13 Aberdeen Way
Elgin, SC 29045
Tel. (803) 427-0791

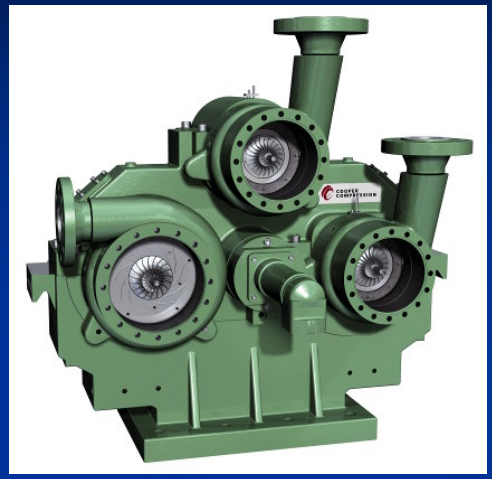
Integrally Geared Centrifugal Air Compressor Vibration Analysis Case Studies

15-Feb-2008

By:
Timothy S. Irwin, P.E.
Senior Engineer
tsi@mbesi.com

Rotating Machinery Diagnostics & Instrumentation Solutions for... "Maintenance That Matters"
www.mbesi.com

Integrally Geared Air Compressors



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How do we monitor these types of machines?

- What kind of components are we trying to monitor in these machines?
  - High speed gearing
  - High speed shafts / impellers
  - Low speed shafts
  - Geared couplings
  - Disc or shim-pack couplings
  - Sleeve bearings
  - Multi-segment tilt pad bearings

This does not include the driver which could be a motor or turbine of which either one can add more complexities to the setup of a monitoring route

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What parameters do we have available for monitoring the overall condition?

- Bearing temperatures
- Stage and drive gear vibration
- Stage inlet and outlet temperatures
- Stage inlet and outlet pressures
- Intercooler inlet and outlet temperatures
- Intercooler inlet and outlet pressures
- Motor amperage or kW

There are a lot of parameters that can be used including the above items and:

- Performance testing
- Oil Analysis
- And visual inspections

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What do we use to monitor the vibration of the machine?

- Is there a permanent probe of some kind on each stage?
- Is there a permanent monitoring / vibration protection system installed?
- Or are our only options temporary accelerometers?

Many permanent monitoring systems will have proximity probes on each stage, are they?

- A single probe on the stage?
- Dual probes at 90 degrees?
- Any there permanent accelerometers?
- Can you ‘plug-in’ to obtain the raw signal in your portable data collector?

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Vibration Analysis:

- Proximity probe use
- Magnetically mounted accelerometers
- High Frequency accelerometers

To use the above probes we need to figure out the expected fault frequencies
So that we can set up the appropriate frequency spans and resolutions

The following segments of the case studies will be on several
Joy (Cameron Compression) MSG 4-stage machines

Case Study #1 – Cameron Compression MSG

What are typical Fault Frequencies:

- Shaft Running Speeds
- Journal Bearing Issues
- Gear Mesh (and other gear fault frequencies)
- Vane Pass (diffuser vs. impeller)
- Coupling/Alignment

Motor

- Shaft Running Speeds
- Journal Bearing Issues
- Electrical Frequencies

Case Study #1 – Cameron Compression MSG

Example Fault Frequencies:

- Shaft Speeds:
  - Motor, Couplings, & Gear – 1781 rpm
  - Pinion Speeds – 14,385 & 21,372 rpm

- Gears (420 teeth, 52 teeth, 35 teeth):
  - Gear Mesh – 748,020 (12,467 Hz)
  - Assembly phase – 187,000 & 21,372 cpm
  - Hunting Tooth – 1198, 203 cpm

- Vane Pass – 362,100 cpm (for bladed diffuser)

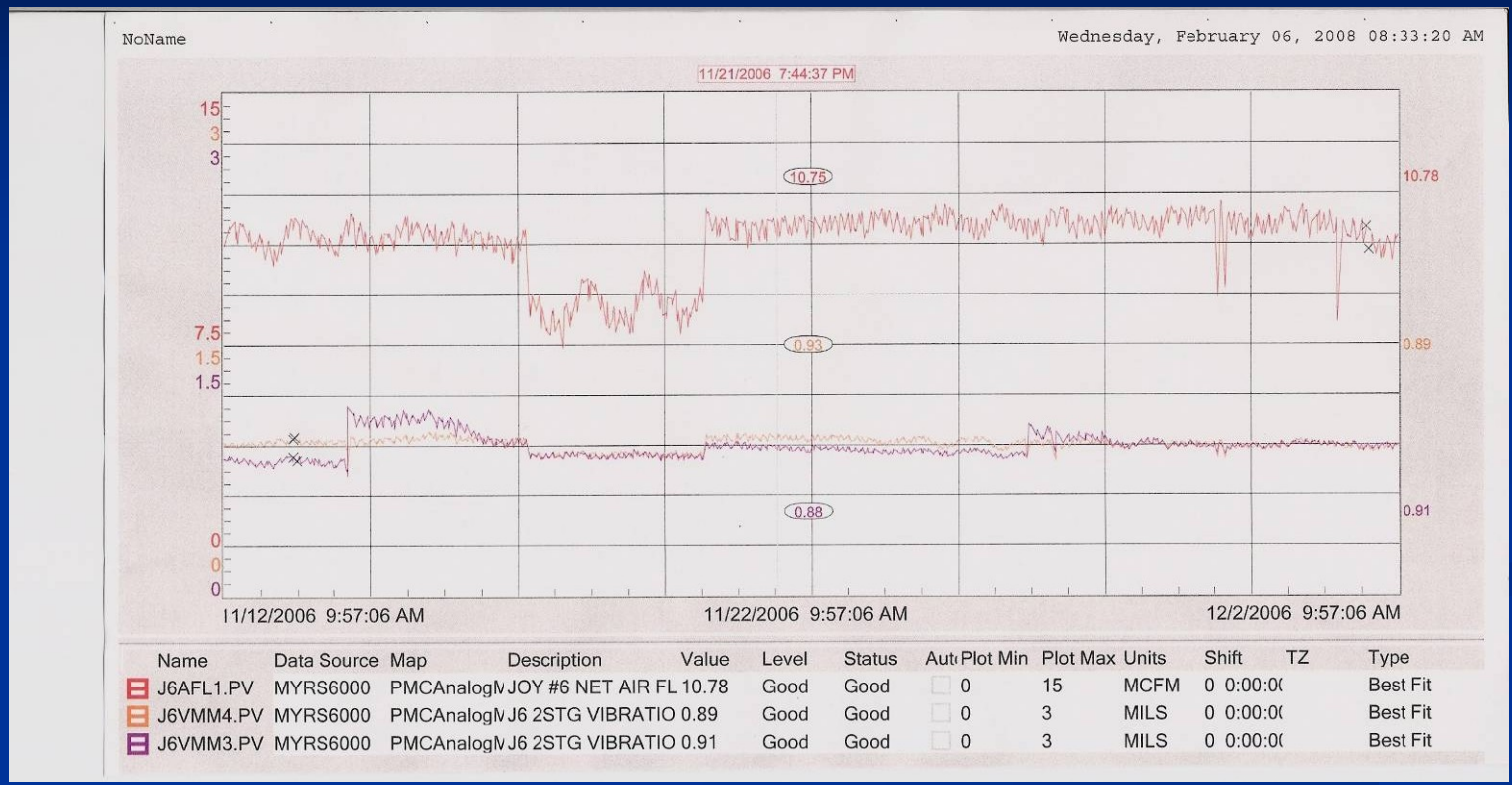
Case Study #1 – Cameron Compression MSG

Displacement – Velocity – Acceleration
What is an acceptable measurementfrequency range:

	3600 rpm	20,000 rpm	750,000 cpm
Displacement (mils)	1	1	1
Velocity (in/s)	0.19	1.05	39.3
Acceleration (g)	0.18	5.68	7988

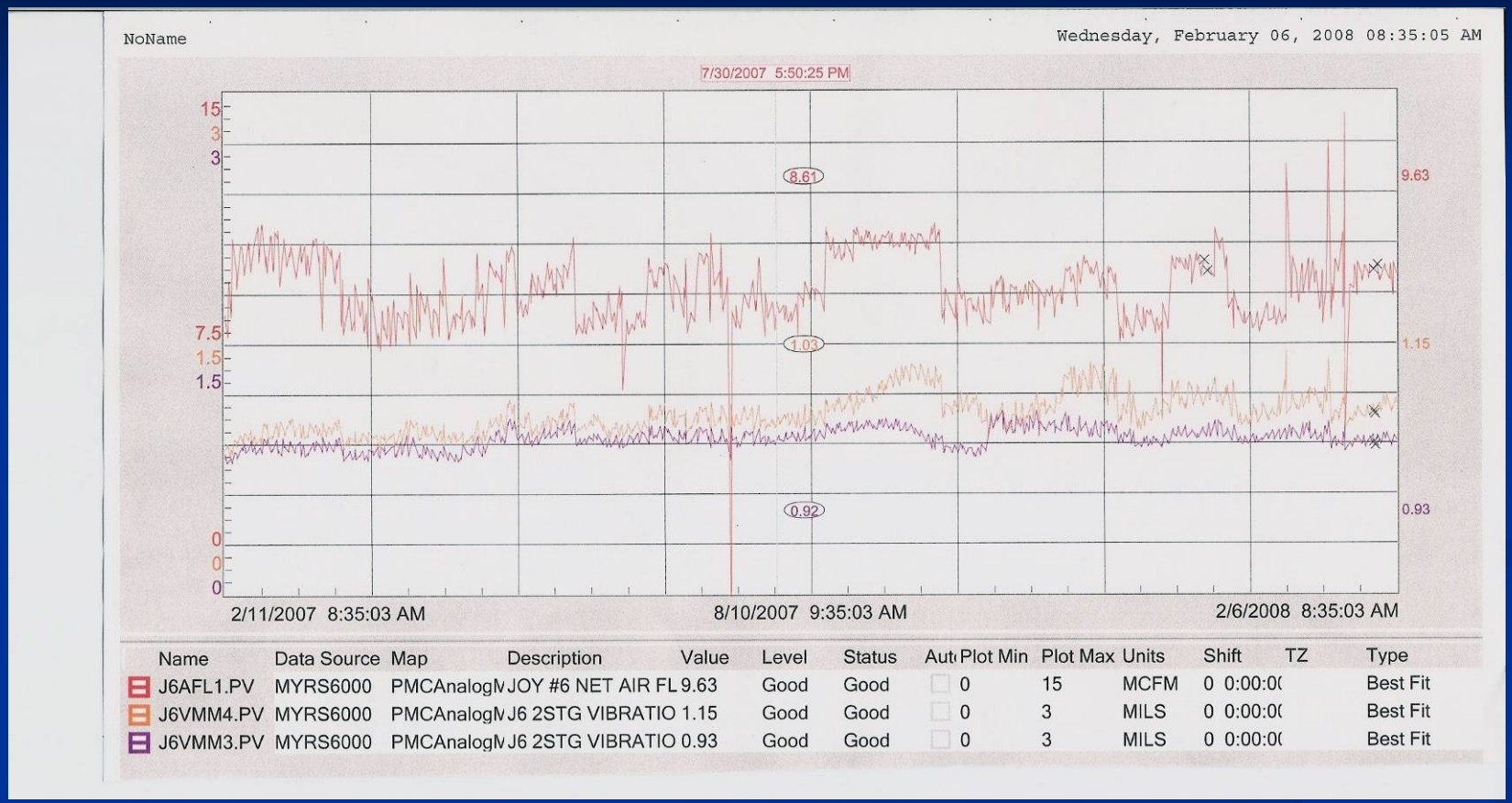
	3600 rpm	20,000 rpm	750,000 cpm
Displacement (mils)	27	0.88	0.0006
Velocity (in/s)	5.1	0.921	0.025
Acceleration (g)	5	5	5

Case Study #1 – Cameron Compression MSG



Note the step changes in the trend plot

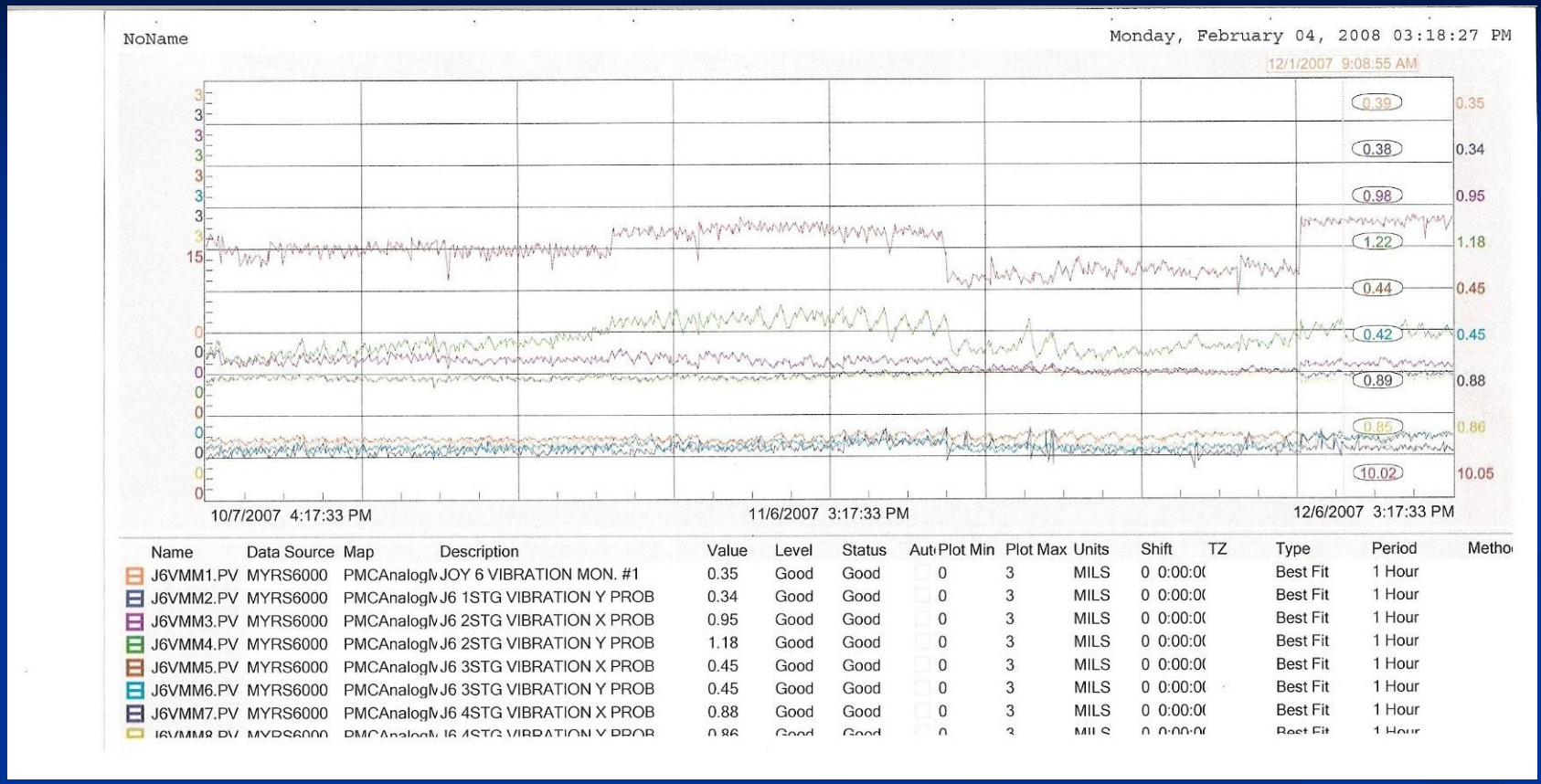
Case Study #1 – Cameron Compression MSG



Name	Data Source	Map	Description	Value	Level	Status	Aut	Plot Min	Plot Max	Units	Shift	TZ	Type
J6AFL1.PV	MYRS6000	PMCAnalogM	JOY #6 NET AIR FL	9.63	Good	Good		0	15	MCFM	0 0:00:0(		Best Fit
J6VMM4.PV	MYRS6000	PMCAnalogM	J6 2STG VIBRATIO	1.15	Good	Good		0	3	MILS	0 0:00:0(		Best Fit
J6VMM3.PV	MYRS6000	PMCAnalogM	J6 2STG VIBRATIO	0.93	Good	Good		0	3	MILS	0 0:00:0(		Best Fit

Note the variations in amplitude over time

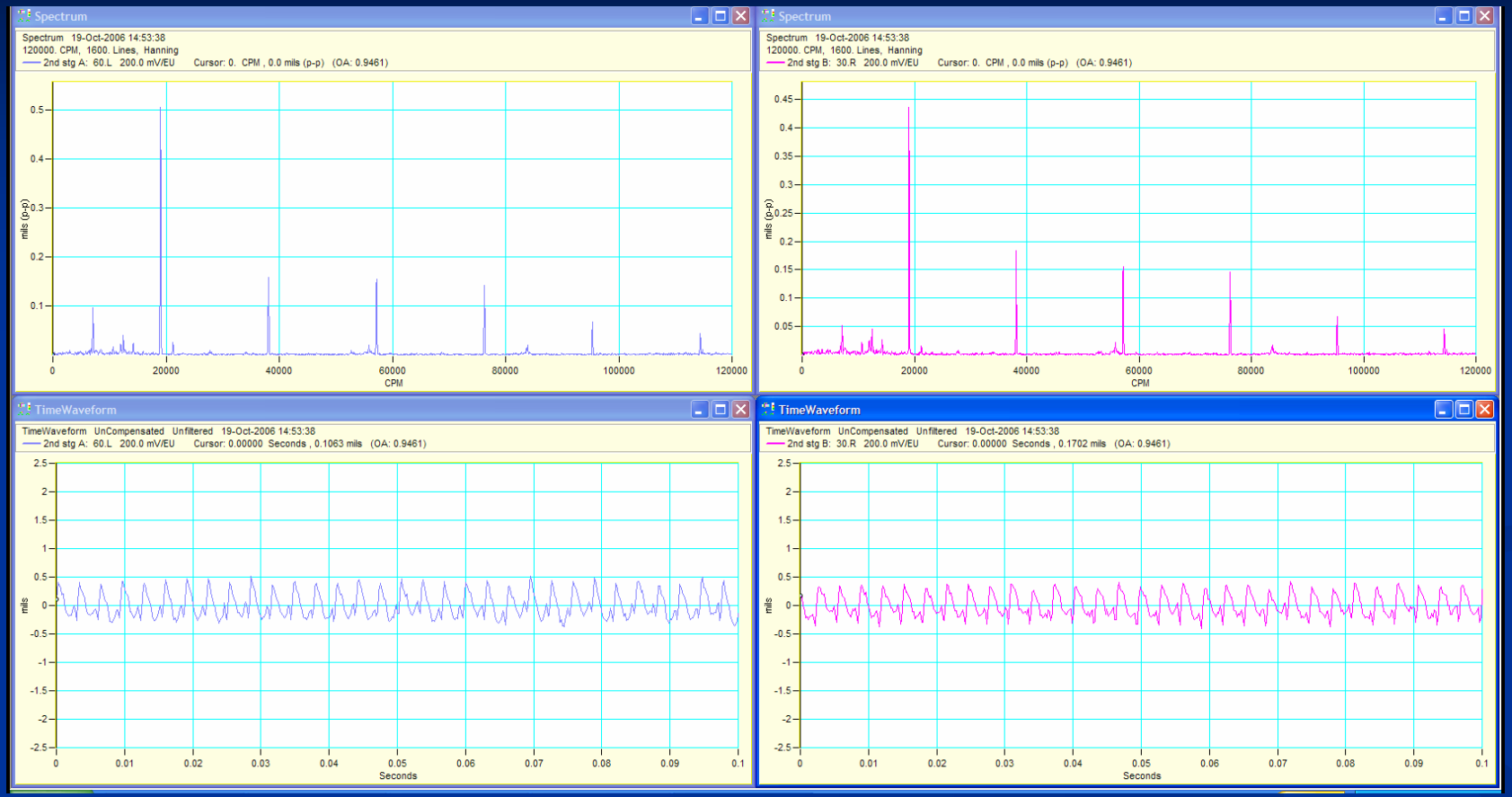
Case Study #1 – Cameron Compression MSG



Name	Data Source	Map	Description	Value	Level	Status	Auto	Plot Min	Plot Max	Units	Shift	TZ	Type	Period	Metho
J6VMM1.PV	MYRS6000	PMCAnalogM	JOY 6 VIBRATION MON. #1	0.35	Good	Good		0	3	MILS	0 0:00:0(		Best Fit	1 Hour	
J6VMM2.PV	MYRS6000	PMCAnalogM	J6 1STG VIBRATION Y PROB	0.34	Good	Good		0	3	MILS	0 0:00:0(		Best Fit	1 Hour	
J6VMM3.PV	MYRS6000	PMCAnalogM	J6 2STG VIBRATION X PROB	0.95	Good	Good		0	3	MILS	0 0:00:0(		Best Fit	1 Hour	
J6VMM4.PV	MYRS6000	PMCAnalogM	J6 2STG VIBRATION Y PROB	1.18	Good	Good		0	3	MILS	0 0:00:0(		Best Fit	1 Hour	
J6VMM5.PV	MYRS6000	PMCAnalogM	J6 3STG VIBRATION X PROB	0.45	Good	Good		0	3	MILS	0 0:00:0(		Best Fit	1 Hour	
J6VMM6.PV	MYRS6000	PMCAnalogM	J6 3STG VIBRATION Y PROB	0.45	Good	Good		0	3	MILS	0 0:00:0(		Best Fit	1 Hour	
J6VMM7.PV	MYRS6000	PMCAnalogM	J6 4STG VIBRATION X PROB	0.88	Good	Good		0	3	MILS	0 0:00:0(		Best Fit	1 Hour	
J6VMM8.PV	MYRS6000	PMCAnalogM	J6 4STG VIBRATION Y PROB	0.86	Good	Good		0	3	MILS	0 0:00:0(		Best Fit	1 Hour	

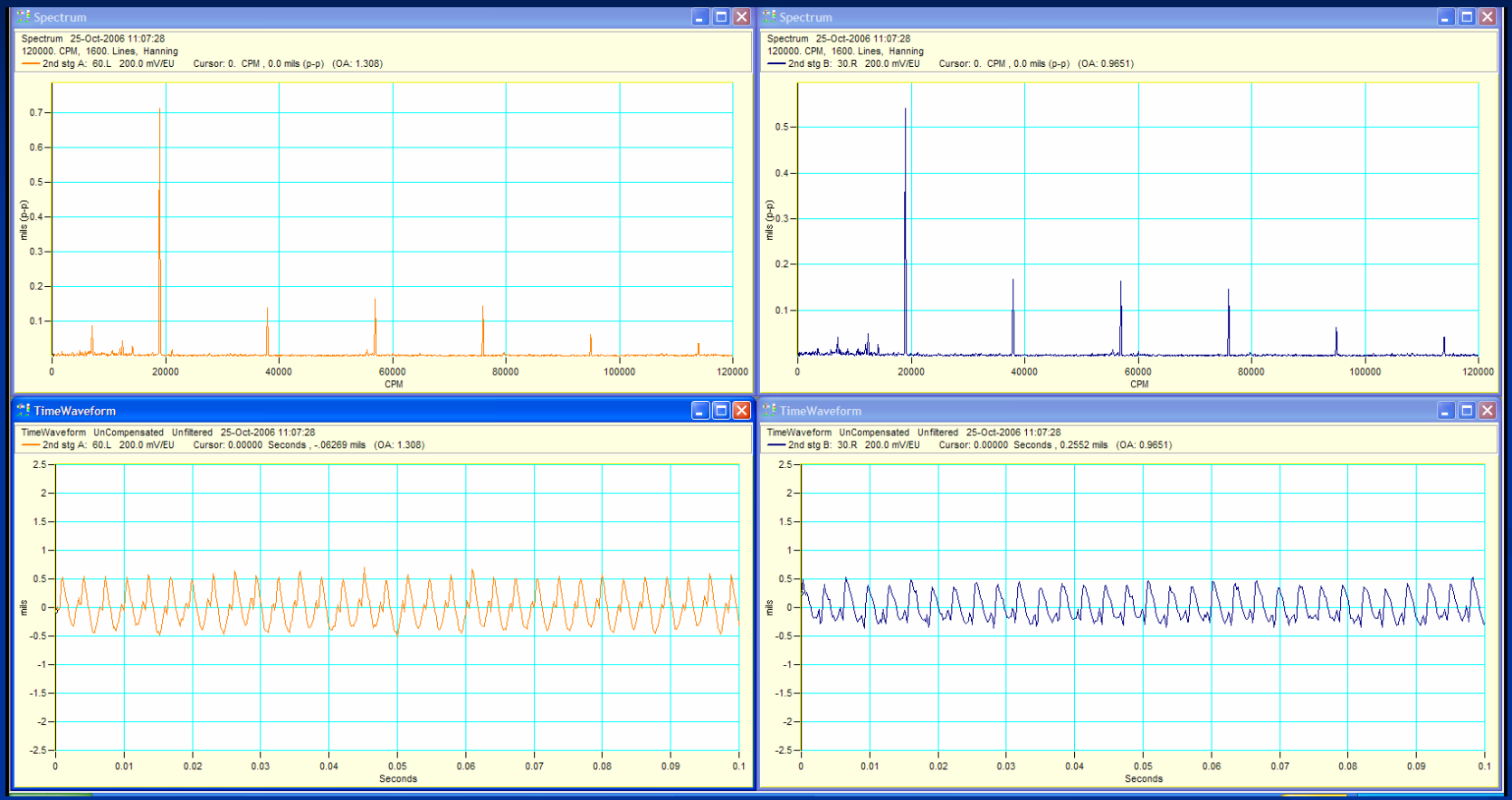
Here is a recent comparison to the other stages on the same machine

Case Study #1 – Cameron Compression MSG



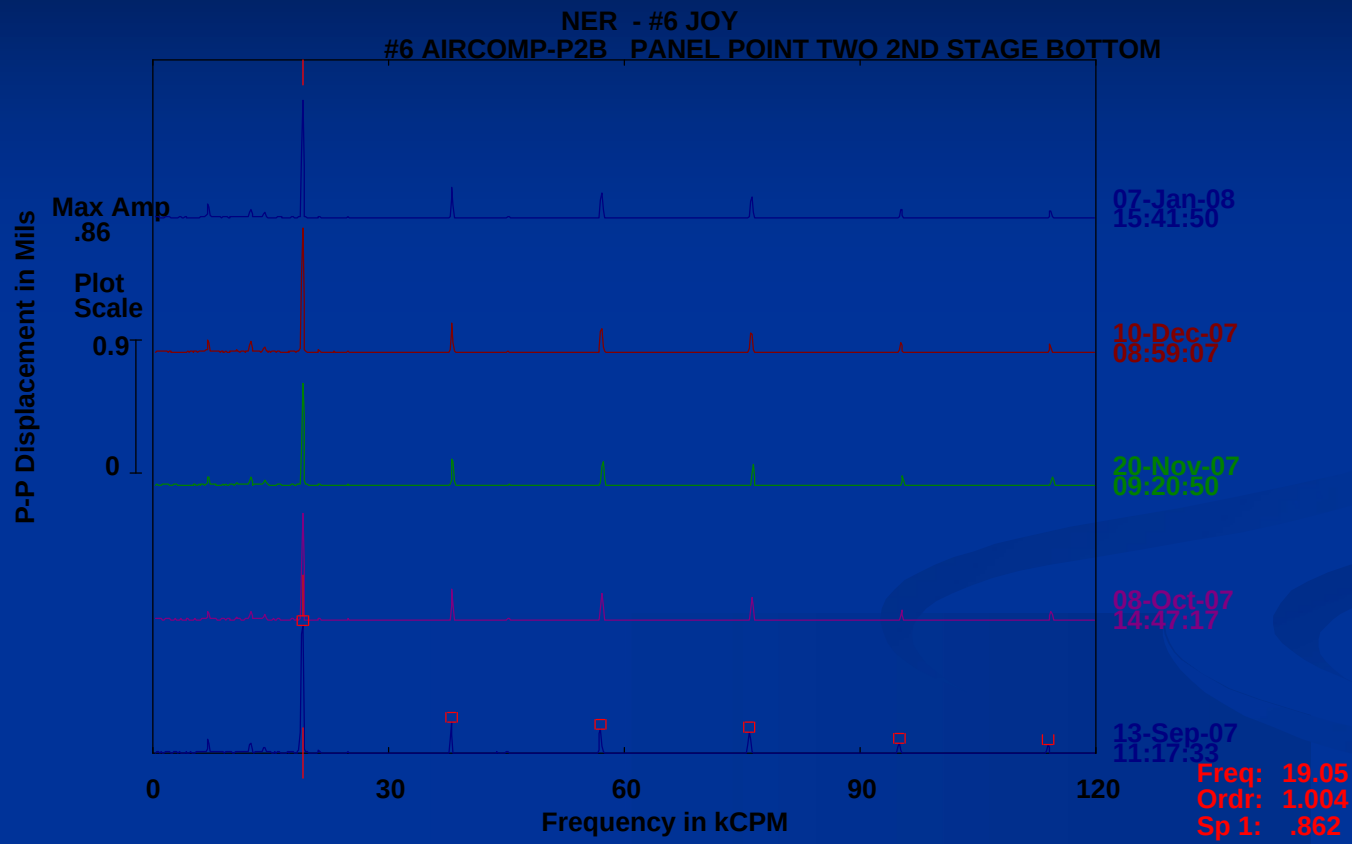
Just after the startup

Case Study #1 – Cameron Compression MSG



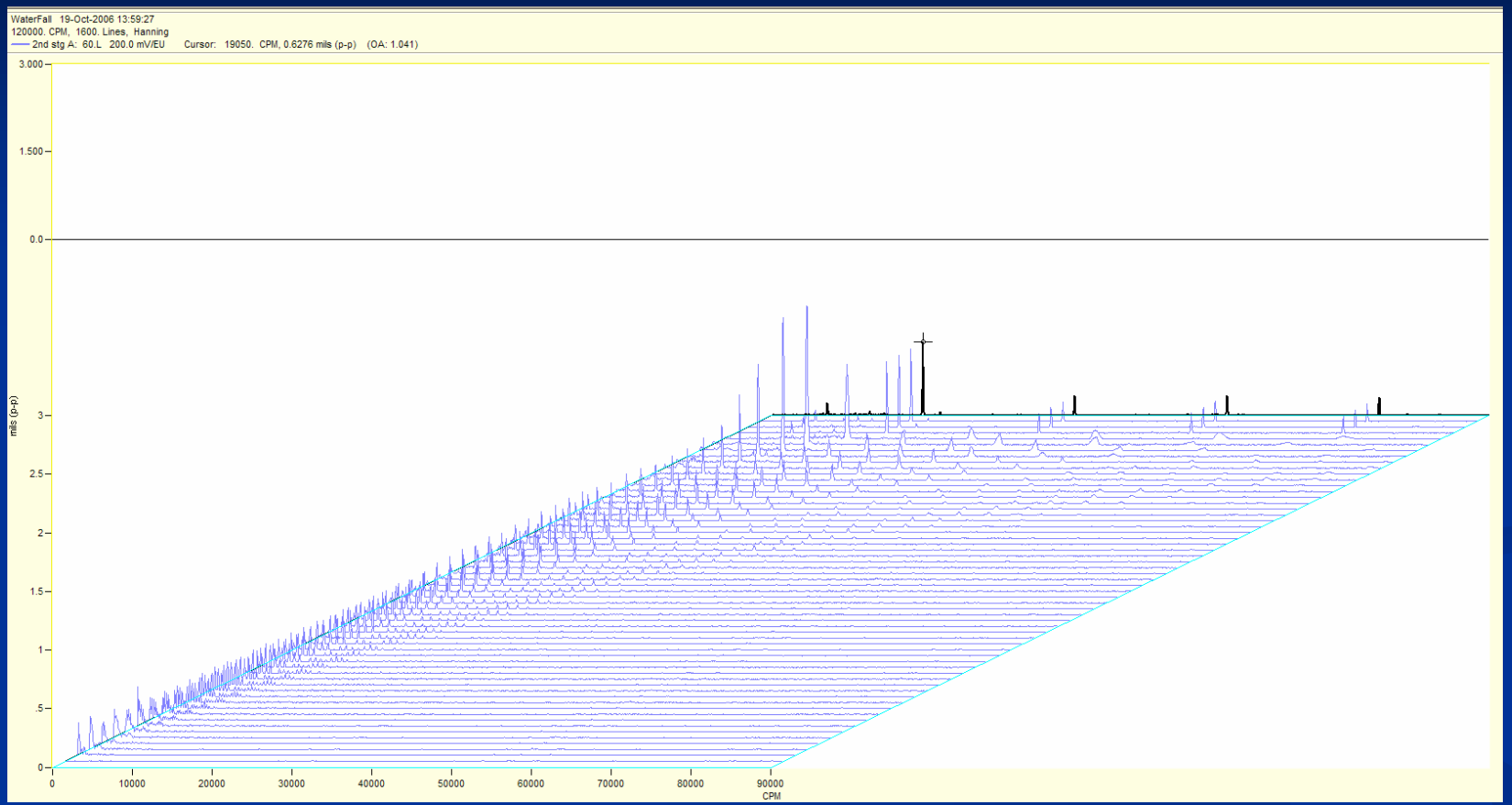
This is only 6 days later

Case Study #1 – Cameron Compression MSG

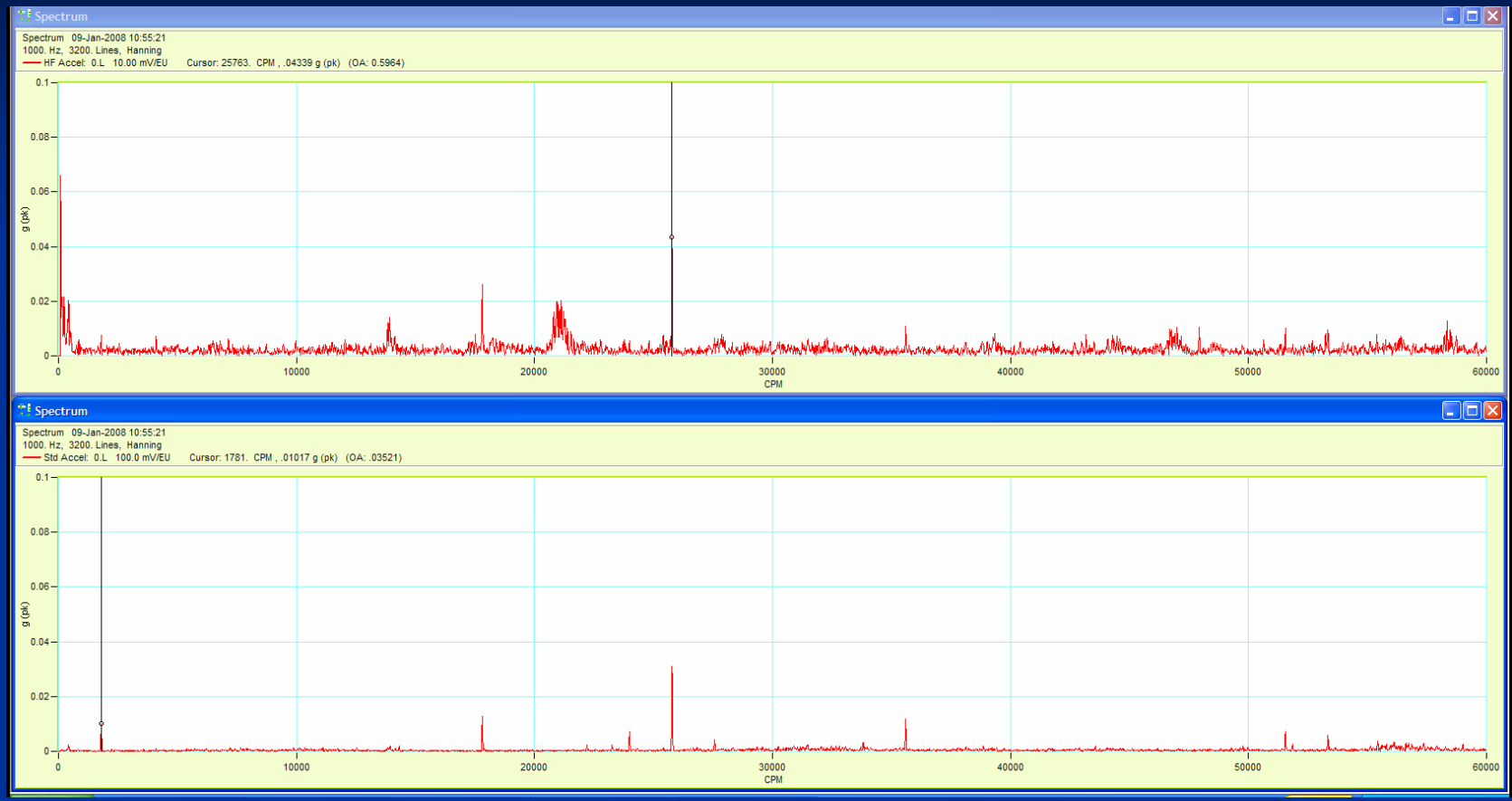


1X Amplitudes at different samples: 0.793; 0.851; 0.709; 0.713; 0.862

Case Study #1 – Cameron Compression MSG

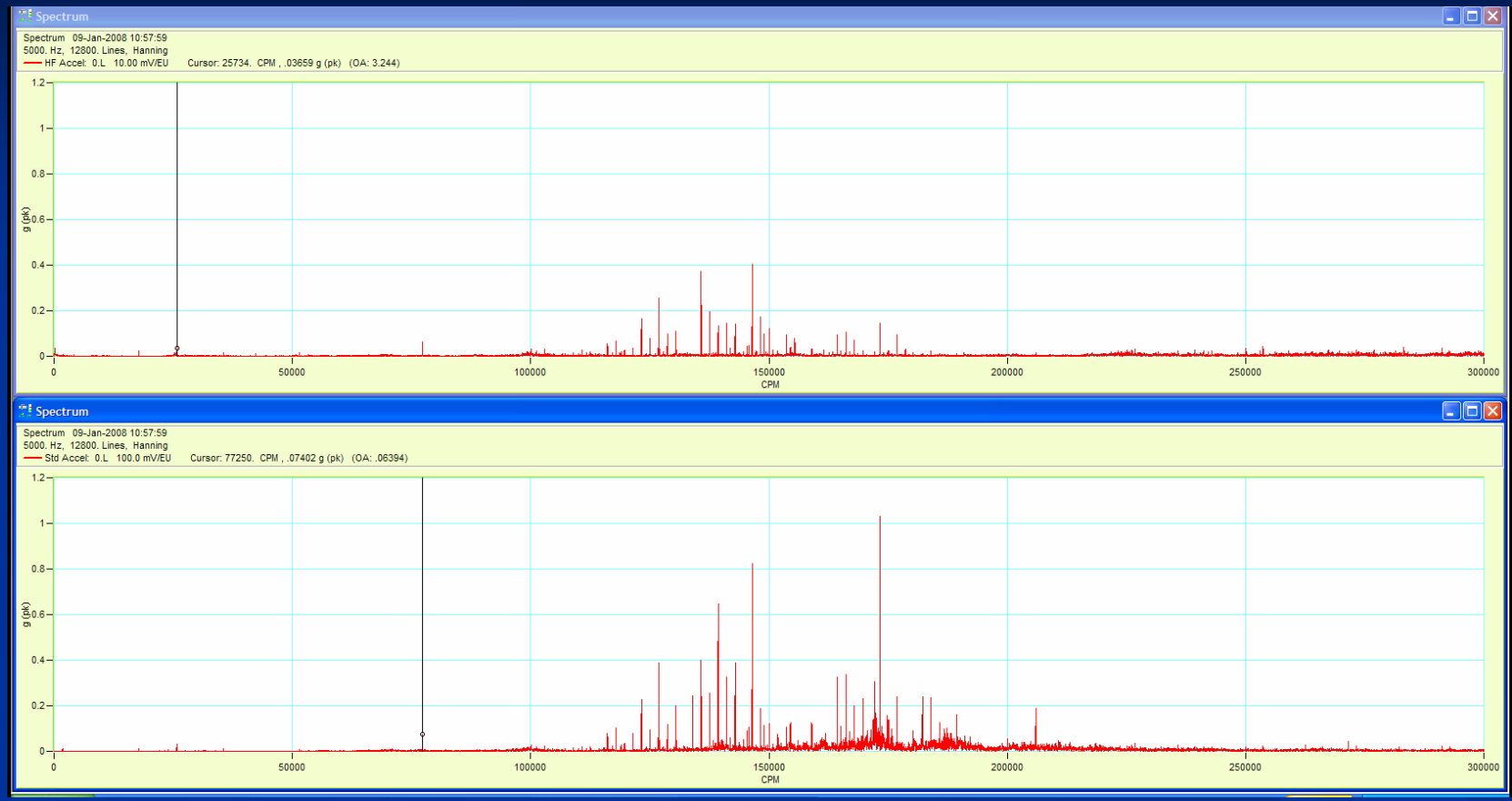


Case Study #2 – Cameron Compression MSG

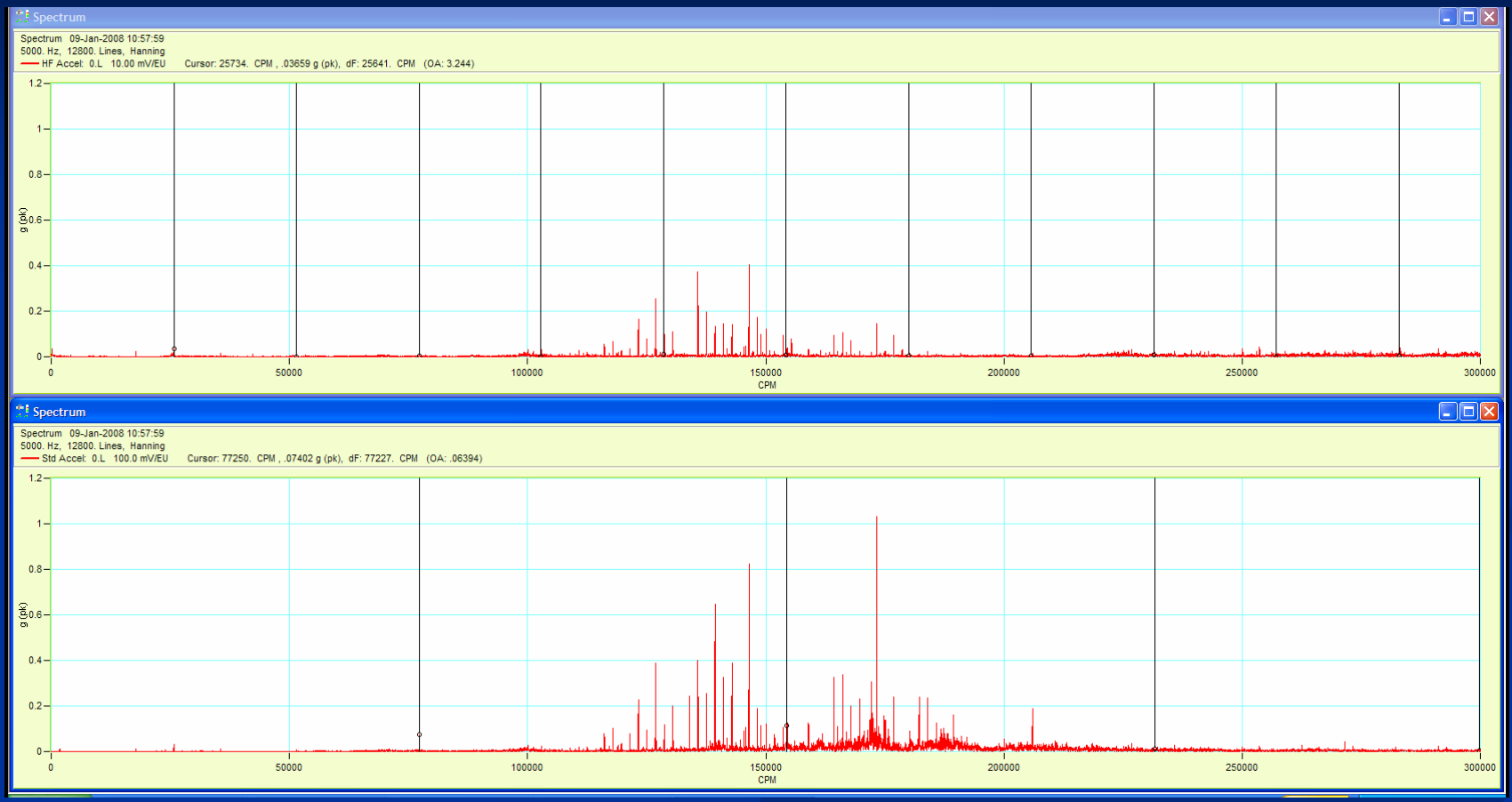


Note the difference in the noise floor of a 10 mV/g vs. 100 mV/g

Case Study #2 – Cameron Compression MSG



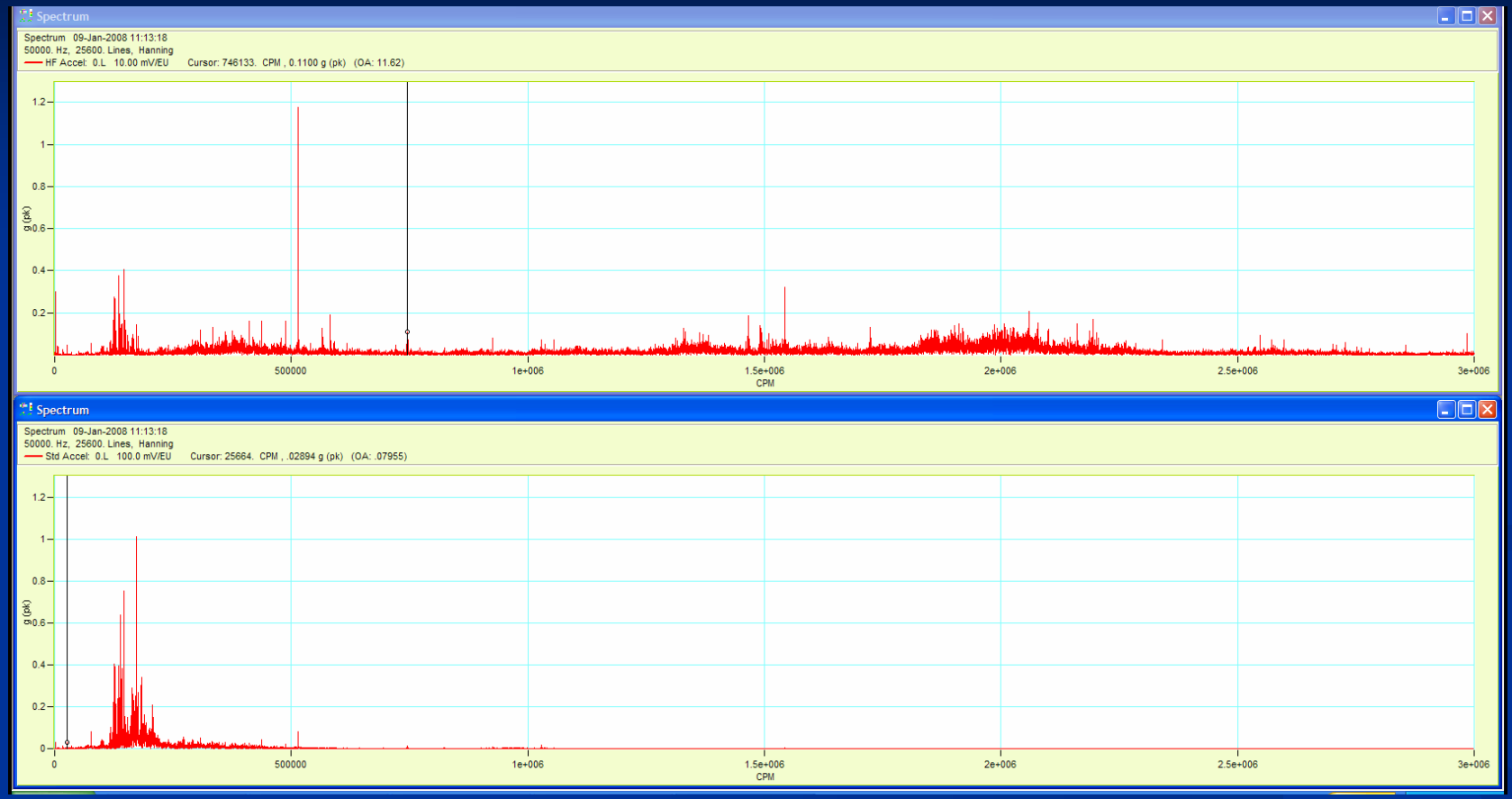
Case Study #2 – Cameron Compression MSG



Case Study #2 – Cameron Compression MSG

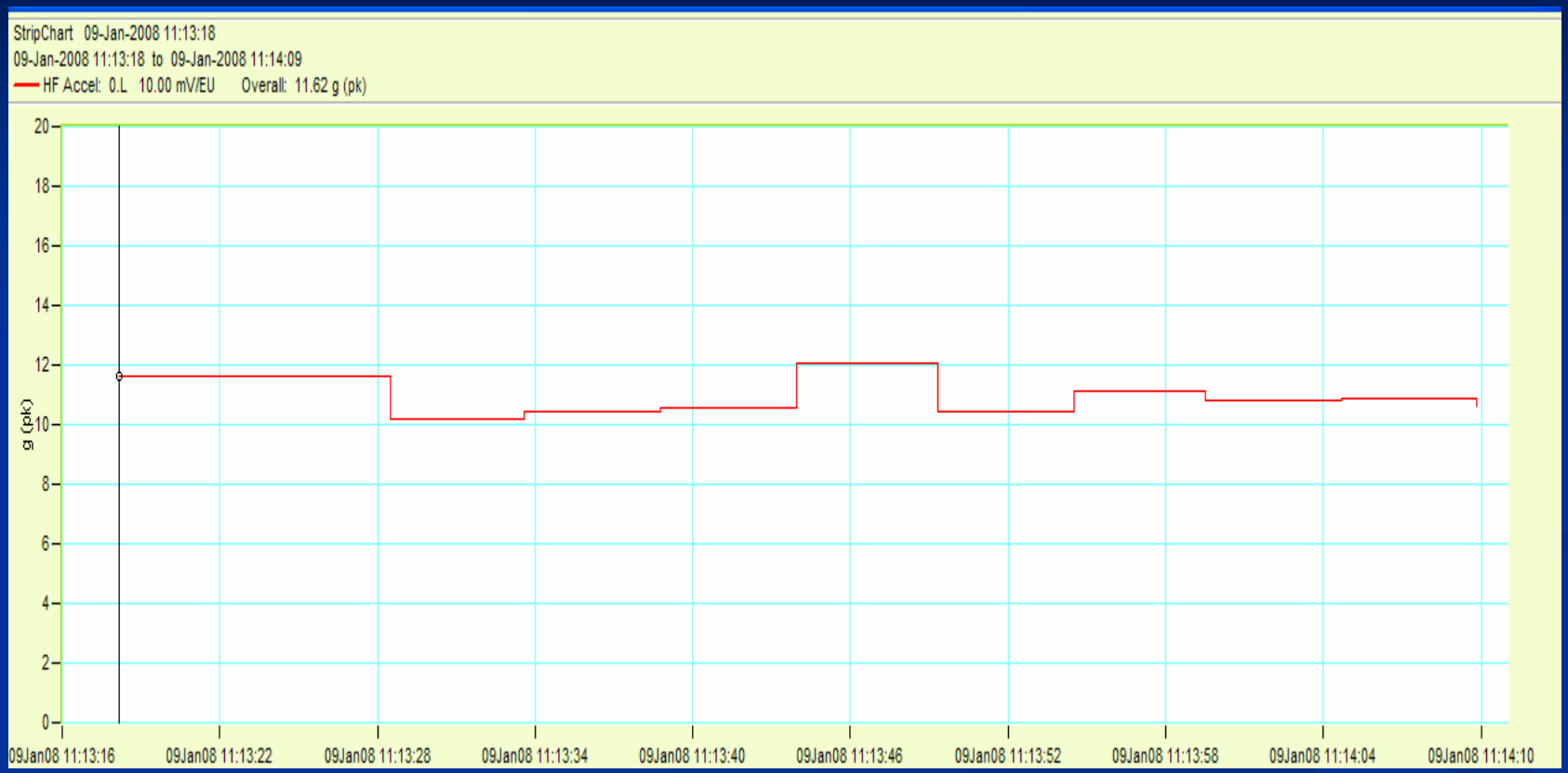
Now we are at 20 kHz Frequency Span

Case Study #2 – Cameron Compression MSG



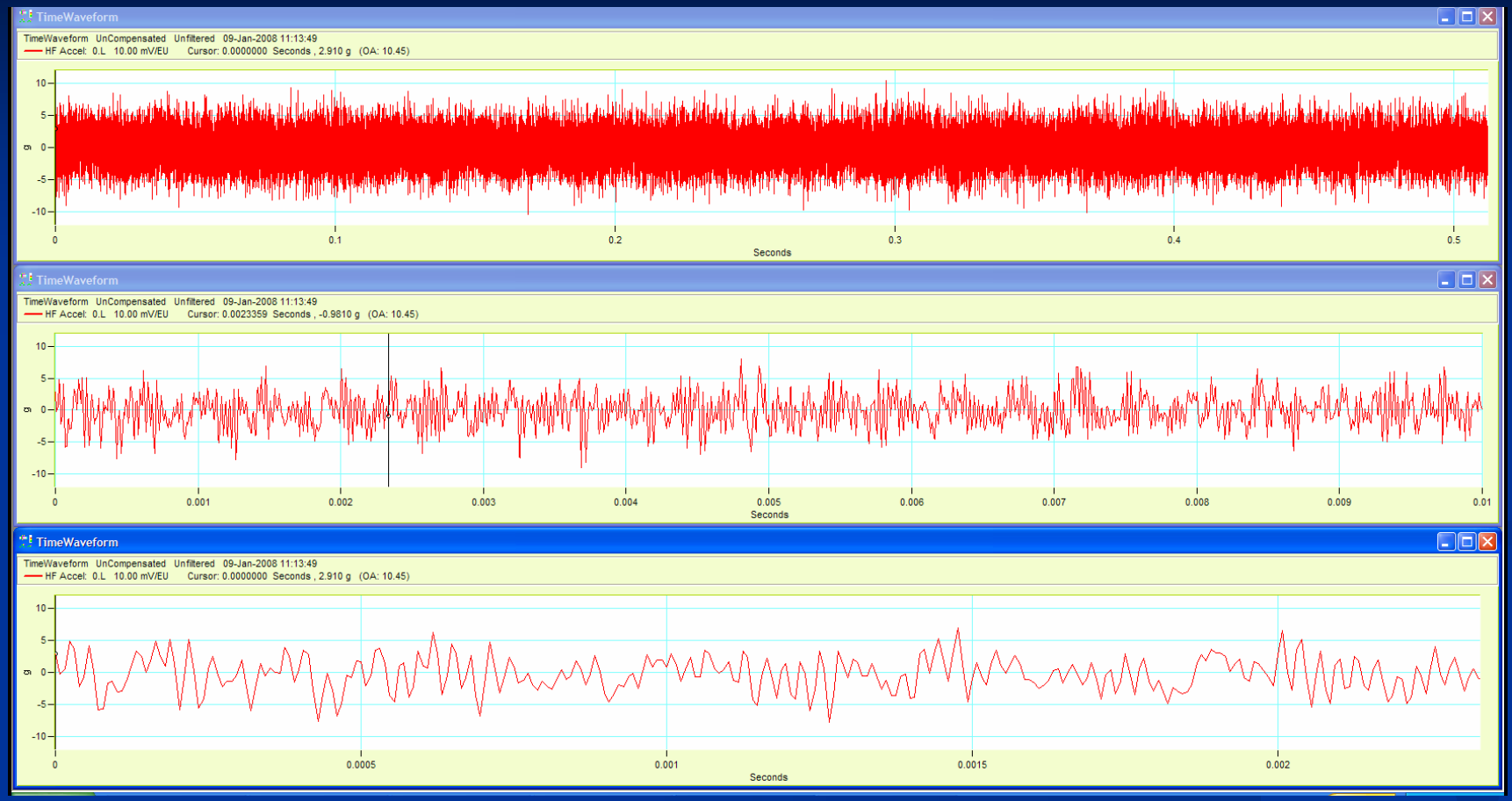
Now we are at 50 kHz

Case Study #2 – Cameron Compression MSG



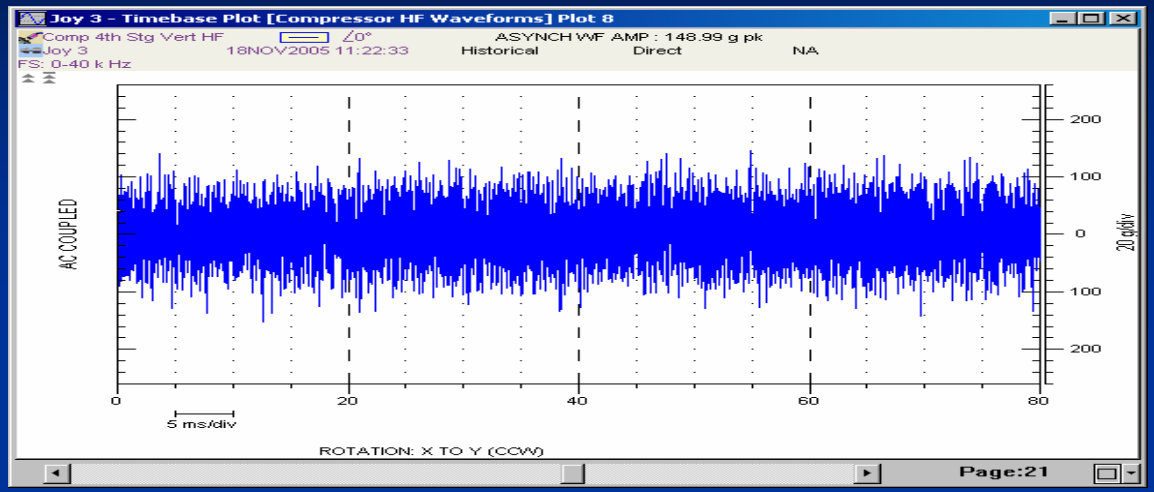
Are the overall amplitudes really higher than expected?

Case Study #2 – Cameron Compression MSG

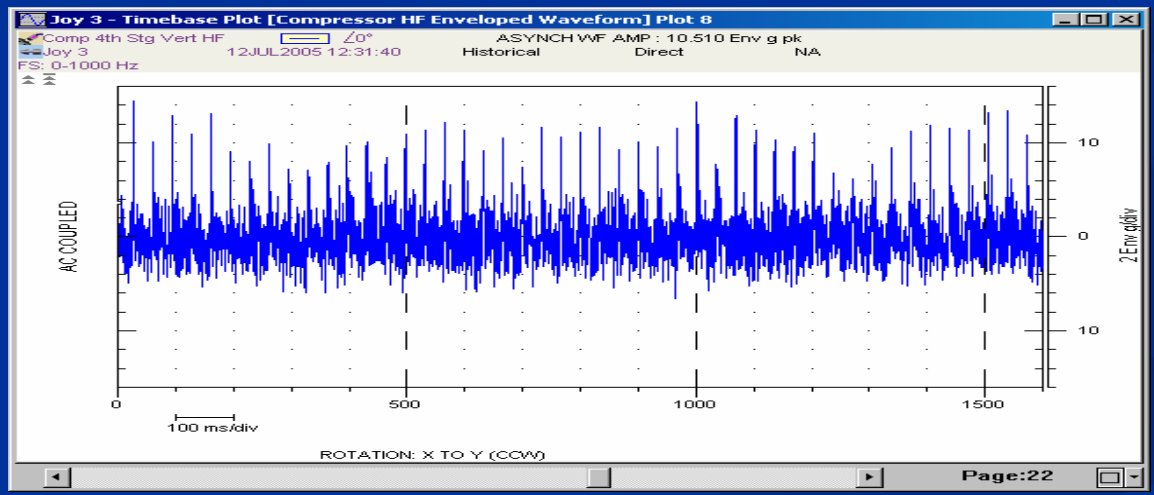


Differing time frames from the high frequency accel

Case Study #3 – Cameron Compression MSG

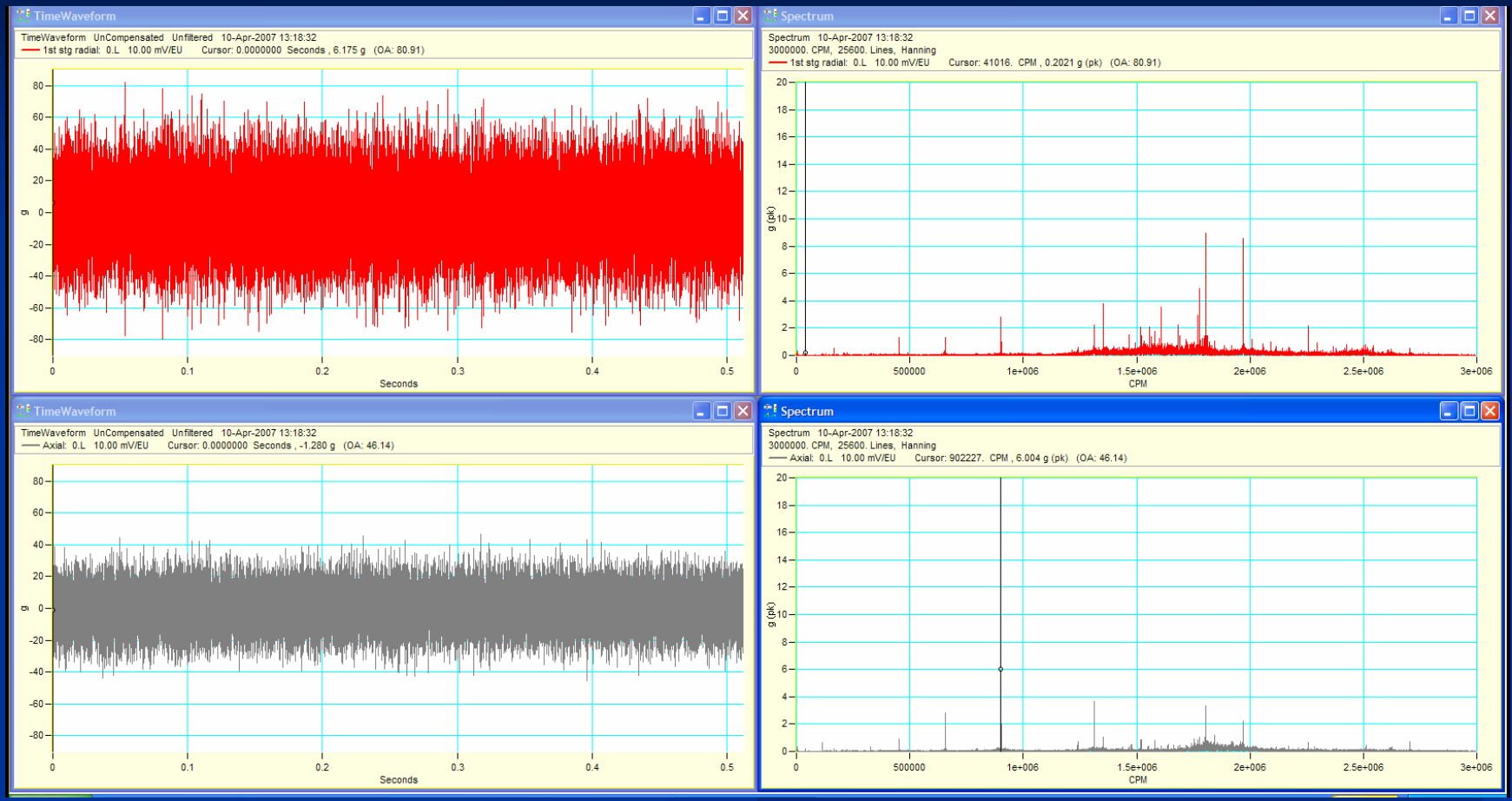


Raw Timebase or Waveform



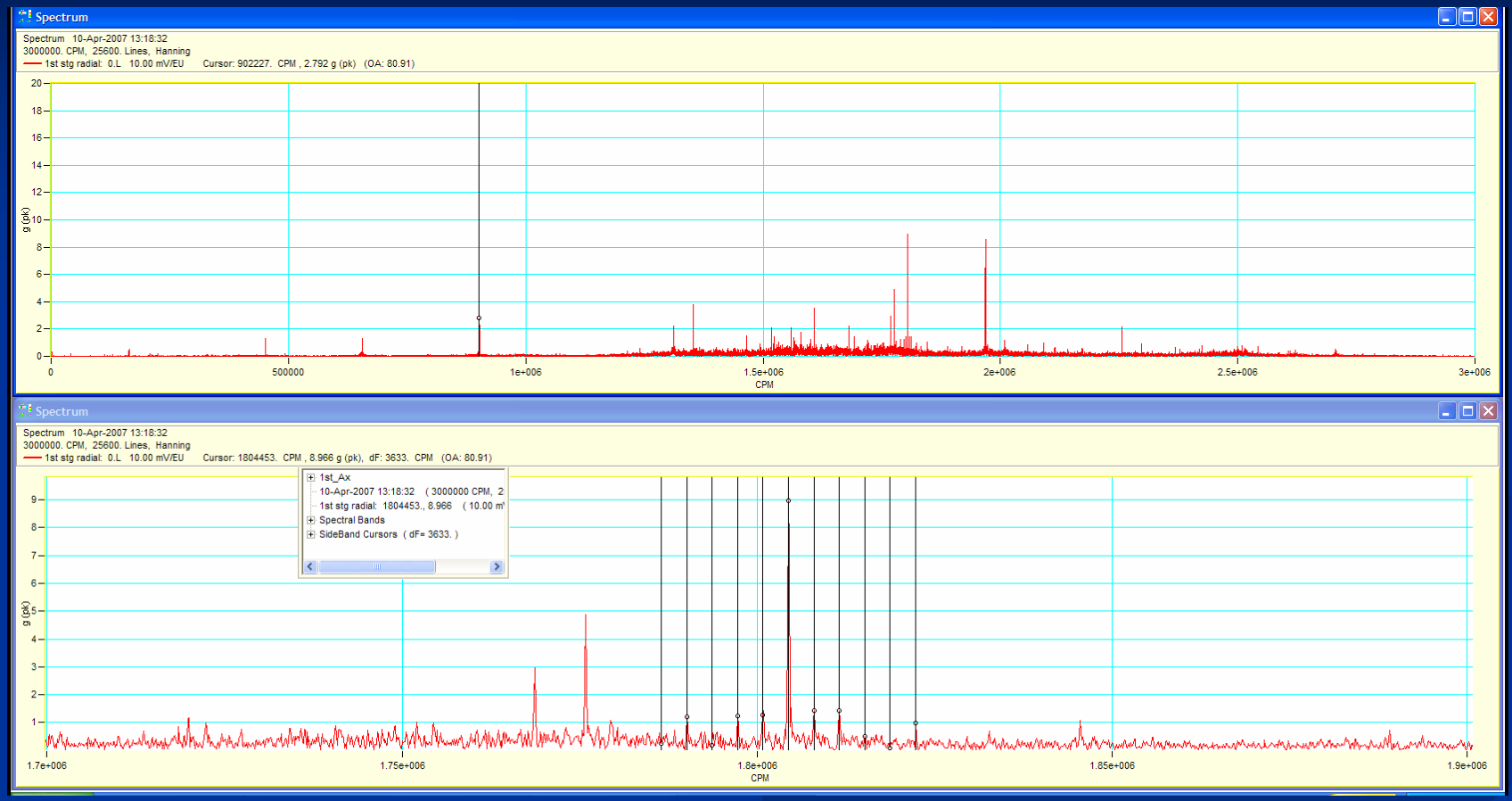
High Frequency Enveloping

Case Study #4 – Ingersoll-Rand Centac II

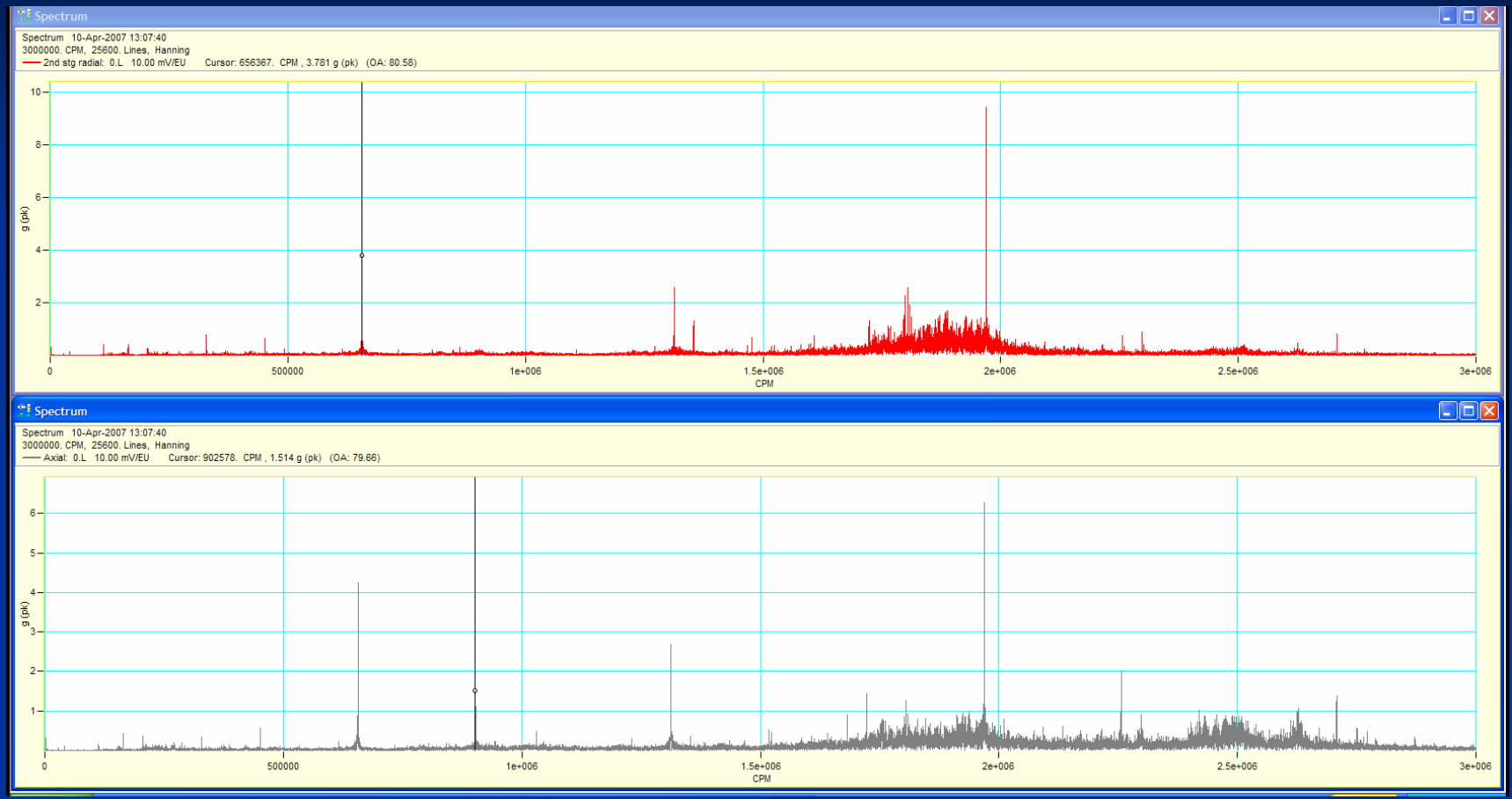


Note the amplitudes

Case Study #4 – Ingersoll-Rand Centac II



Case Study #4 – Ingersoll-Rand Centac II



Thank You – Any Questions?