CASE HISTORY#3

COOLING TOWER GEARBOX BEARING FAULT

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COOLING TOWER GEARBOX BEARING FAULT

- A series of ten cooling tower fans were commissioned at an industrial plant (4A-4F & 5A-5D).
- Each cooling tower fan was driven by a direct, close-coupled drive by a 4-pole, VFD driven motor and a single reduction, right angle gear unit.
- The gearbox reduction was 6.5:1 and each fan wheel had 5-ea blades.
- The gearbox had 12-ea teeth on the pinion gear and was a single reduction box.
- Baseline vibration data was collected on both the motor & gearbox from 50-100% full speed in 10% increments.

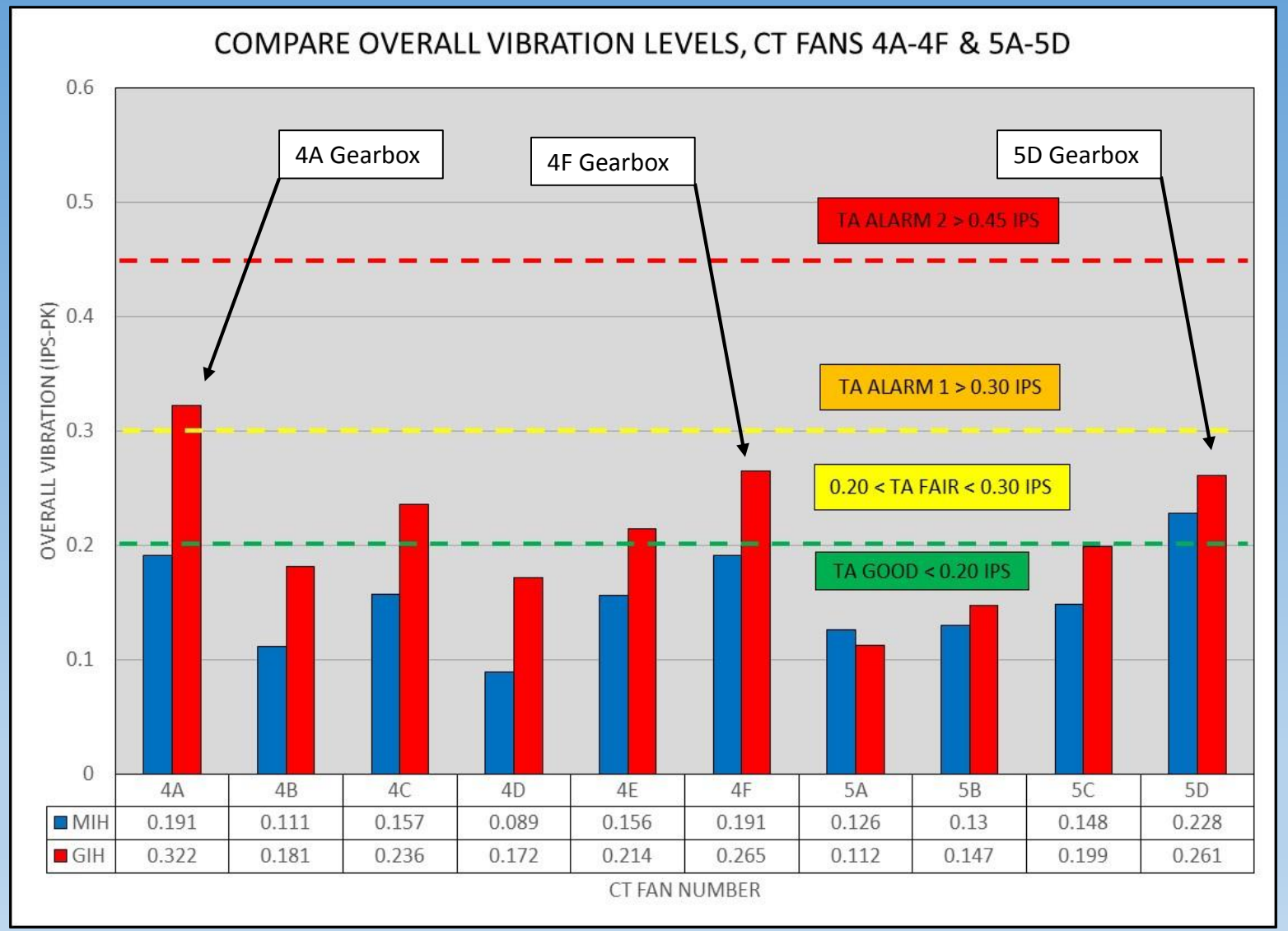
COOLING TOWER FORCING FREQUENCIES

% FULL SPEED	MOTOR SPEED (RPM)	FAN SPEED (RPM)	FAN BLADE-PASS (CPM)	GEARMESH (CPM)
50	875	135	673	10,500
60	1,044	161	803	12,528
70	1,216	187	935	14,592
80	1,387	213	1,067	16,644
90	1,559	240	1,199	18,708
100	1,718	264	1,322	20,616

- The table above shows the four major forcing frequencies present at these 10 cooling tower fans at each test speed: motor speed, fan speed, blade-pass & gearmesh frequency.

COMPARE OVERALL VIBRATION LEVELS – ALL CT FANS

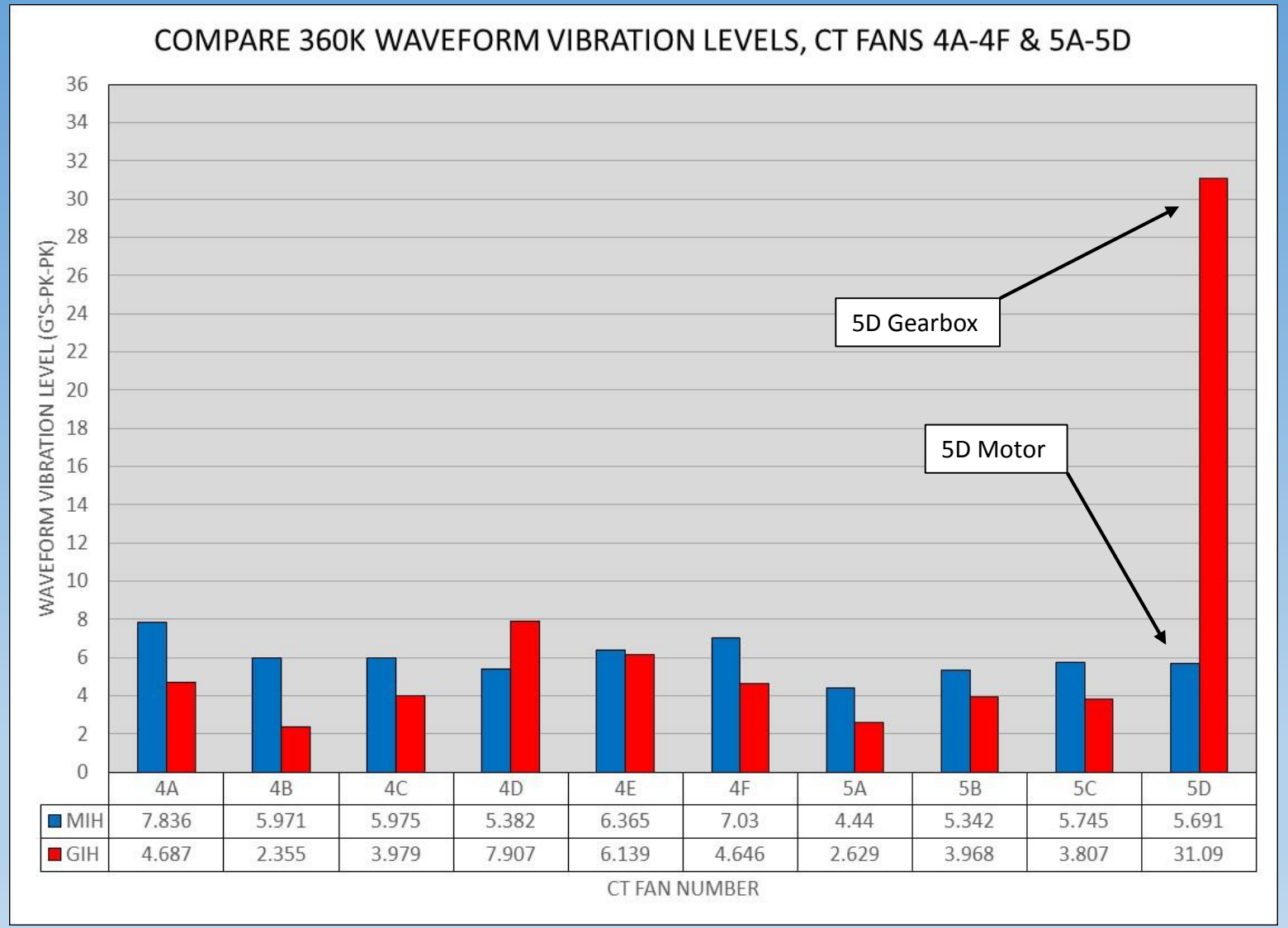
- The plot at right shows the overall vibration levels measured at the motor & gearbox of each CT Fan (4A-4F & 5A-5D).
- Similar conditions of speed & load were present for all fans (80% full speed).
- Note how in general, levels are higher at the gearboxes versus the motors.
- Note also how gearbox levels at 4A, 4F & 5D approach or exceed the TA alarm 1 levels for close-coupled CT fans.



	4A	4B	4C	4D	4E	4F	5A	5B	5C	5D
MIH	0.191	0.111	0.157	0.089	0.156	0.191	0.126	0.13	0.148	0.228
GIH	0.322	0.181	0.236	0.172	0.214	0.265	0.112	0.147	0.199	0.261

COMPARE 360K WAVEFORM VIBRATION LEVELS – ALL CT FANS

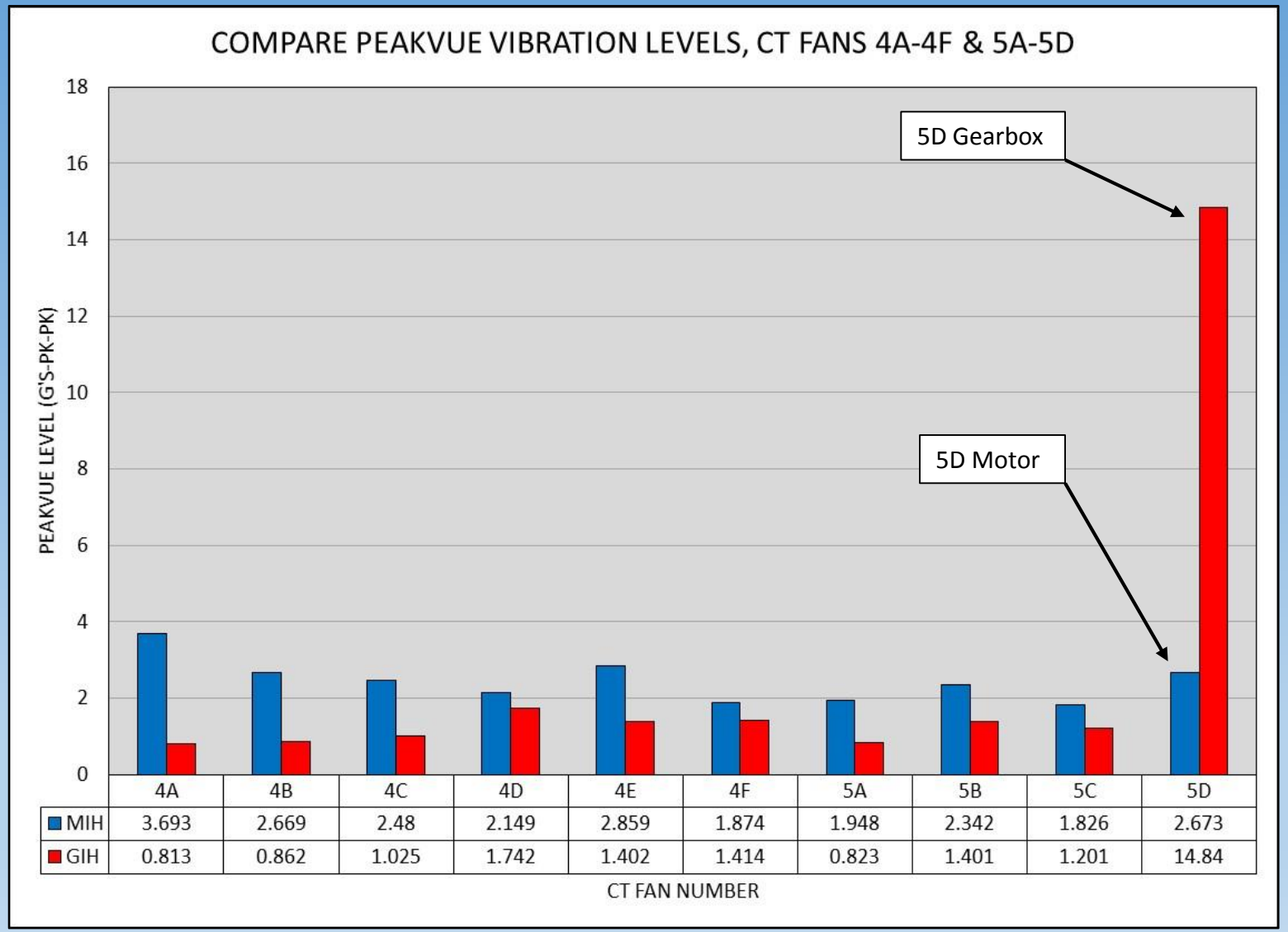
- The plot at right shows the 360K waveform vibration levels measured in units of acceleration at the motor & gearbox of each CT Fan (4A-4F & 5A-5D).
- This vibration parameter emphasizes the high frequency energy present at each point much more than the overall levels expressed earlier.
- Similar conditions of speed & load were present for all fans (80% full speed).
- Note how the levels at 5D gearbox clearly stand out in comparison to all others.
- Note also how corresponding 5D motor levels are in line with the other motors.



	4A	4B	4C	4D	4E	4F	5A	5B	5C	5D
MIH	7.836	5.971	5.975	5.382	6.365	7.03	4.44	5.342	5.745	5.691
GIH	4.687	2.355	3.979	7.907	6.139	4.646	2.629	3.968	3.807	31.09

COMPARE PEAKVUE WAVEFORM VIBRATION LEVELS – ALL CT FANS

- The plot at right shows the Peakvue waveform vibration levels measured at the motor & gearbox of each CT Fan (4A-4F & 5A-5D).
- This vibration parameter also emphasizes the high frequency energy present at each measurement point much more than the overall levels expressed earlier.
- Similar conditions of speed & load were present for all fans (80% full speed).
- Note how again the levels at 5D gearbox clearly stand out in comparison to all others.
- Note also how again corresponding 5D motor levels are in line with the other motors.



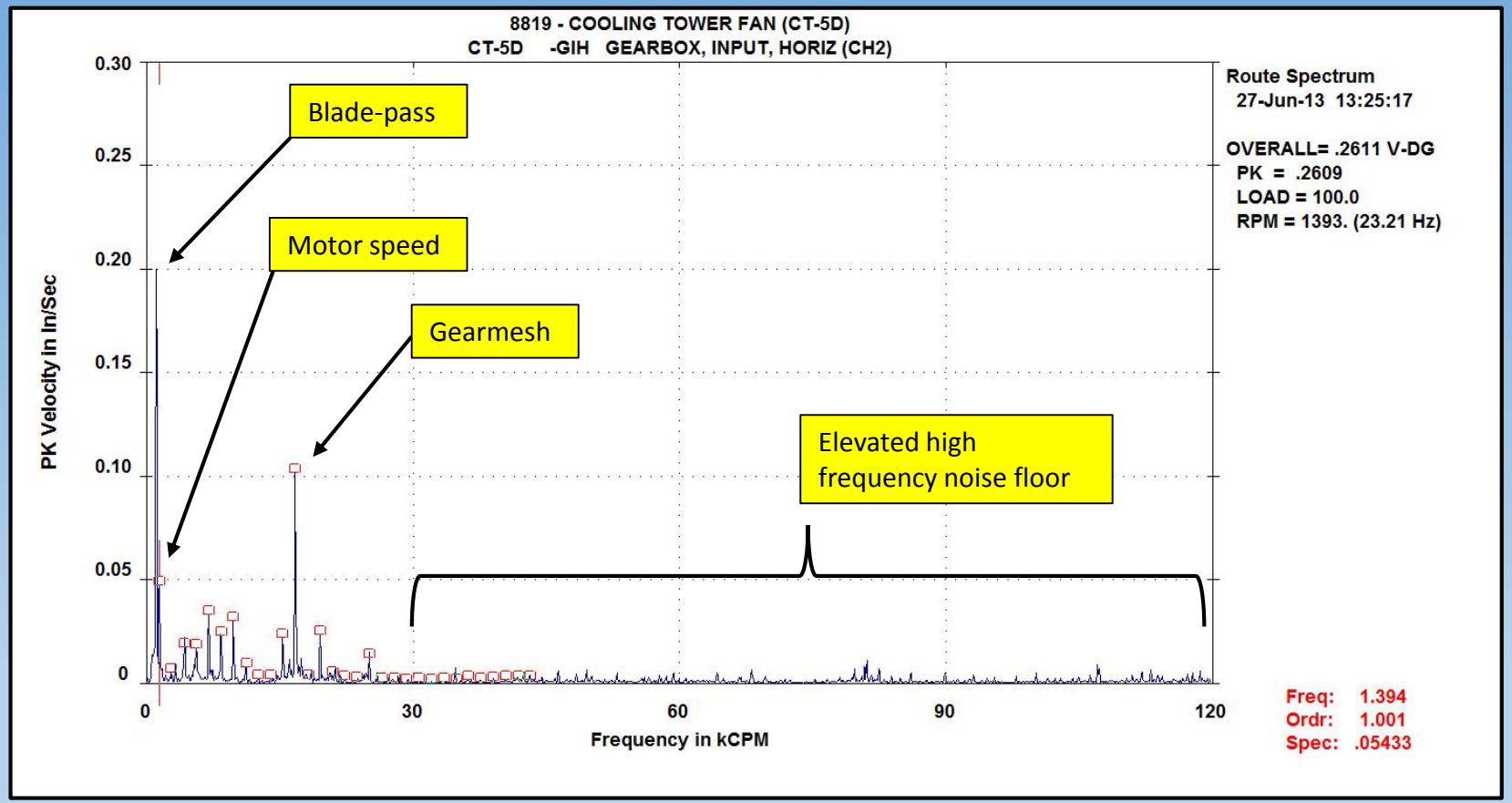
	4A	4B	4C	4D	4E	4F	5A	5B	5C	5D
MIH	3.693	2.669	2.48	2.149	2.859	1.874	1.948	2.342	1.826	2.673
GIH	0.813	0.862	1.025	1.742	1.402	1.414	0.823	1.401	1.201	14.84

5D GEARBOX VIBRATION SPECTRAL DATA

- The plot at right shows the vibration spectral data measured at 5D gearbox at 80% full speed.
- Note how this plot in velocity units shows dominant vibration occurring at:

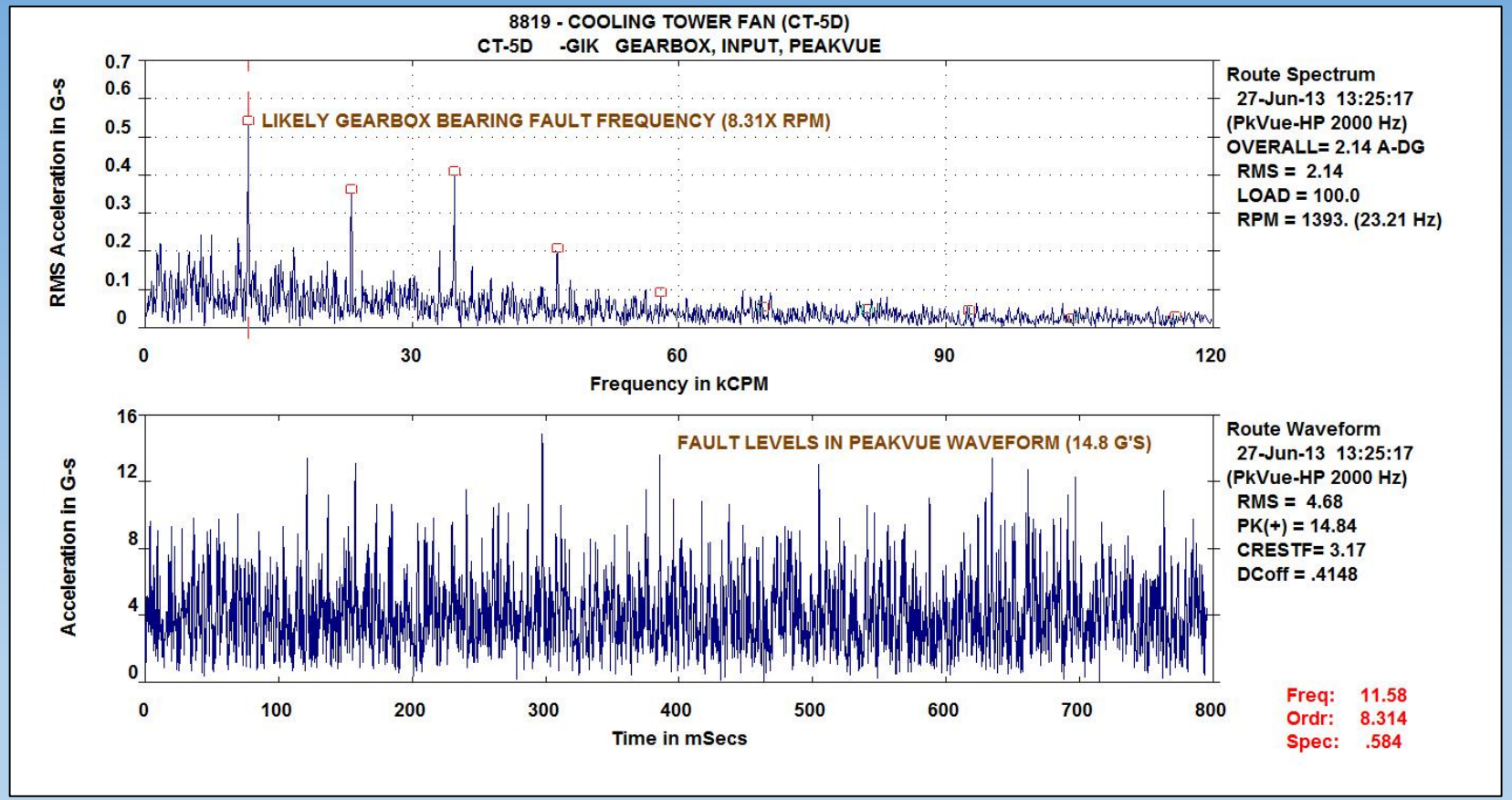
1) Fan blade-pass
2) Motor speed
3) Gearmesh

- A higher than expected noise floor is also seen at higher frequencies (> 30kcpm).



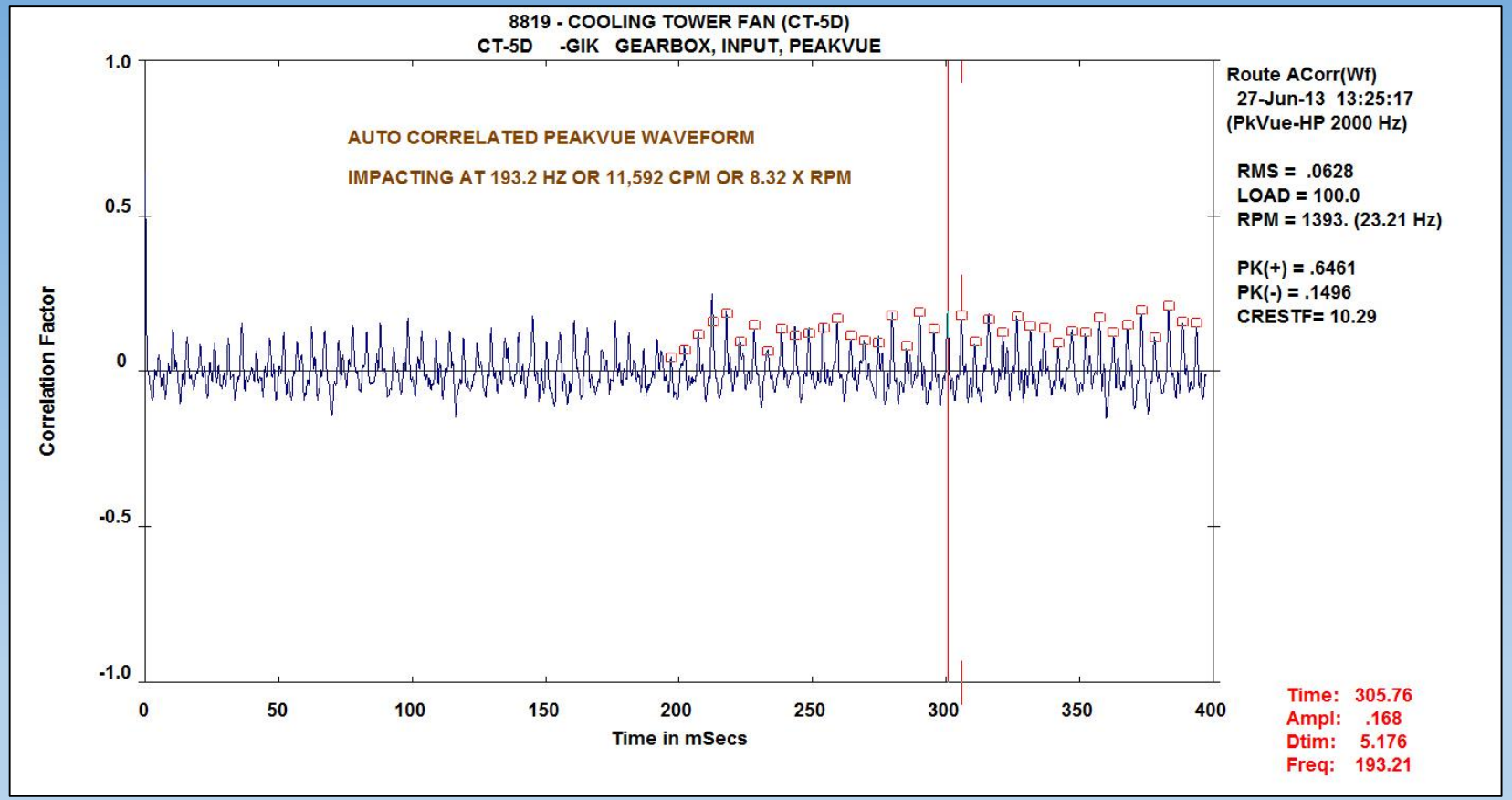
5D GEARBOX PEAKVUE SPECTRAL DATA

- The plot at right shows the Peakvue spectral & waveform data measured at 5D gearbox at 80% full speed.
- Note how unlike the earlier plot in velocity, this plot is in units of acceleration and shows dominant vibration occurring at 8.31x rpm and a raised noise floor.
- Waveform levels at bottom are also very high at 14.8 g's-pk-pk.
- This vibration at 8.31x input rpm with multiples is non-synchronous and a likely gearbox bearing defect frequency.



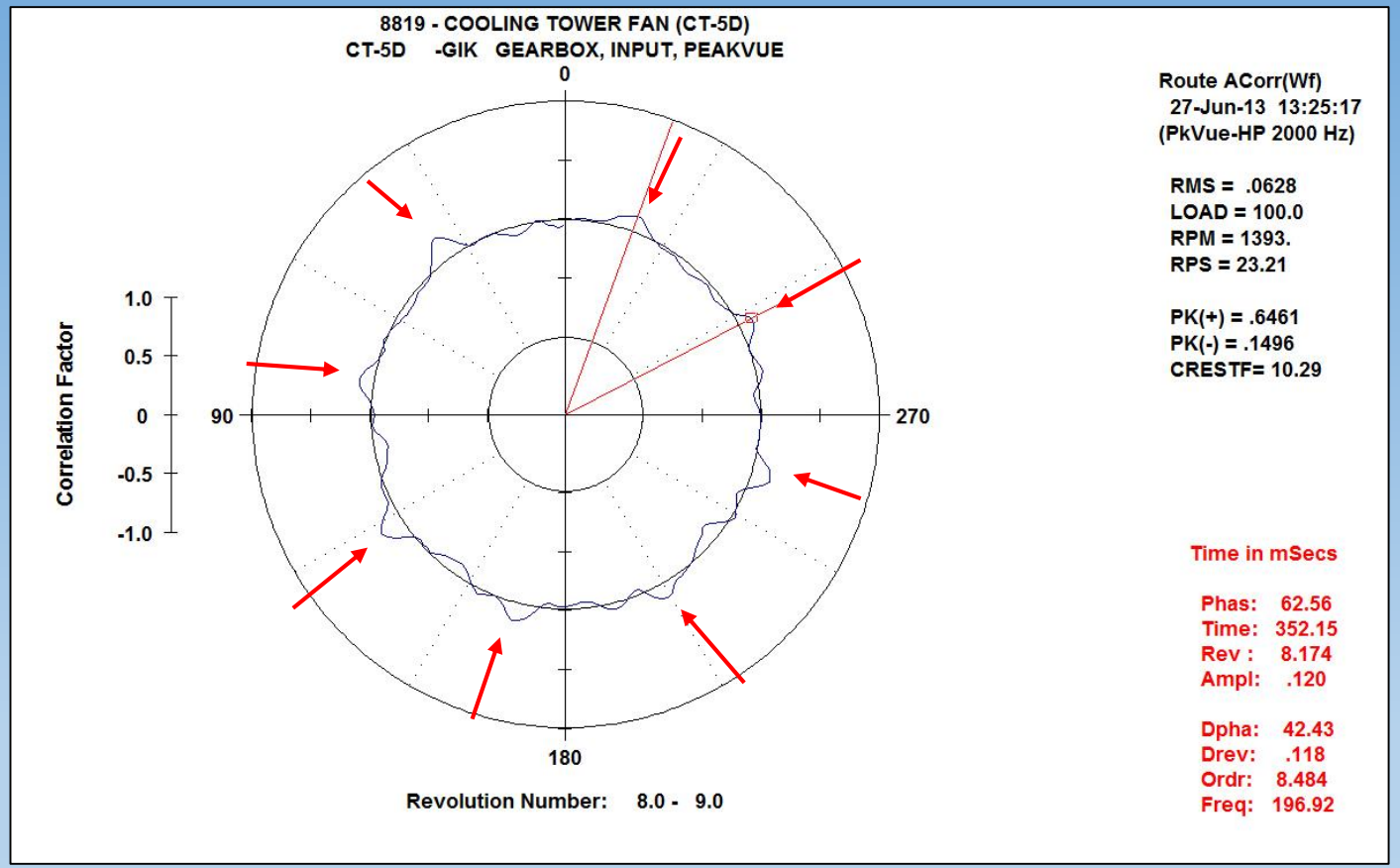
5D GEARBOX PEAKVUE AUTO-CORRELATED WAVEFORM DATA

- The plot at right shows the auto-correlated Peakvue waveform data measured at 5D gearbox at 80% full speed.
- The auto-correlation process attempts to “pull out” or amplify the repeating or periodic portions of the signal and diminish the non-periodic, transient or random aspects.
- Note how the dominant, periodic or repeating part of this signal is impacting at ~ 193.2 Hz or 11,592 cpm or 8.32x input speed.



5D GEARBOX PEAKVUE AUTO-CORRELATED WAVEFORM DATA – CIRCULAR PLOT

- The plot at right shows a circular plot of the auto-correlated Peakvue waveform data shown earlier.
- This unique plotting method departs from normal, linear plotting and instead plots the waveform in a circle with one shaft revolution of time = one revolution on the plot.
- Note how a little more than 8 impacts occur over one revolution of the input shaft – this is due to the suspected gearbox bearing fault.



SUMMARY – CONCLUSIONS & RECOMMENDATIONS

1) A baseline survey of 10-ea similar cooling tower fans identified a likely bearing fault at 5D cooling tower fan gearbox.
2) A comparison of identical overall vibration measurements between the 10-ea fans failed to flag or identify the problem.
3) A comparison of identical high frequency vibration measurements such as Peakvue & acceleration waveform data made clear identification of this problem easy (better suited parameters to identify this problem*). If you choose the appropriate parameters, your machinery problems become statistical outliers and are much easier to identify.*
4) If data were only collected on the motors driving these fans and not the gearboxes also, the problem would have gone undetected until perhaps a more severe condition were present.
5) Installing at least one sensor on the gearboxes is important and will allow for detection of gearbox or fan problems much sooner than motor measurements alone.
6) The recommendation was made to change the gearbox when possible due to suspected bearing faults there. Prior to the gearbox change, an inspection of the gearbox oil level found very little oil present. Close inspection of the oil fill line (hose) going to the gearbox from the outside found no leaks present. Close inspection of the input seal and all around the gearbox found no obvious oil leaks.
7) Due to the lack of evidence of oil leaks of any significance at the gearbox or at its oil fill line, some doubt existed as to whether or not the proper oil level was ever present in the gearbox from startup.