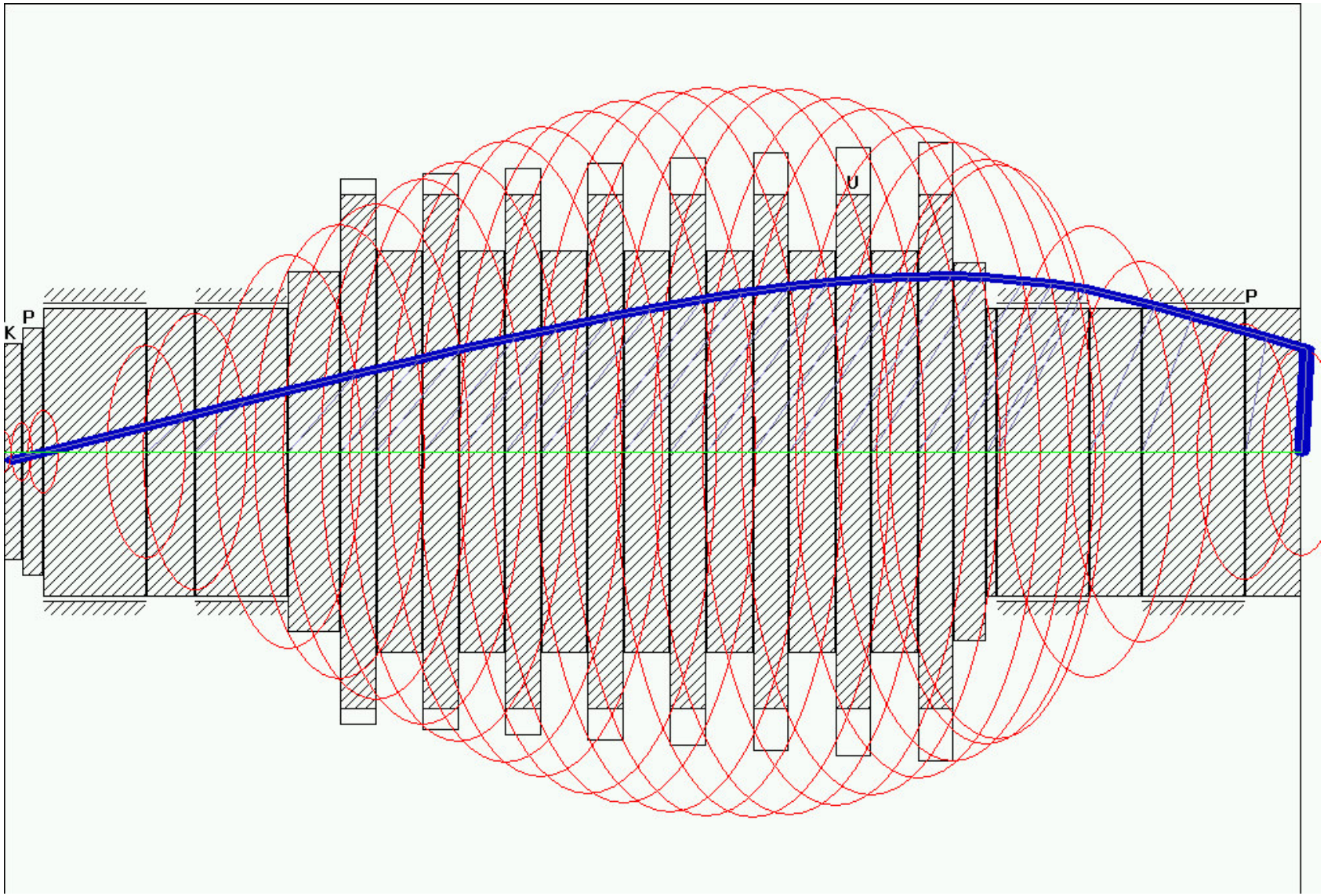
POINT: 2YD ∠45° Right 1X UNCOMP 0∠0° @0 RPM

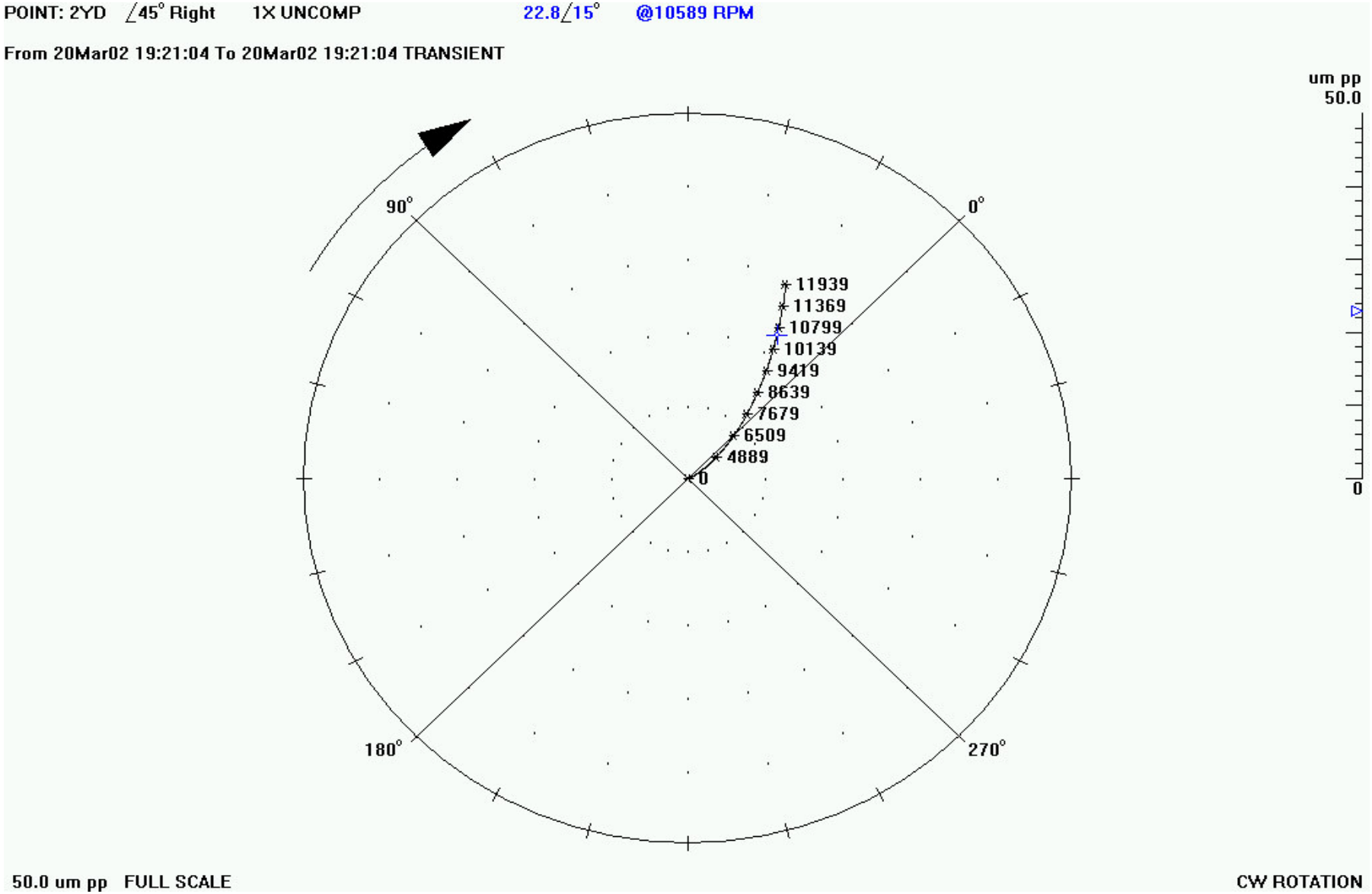
From 20Mar02 19:59:07 To 20Mar02 19:59:07 TRANSIENT

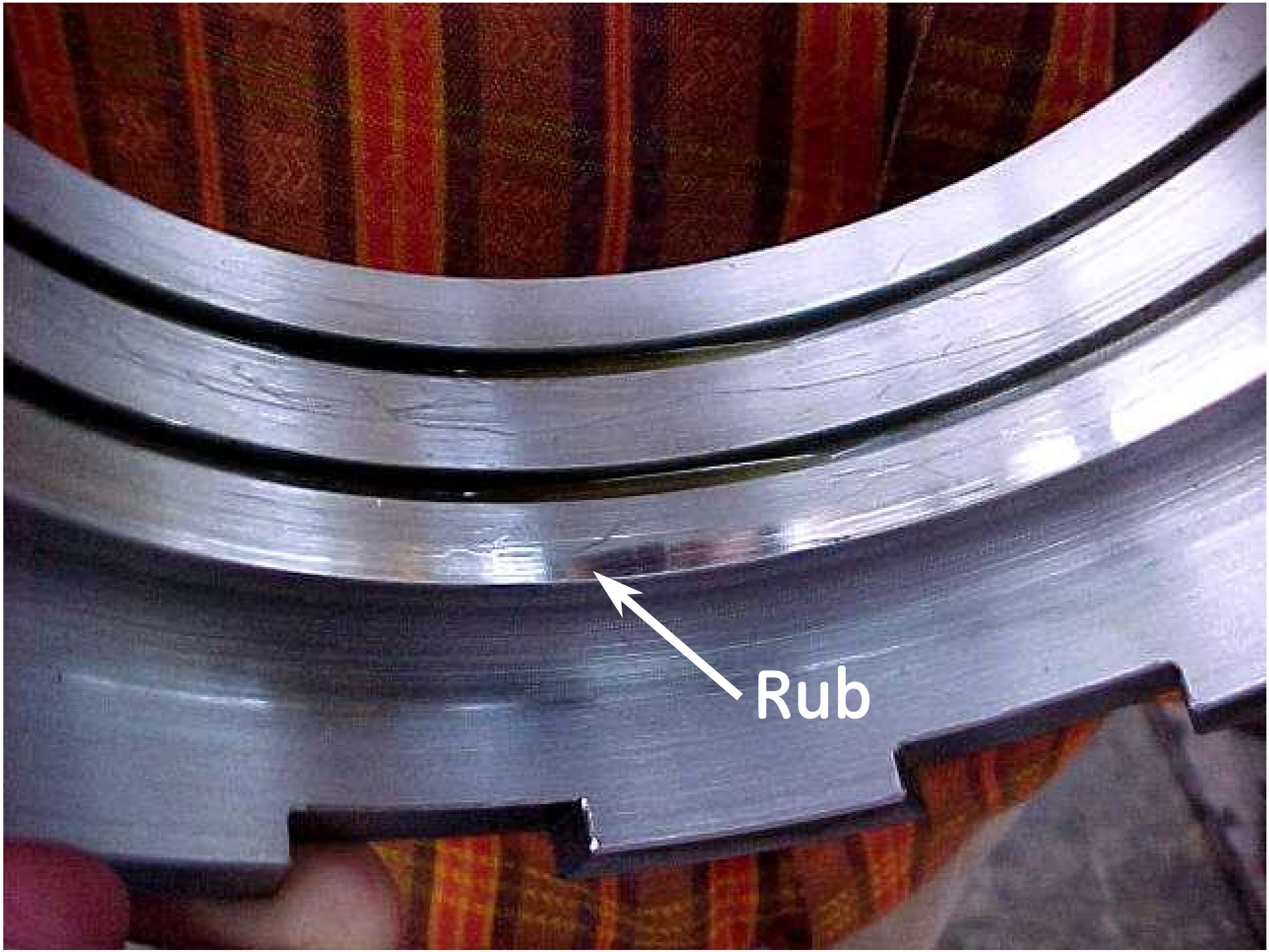


19999 um pp FULL SCALE

CW ROTATION


K
P
U
P

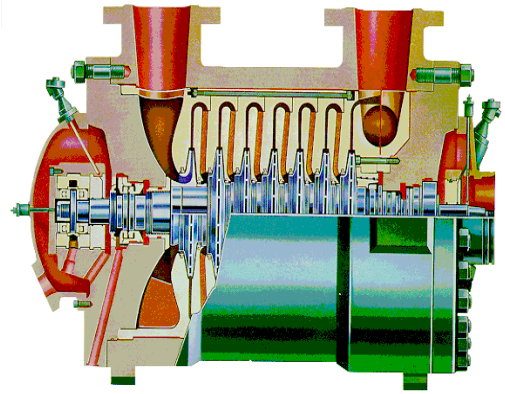

POINT: 2YD ∠45° Right 1X UNCOMP
22.8∠15° @10589 RPM
From 20Mar02 19:21:04 To 20Mar02 19:21:04 TRANSIENT
um pp
50.0
0
90°
0°
180°
270°
11939
11369
10799
10139
9419
8639
7679
6509
4889
0
50.0 um pp FULL SCALE
CW ROTATION


Rub

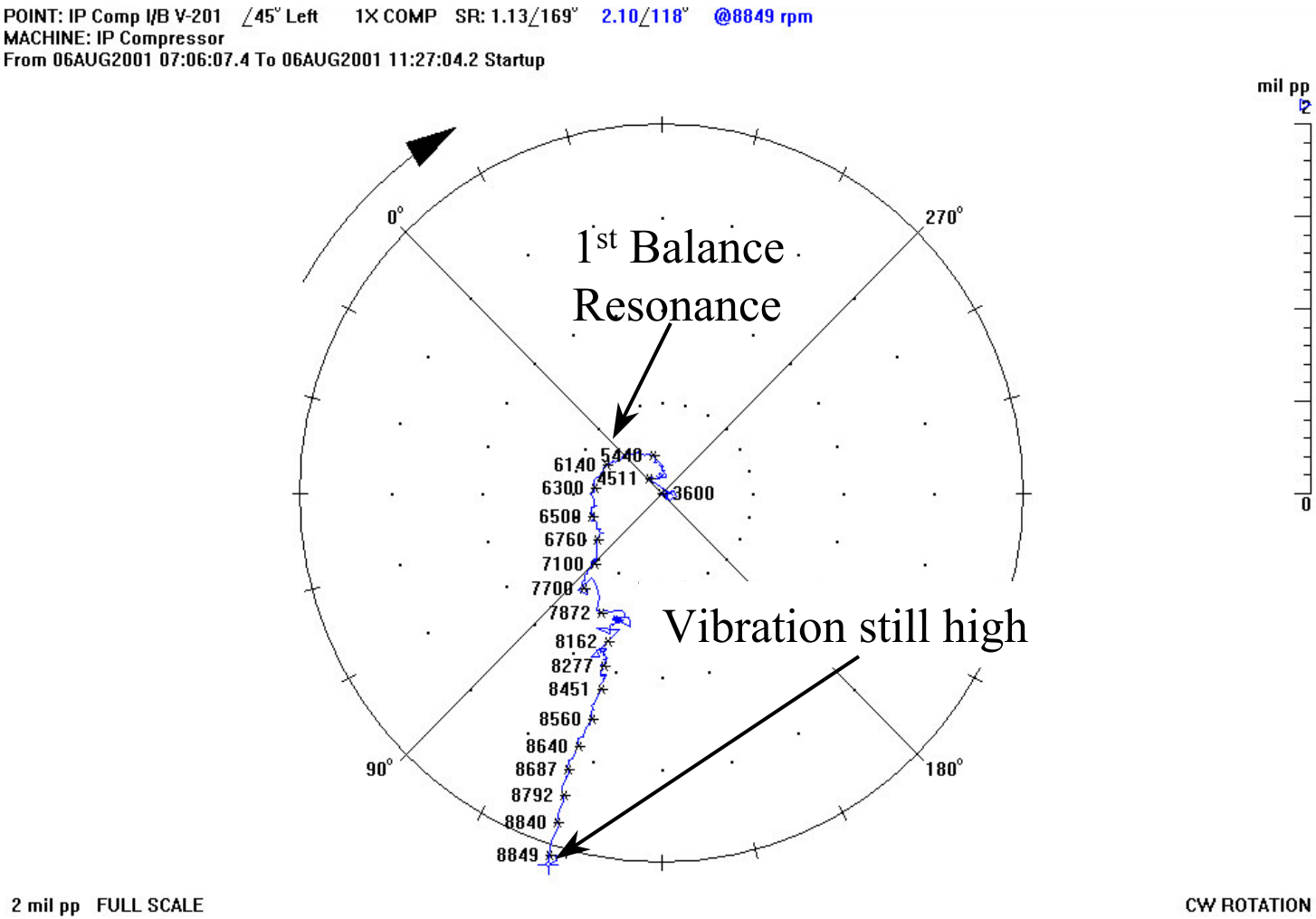
Corrective action:

- Increased the seal rings clearance, typically from 0.001 to 0.003 inch (OEM Recommendation)
- Adjusted the anti-rotation pins to allow maximum floating

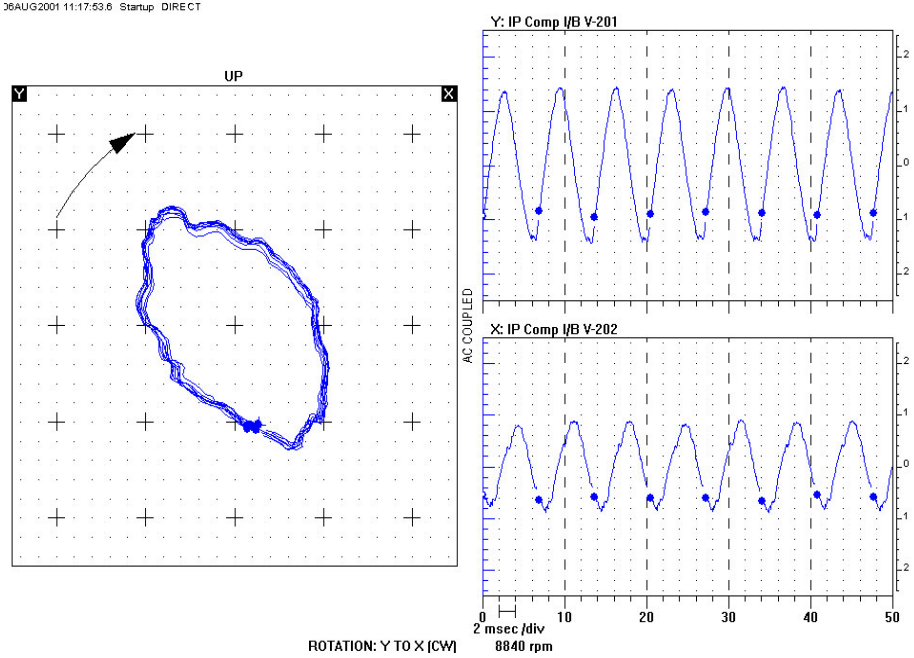
Data collected during startup



Startup Polar Plot

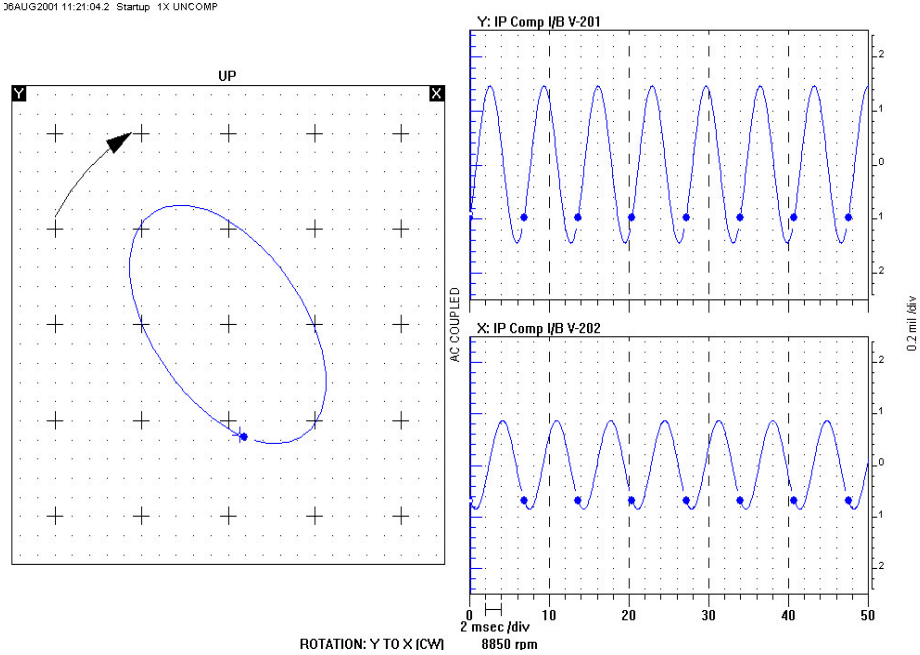


Y: IP Comp I/B V-201 ∠45° Left DIR AMPL: 2.85 mil pp
X: IP Comp I/B V-202 ∠45° Right DIR AMPL: 1.82 mil pp
MACHINE: IP Compressor
06AUG2001 11:17:53.6 Startup DIRECT



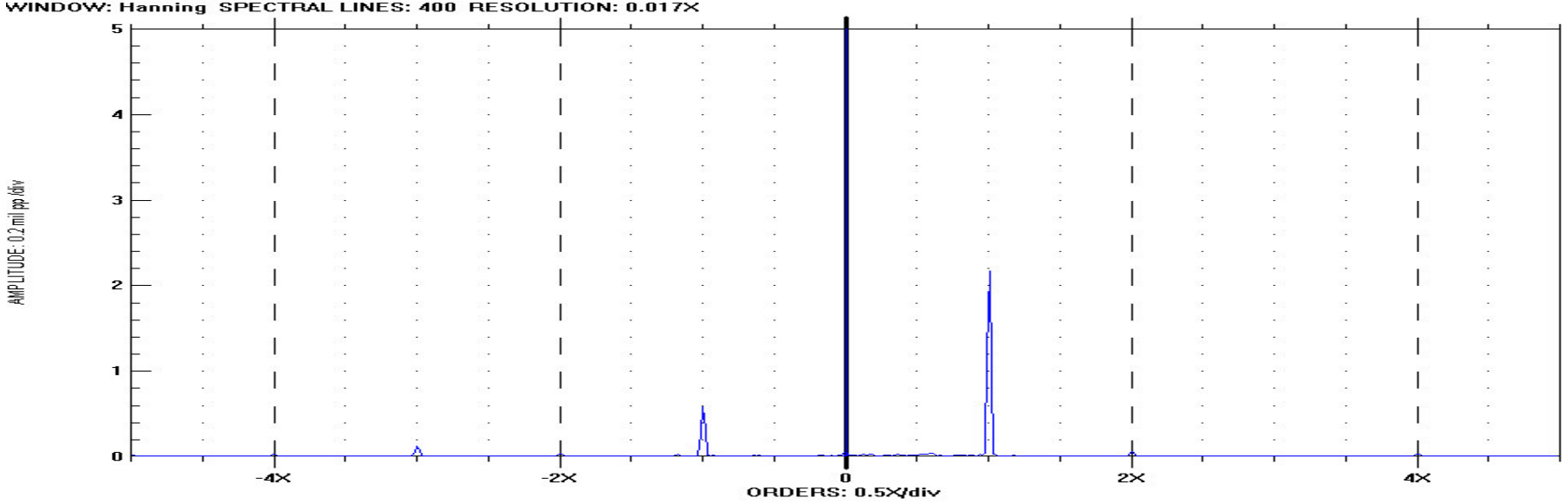
ROTATION: Y TO X (CW) 8840 rpm

X: IP Comp I/B V-202 ∠45° Right VECTOR: 1.72 mil pp∠219°
MACHINE: IP Compressor
06AUG2001 11:21:04.2 Startup 1X UNCOMP

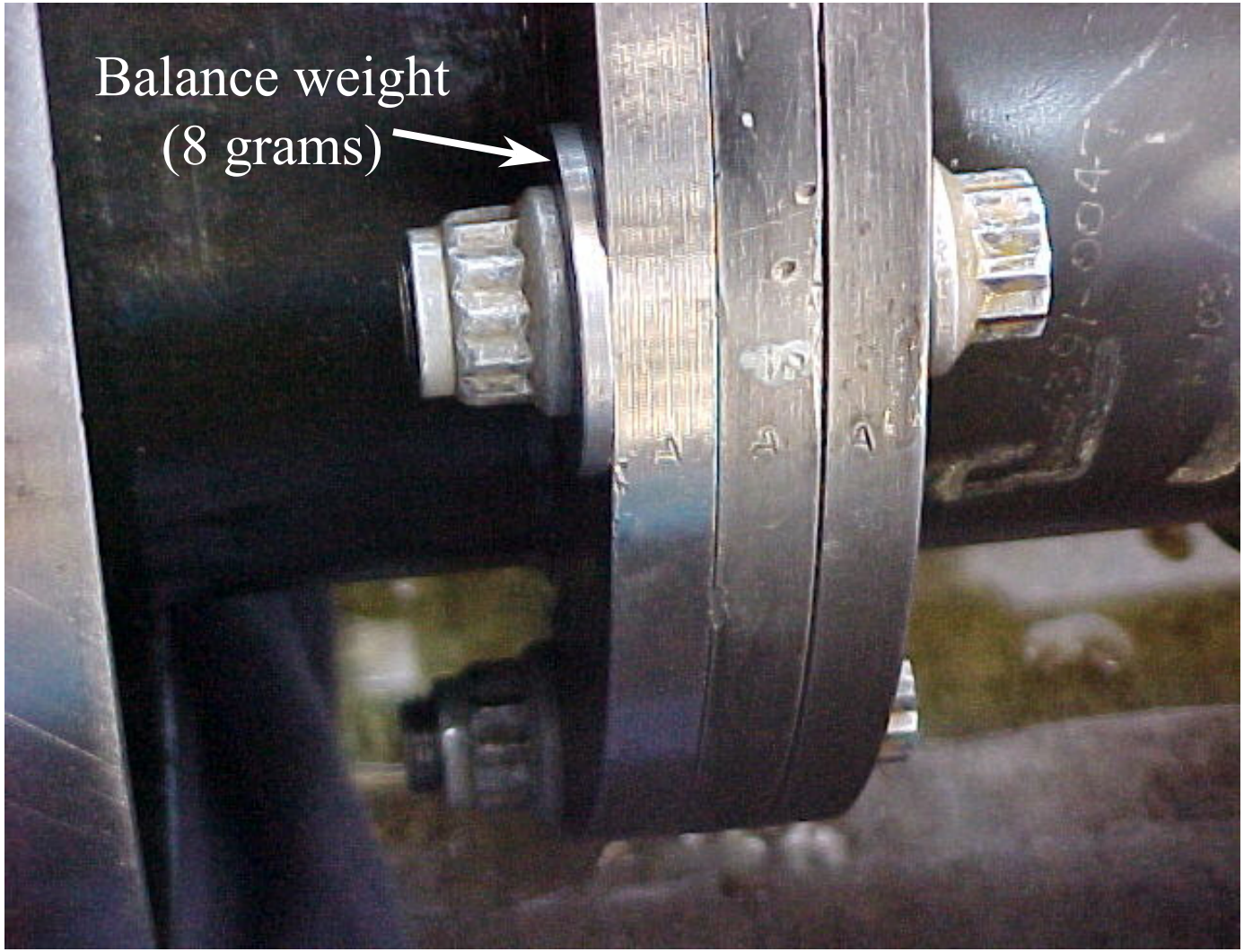


ROTATION: Y TO X (CW) 8850 rpm

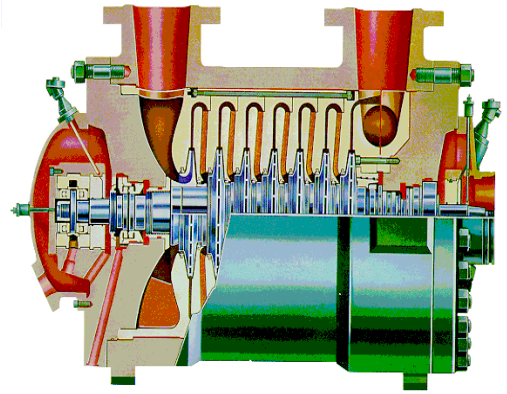
POINT: IP Comp I/B V-201 ∠45° Left DIR AMPL: 2.85 mil pp
POINT: IP Comp I/B V-202 ∠45° Right DIR AMPL: 1.82 mil pp
MACHINE: IP Compressor MACHINE SPEED: 8840 rpm
06 AUG 2001 11:17:53.6 Startup
WINDOW: Hanning SPECTRAL LINES: 400 RESOLUTION: 0.017X



REV VIB COMPONENTS CW ROTATION FWD VIB COMPONENTS

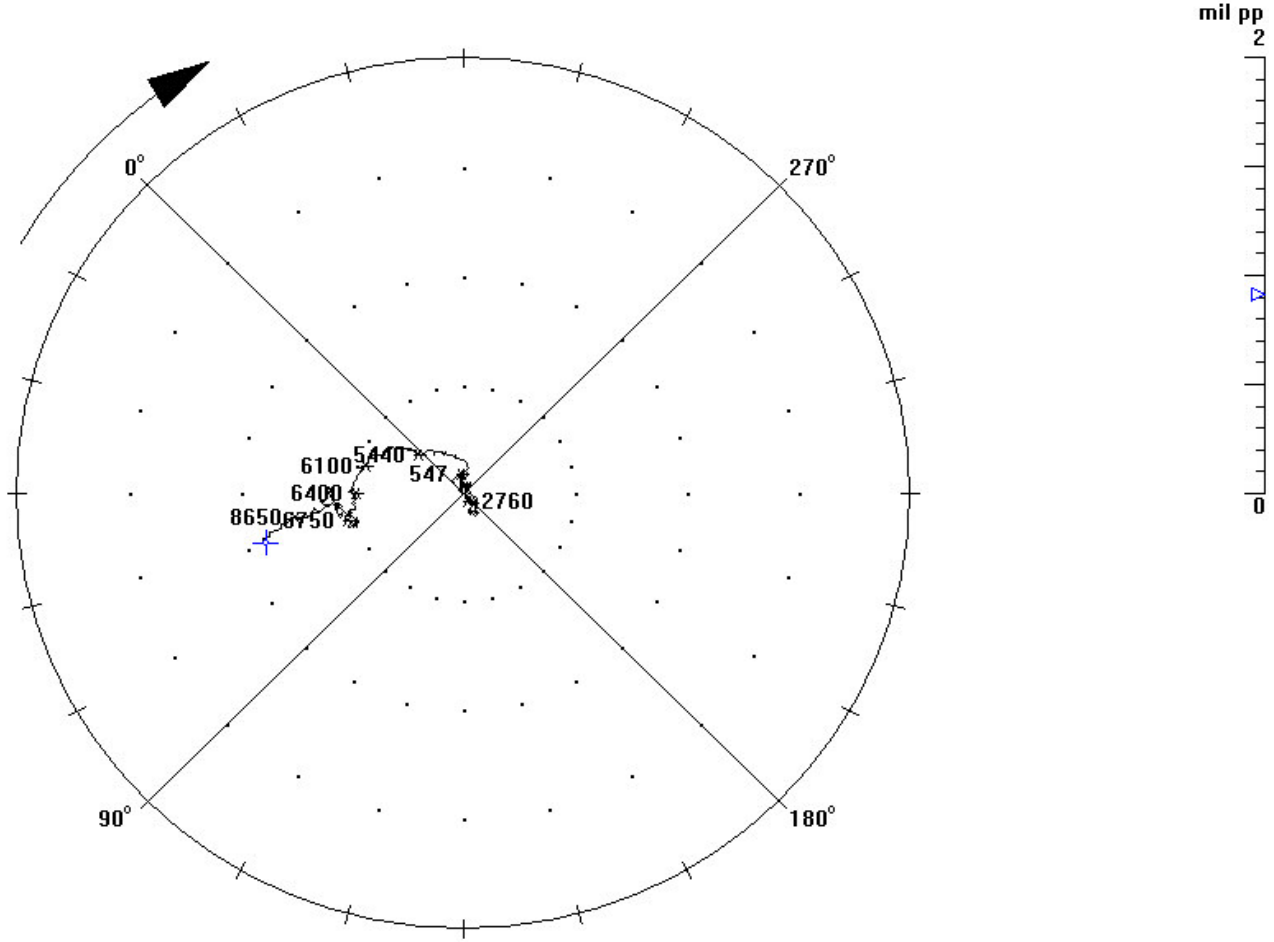

Balance weight
(8 grams)

Data acquired after balancing



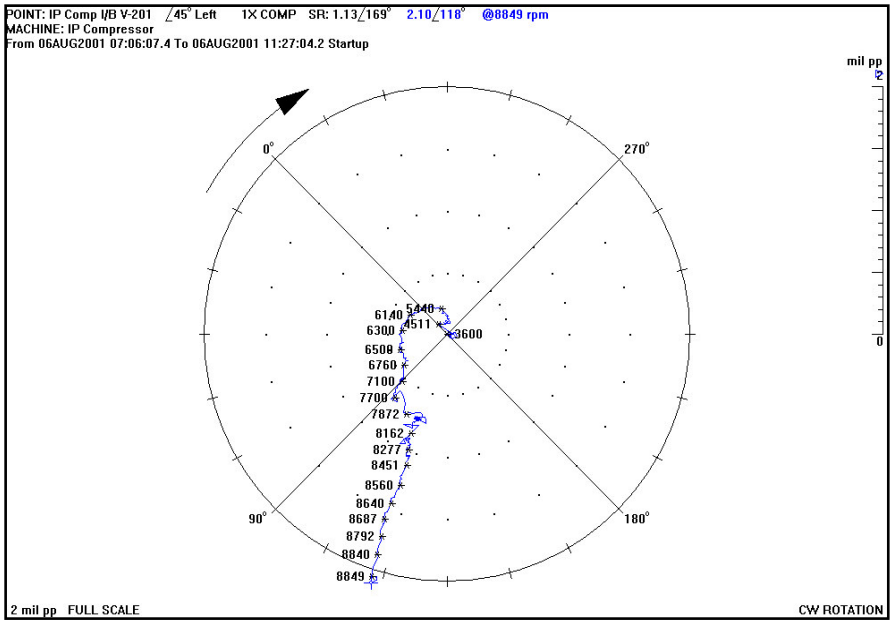
Startup Polar Plot

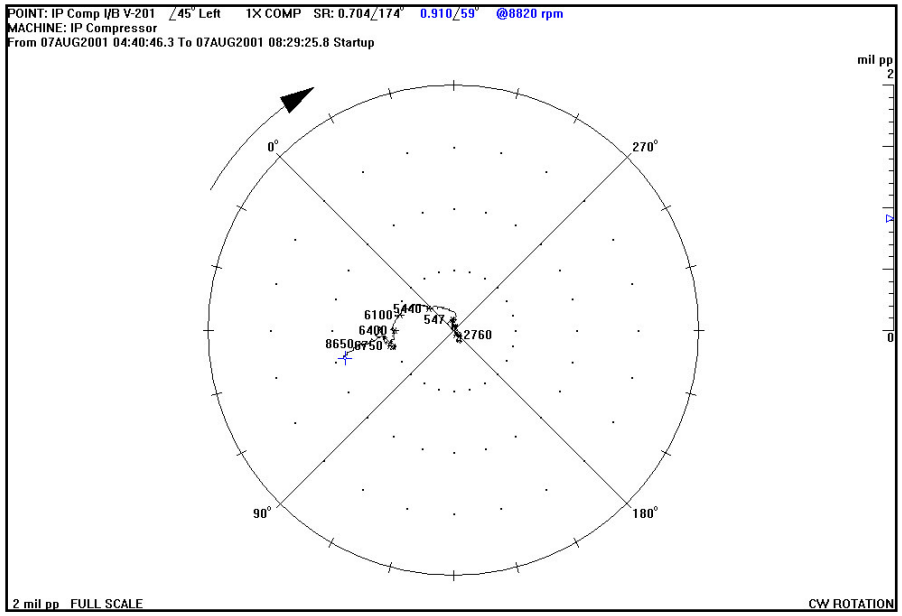
POINT: IP Comp I/B V-201 ∠45° Left 1X COMP SR: 0.704∠174° 0.910∠59° @8820 rpm
MACHINE: IP Compressor
From 07AUG2001 04:40:46.3 To 07AUG2001 08:29:25.8 Startup



2 mil pp FULL SCALE

CW ROTATION





Prior to balancing

After balancing

CONCLUSIONS:

- The system stiffness increased, due to a locked-up seal ring acting as an additional bearing
- Transient data helped determine the root cause of the problem
- This problem could be misdiagnosed as an unbalance problem

THANKS,

ANY QUESTIONS?