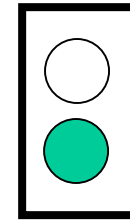


Case Study: 1 - Loose coils cause harmonics of $2*LF$



Plant Application: Condensate Pump Motors

Machine Description: 4000 hp, 1200 rpm, 13.2kv vertical motors built by Parsons Peebles in late-70's/early-80's

Symptoms:

Very low-magnitude peaks (0.005 ips or less) at harmonics of $2*LF$. Stator coils found loose in slot during inspection,

Findings/Conclusions: The pattern of $2*LF$, $4*LF$ etc was caused by the loose coils. This conclusion is predicted by theory and is very strongly supported by experience with all 6 Plant condensate motors.

Theoretical - the mechanism which produces harmonics of Running Speed (RS) in the presence of a force at RS frequency and can also cause harmonics of 2LF in the presence of a force at 2*LF. (assuming looseness is present in both cases)

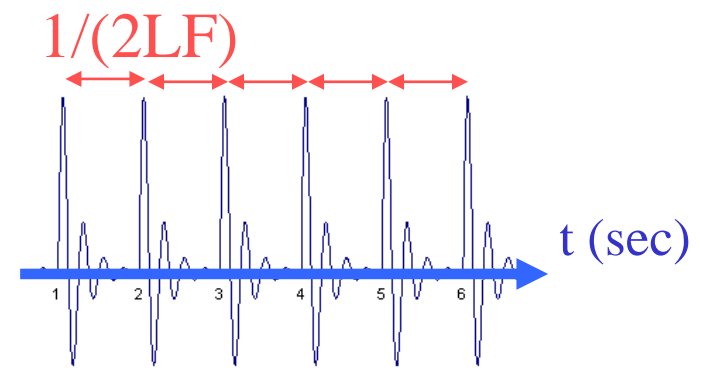
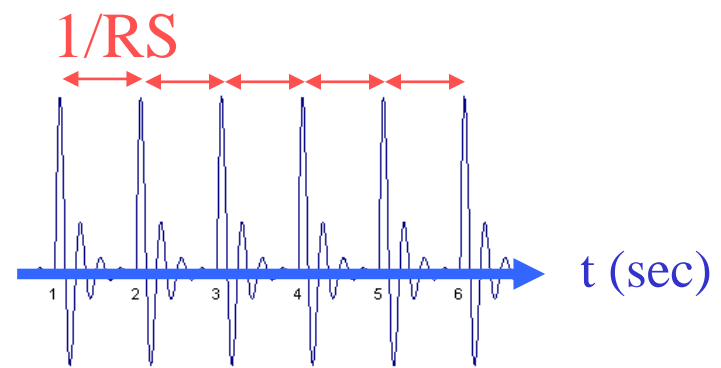
Looseness

Excited by RS force (ex - unbalance)

Excited by 2*LF force (magnetic)

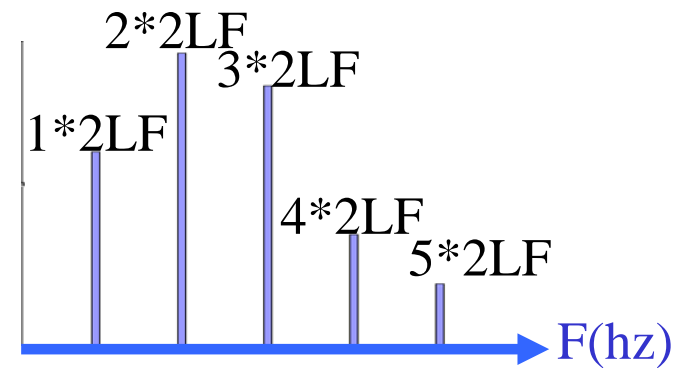
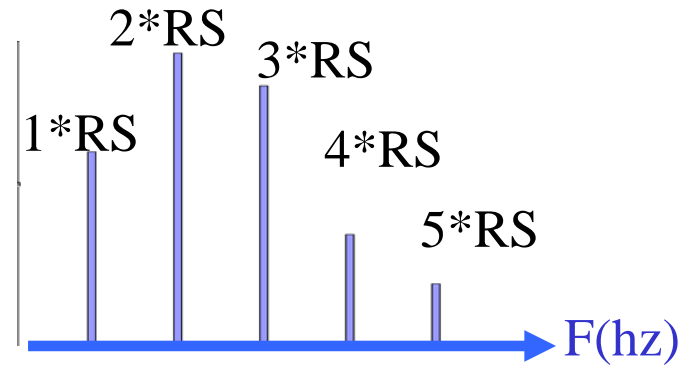
TWF = "Impacts" periodic at RS

TWF = "Impacts" periodic at 2LF



Spectrum = "Harmonics of RS"

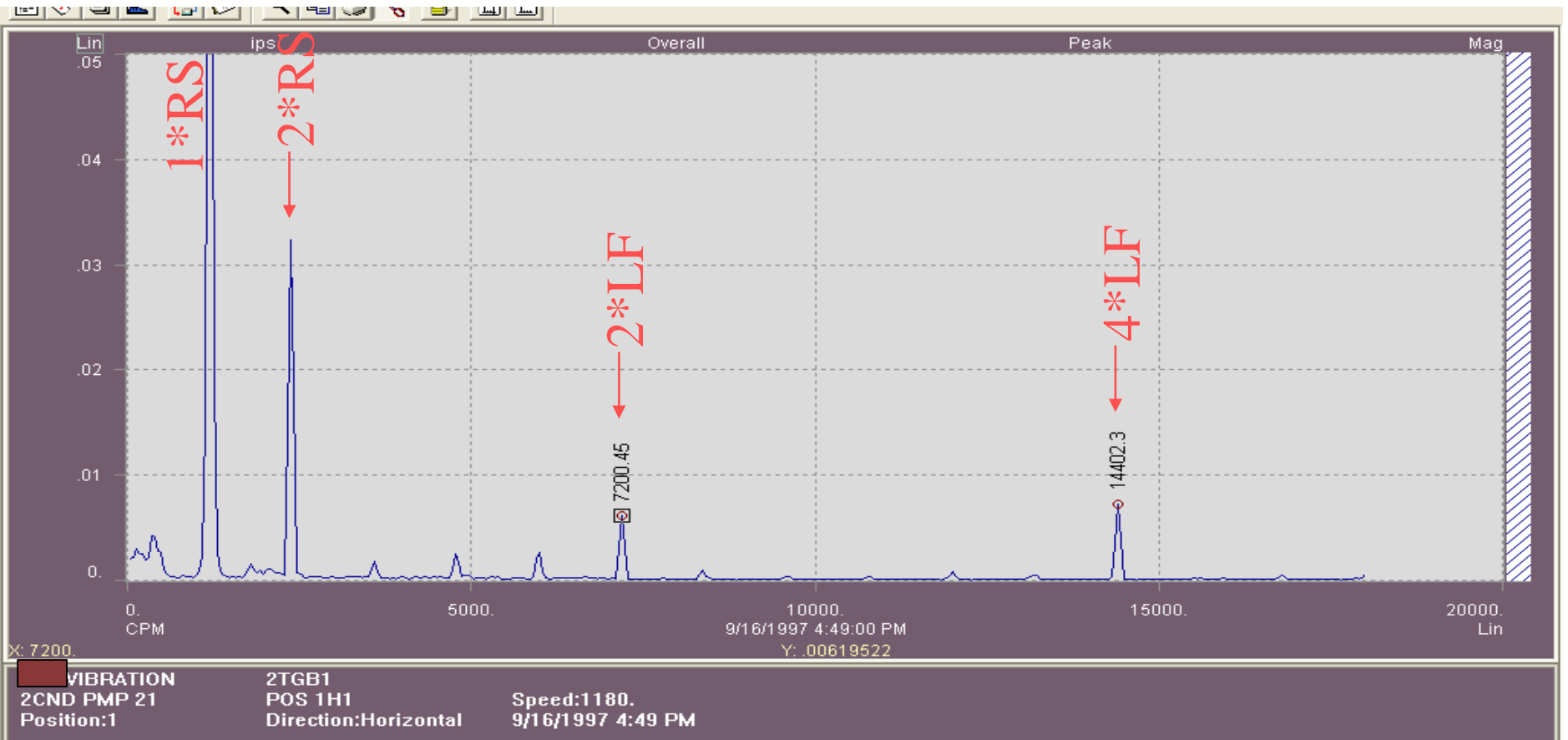
Spectrum = "Harmonics of (2LF)"



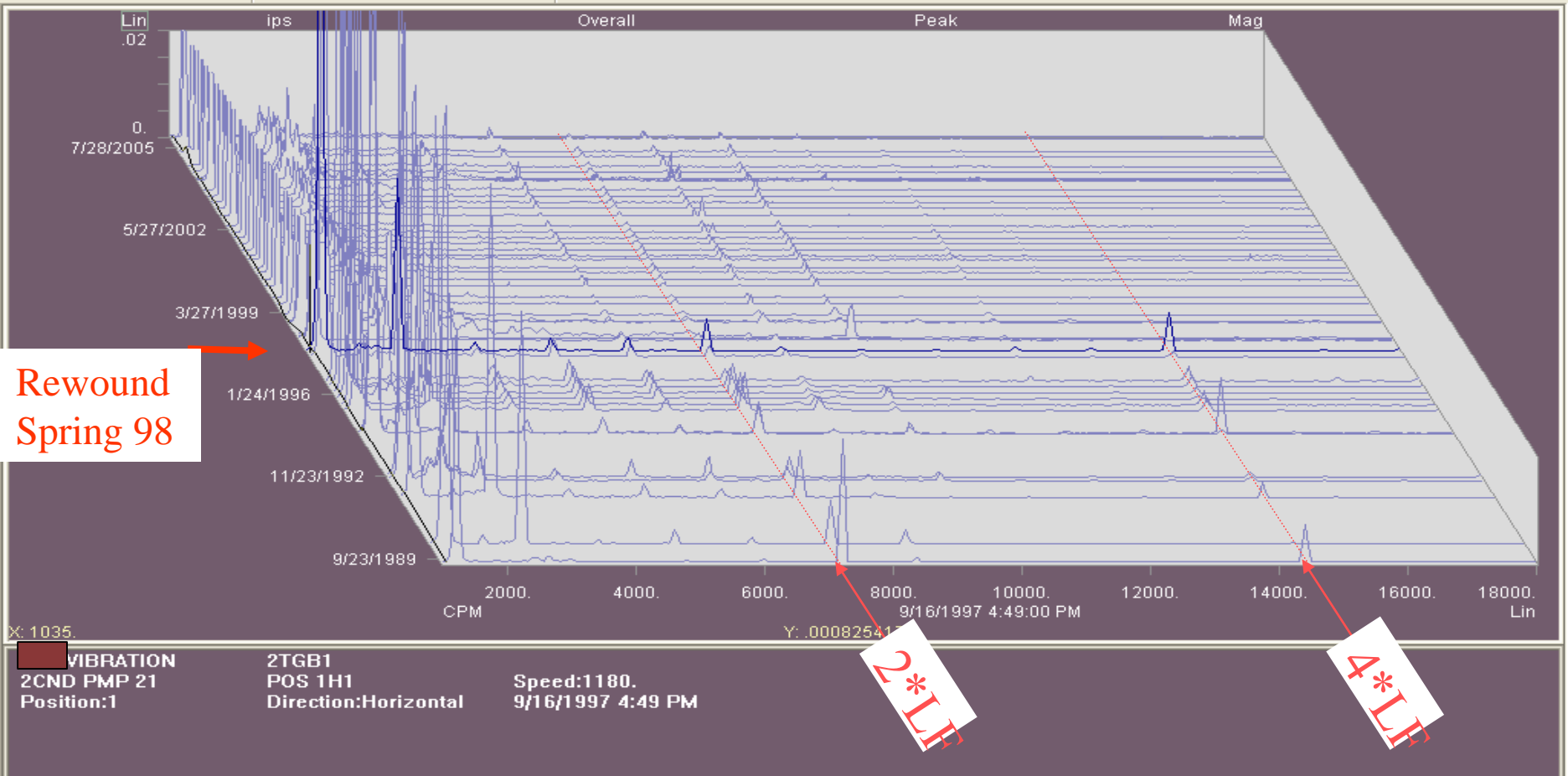
Relevant Plant History

- * CD 21 motor failed DC step voltage test (< 24 kvdc) in Spring 98.
- * Inspection of CD21 after failure showed very loose coils and severe abrasion of groundwall (ladder pattern).
- * All CD motors historically showed low magnitude 2*LF and 4*LF pattern. 4*LF disappeared upon rewind of CD21. (note Plant spectrum does not go high enough to capture 6*LF if present)
- Loose coils are a characteristic of Parsons Peebles machines of this vintage based on Plant experience in three different families of machines
- * 5 remaining CD motors all had 2*LF, 4*LF pattern. These were all inspected and all found to have some degree of loose coils. 4 were rewound and one was rewedged. 4*LF disappeared in all cases.
- * The highest 4*LF was in the motor with loosest coils (CD21)

CD21 Spectrum - just before failed DC step voltage test.

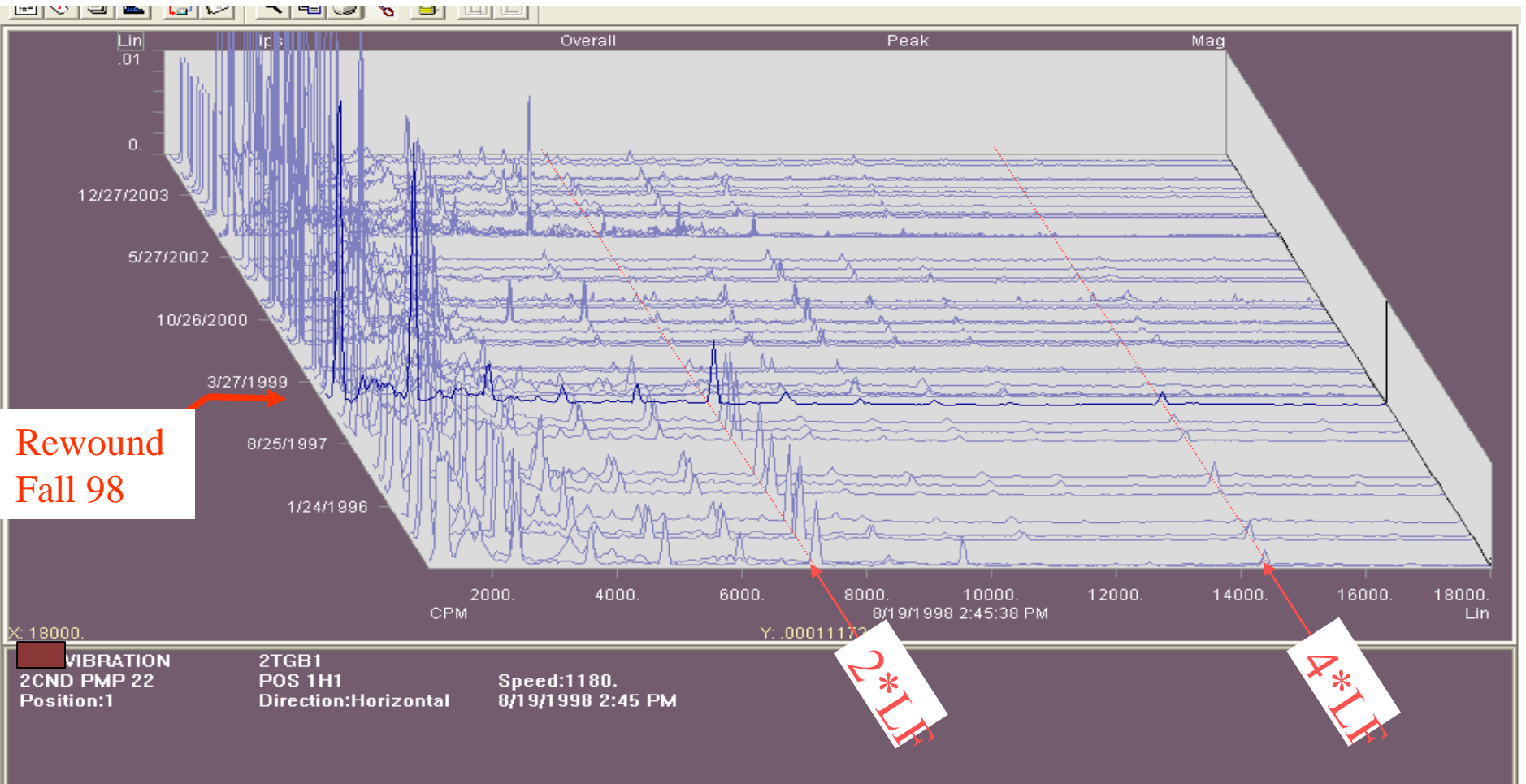


CD21 – 4LF disappeared upon rewind.
(Scale for CD21 is the highest ...0 - 0.02 ips)

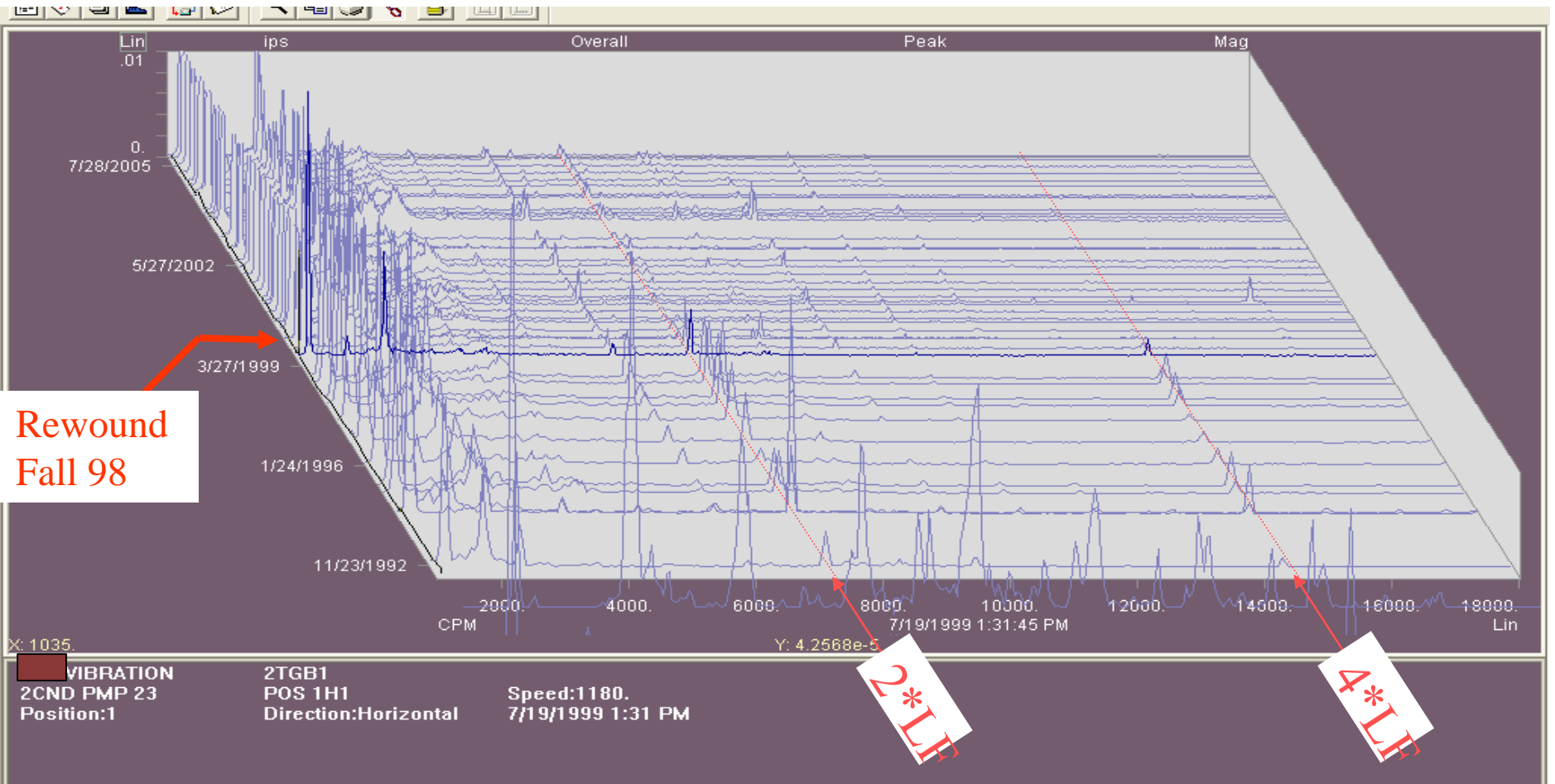


CD22 – 4LF disappeared on rewind.

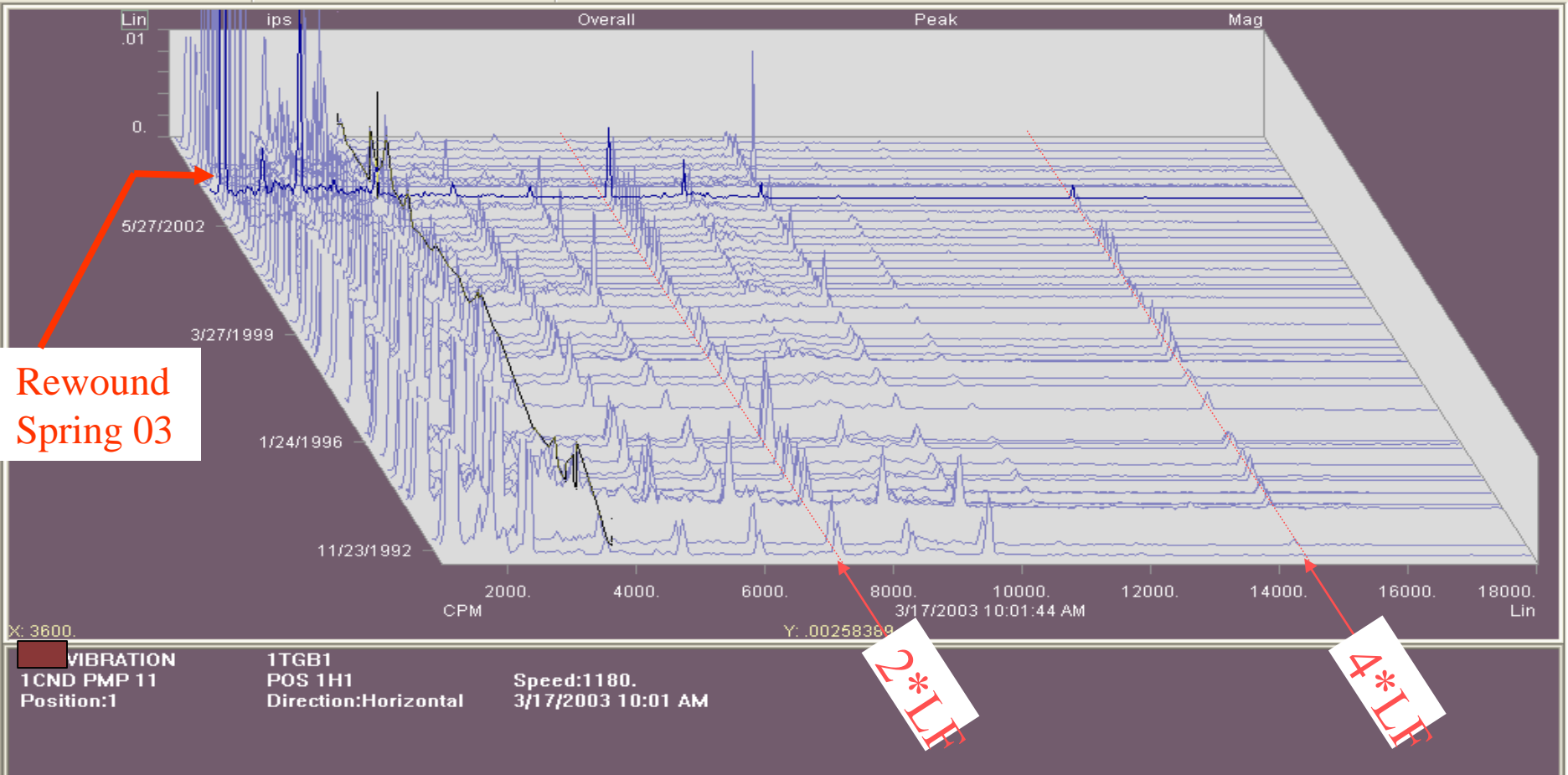
(Scale on this slide and remaining slides is lower...0-0.01 ips)



CD23 – 4LF disappeared upon rewind



CD11 – 4LF disappeared on rewind

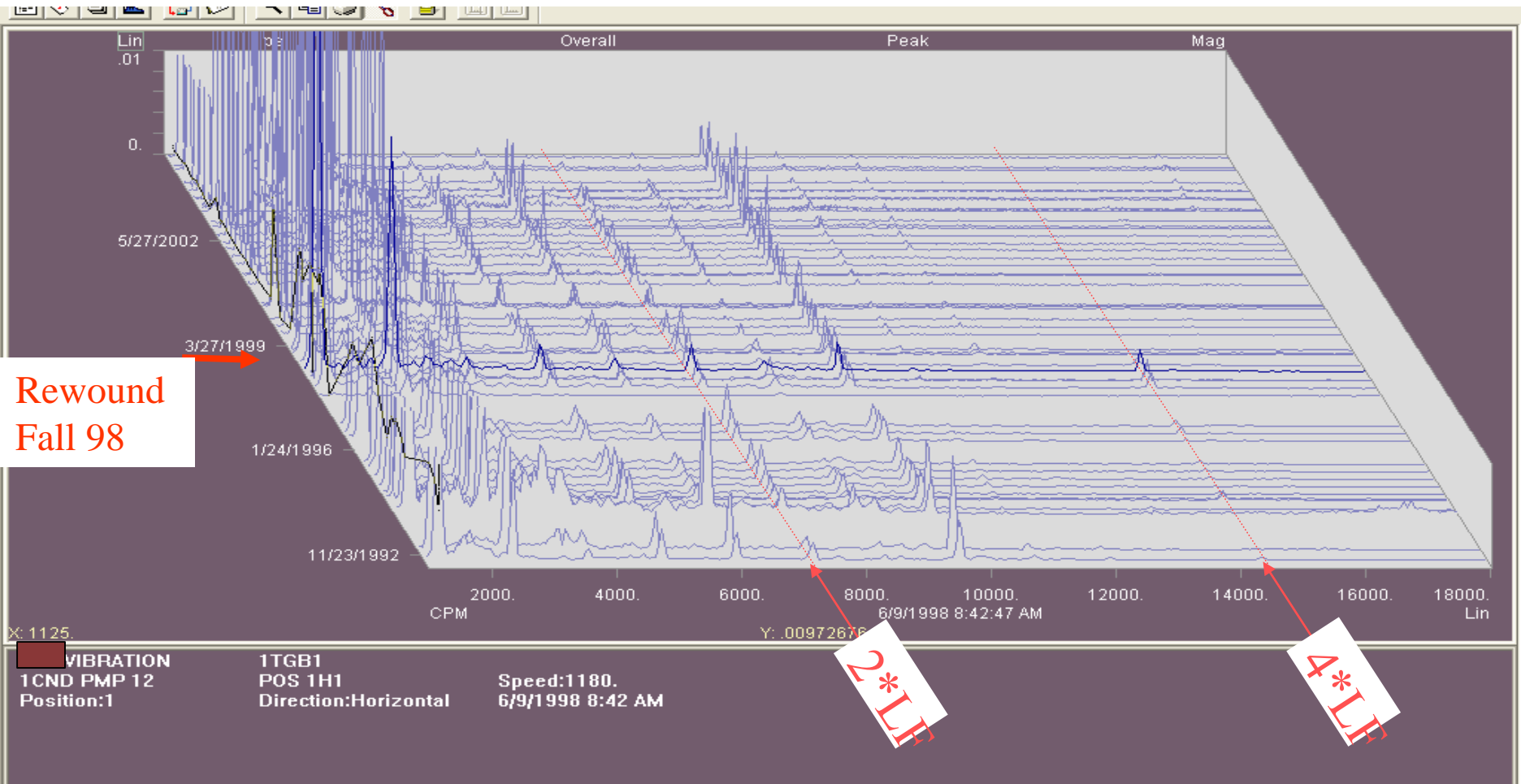


Rewound
Spring 03

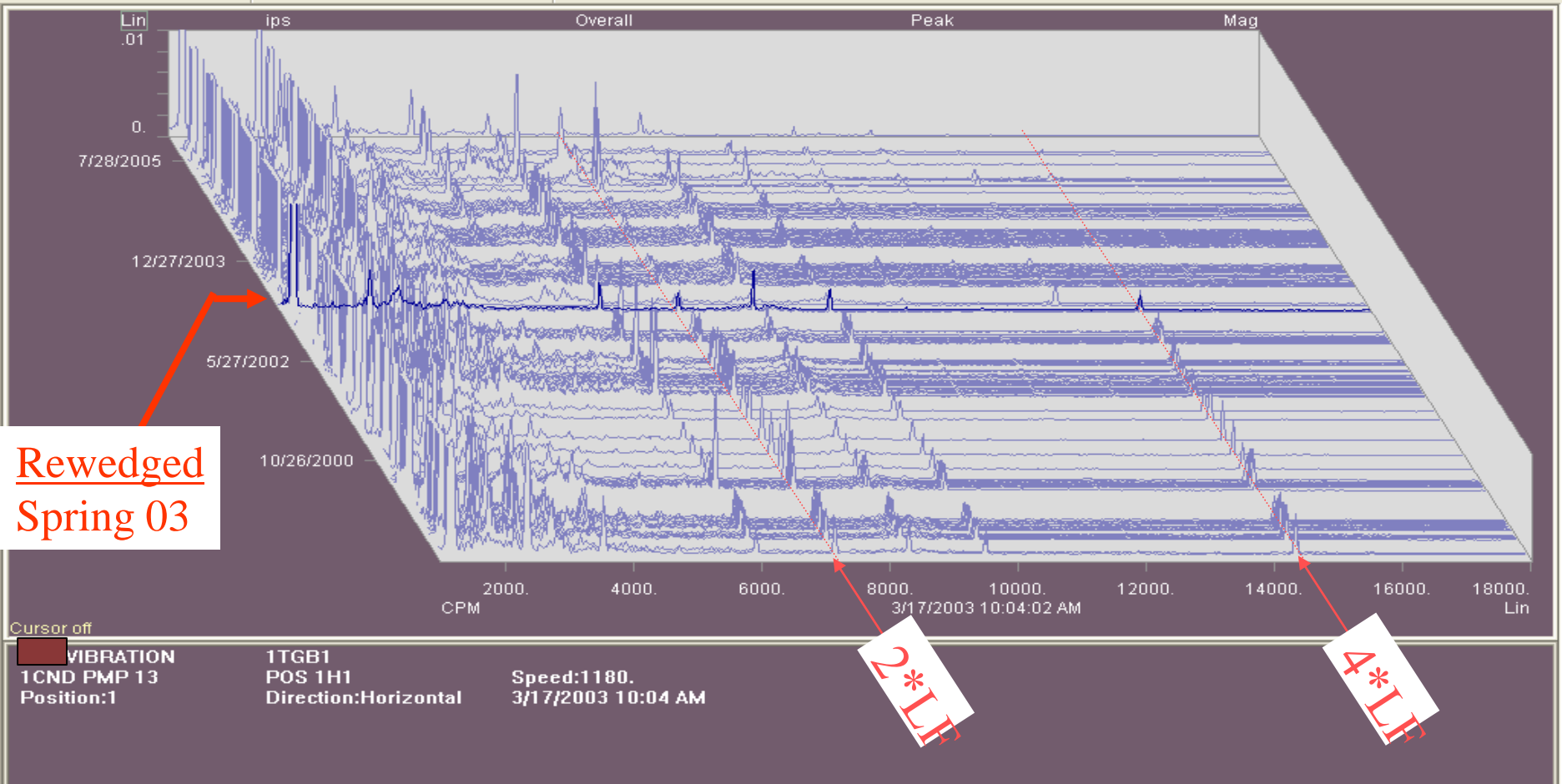
2*LF

4*LF

CD12 – 4LF disappeared upon rewind



CD13 – 4*LF disappeared when REWEDGED



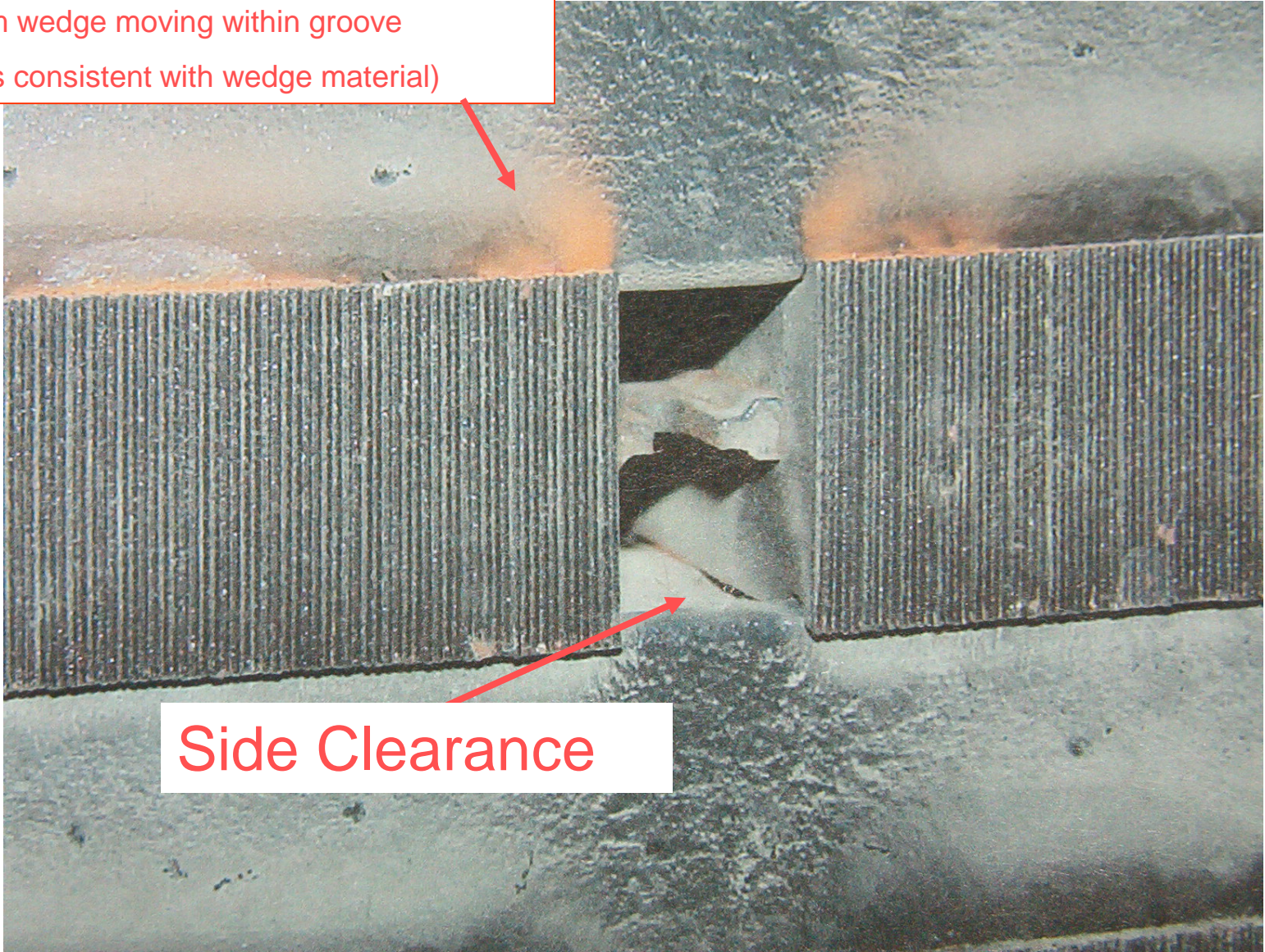
Rewedged
Spring 03

2*LF

4*LF

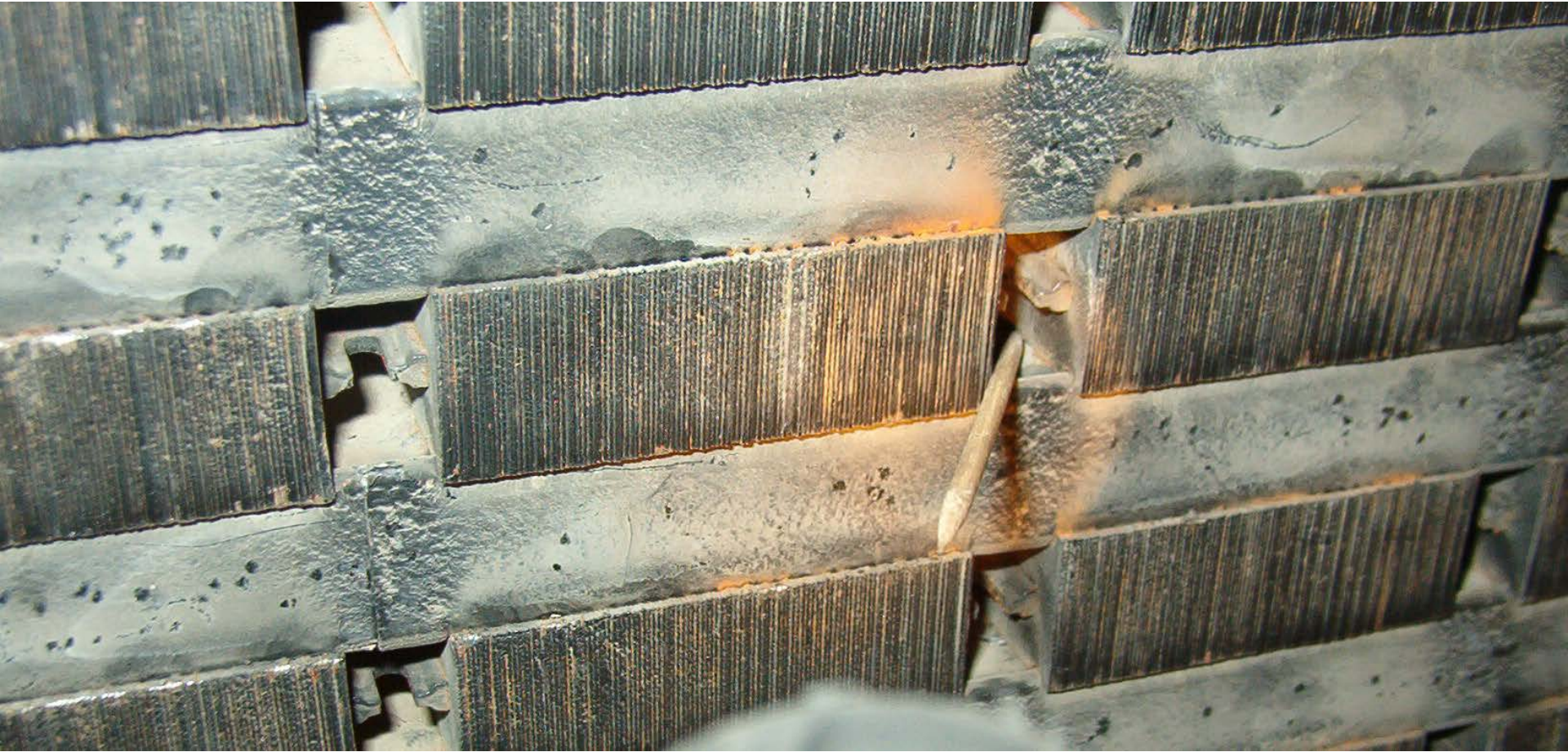
Side clearance visible through air duct (from another family of Parsons Peebles machines)

Powder from wedge moving within groove
(lab analysis consistent with wedge material)



Side Clearance

...Enough clearance to hold a toothpick



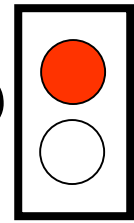
Signs of abrasion at slot exit



Tap test and other inspections confirm loose wedges

CONCLUSIONS

from Case Study: 1 (Loose coils cause harmonics of $2*LF$)



Conclusions: There was very good correlation between low-magnitude harmonics of $2*LF$ and loose stator coils in this case. $2*LF$ harmonics should prompt consideration of POSSIBLE loose coils (see caveats)

Caveats:

- * $2LF$ by itself (w/o harmonics) obviously does not signal looseness.
- * Harmonics of $2*LF$ can be caused by other causes:
 - > magnetic force exciting looseness at other locations
 - > magnetic saturation
 - > $6*LF$, $12*LF$ can come from electronic power supplies
- * MOST IMPORTANTLY - Diverse means of evaluation (boroscope, visual inspection, tap test) should always be used before taking any drastic action based on low-magnitude vibration peaks such as these.