

# CASE HISTORY#1

## BAD COOLING TOWER GEARBOX?

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# CASE HISTORY – BAD CT GEARBOX?

- The customer reported a terrible noise coming from at least one of his cooling tower fans (CT fan C). He and his staff were convinced the gearbox was bad.
- The customer had already prepared to have the gearbox changed, but wanted confirmation via vibration analysis prior to performing the work.
- The facility had three identical cooling towers on-site (units A, B & C).
- All three cooling tower fans were 6-blade, driven via right angle gearboxes (5.5:1 ratios) thru a long spacer shaft by a 4-pole motor operating on a variable frequency drive.

# ON-SITE INSPECTIONS

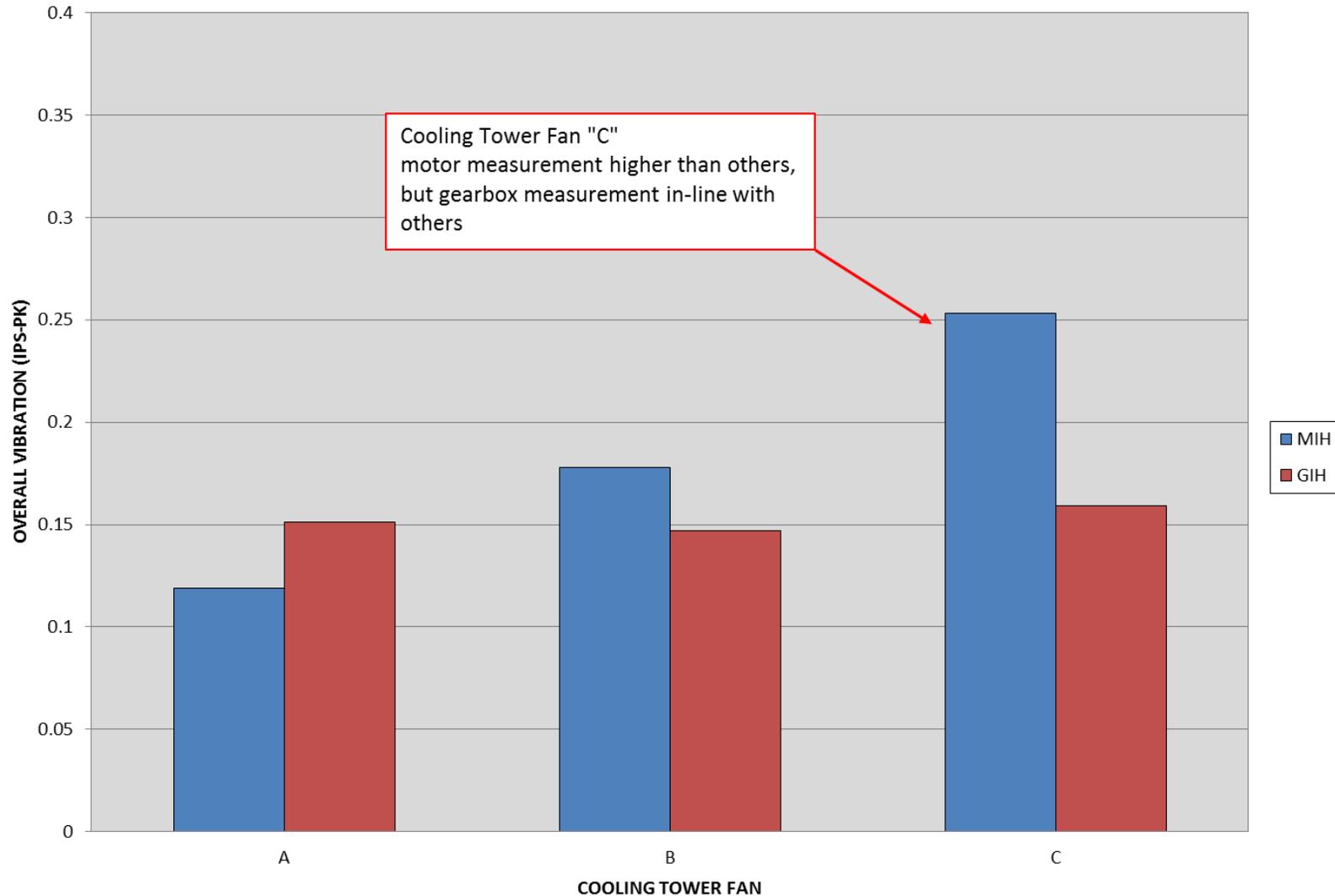
Before any vibration data was collected on the fans, an on-site inspection of all three cooling tower fans found the following:

- 1) The pitch of all blades on all fans were checked for consistency via a scribe mark on the shroud. The pitch of some blades at both B & C fans were found off by a significant amount. These blades were adjusted accordingly to conform to the others.
- 2) The distance from the blade tips to the nearby shroud was checked on all fans and no significant problems were found.
- 3) The condition of the jackshaft couplings was inspected and no significant cracking or swelling of the rubber grommets was noticed at any of the three fans.
- 4) All jackshafts appeared ok and no obvious distortion or other shaft damage was noticed.
- 5) All bolts holding the gearbox to the tower frame appeared tight.
- 6) Minor oil leaks were noticed at the input shaft seal of each gearbox. This leaking may have been due to overfilling of oil in the units in the past?
- 7) The rubber oil drain hoses at each gearbox were discolored, beginning to crack at spots and generally in bad shape.

# VIBRATION DATA

- After the on-site inspections & minor repairs were complete, vibration measurements were taken on all three cooling tower fans using magnetically mounted accelerometers on both the motor and gearbox in the horizontal direction.
- A laser tach was used to measure machine speed and vibration data was collected with the fans running at both full speed and thru their normal speed range (30-100% full speed).
- A spectral range of 120-120,000 cpm was used.
- As reported by plant personnel, during vibration testing, an unusual noise was heard at fan C that wasn't heard at the other two units. *This noise was evident at the higher speeds only.*
- A comparison of vibration data collected from the three fans is shown below.

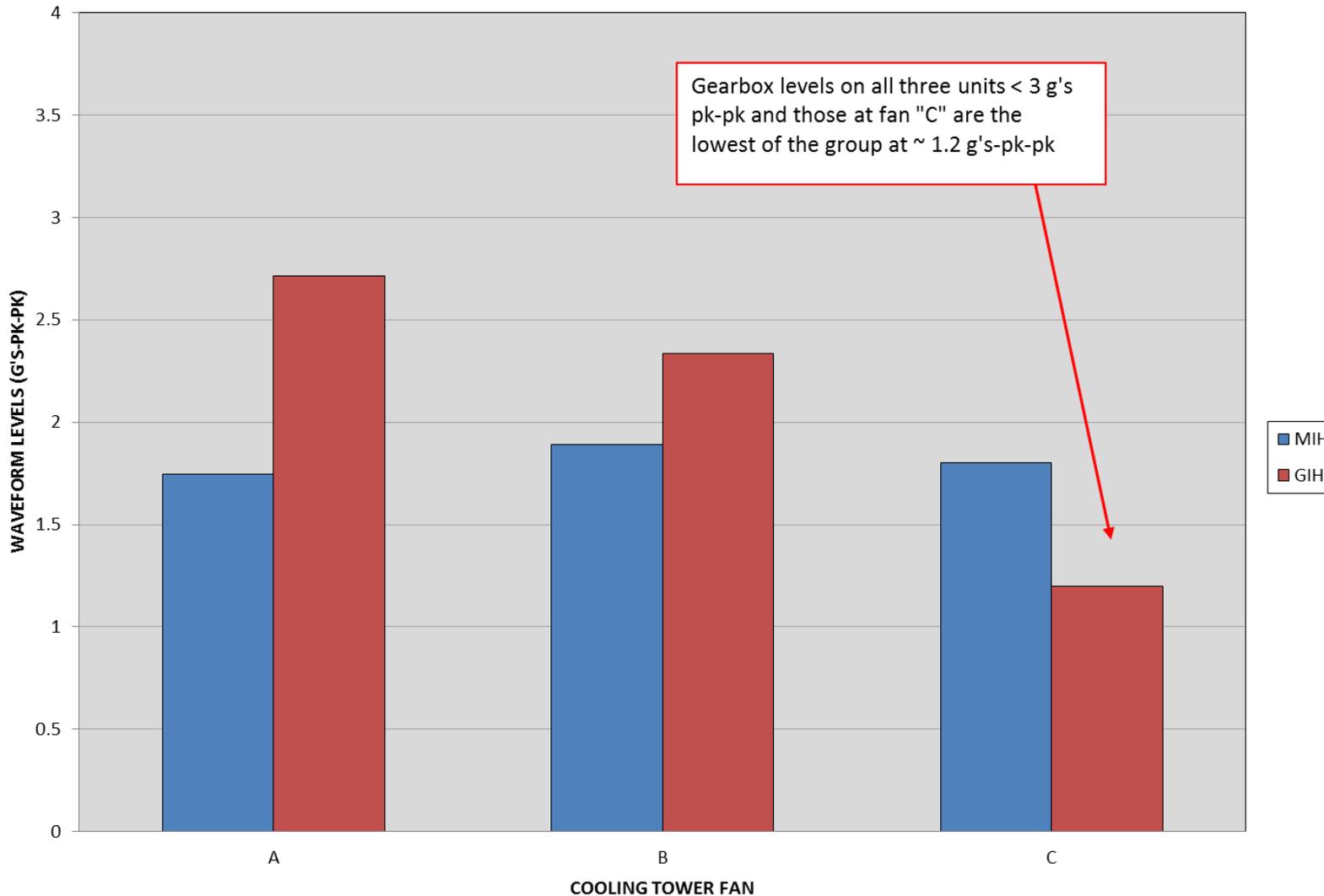
## COOLING TOWER FANS, OVERALL VIBRATION LEVELS



## COOLING TOWER OVERALL VIBRATION LEVELS (IPS-PK)

- All gearbox levels were < 0.2 ips-pk (not that bad).
- Gearbox levels at fan “C” were in-line with the other two units.
- Motor levels at fan “C” were clearly higher than the others (potential problem).

## COOLING TOWER FANS, WAVEFORM VIBRATION LEVELS



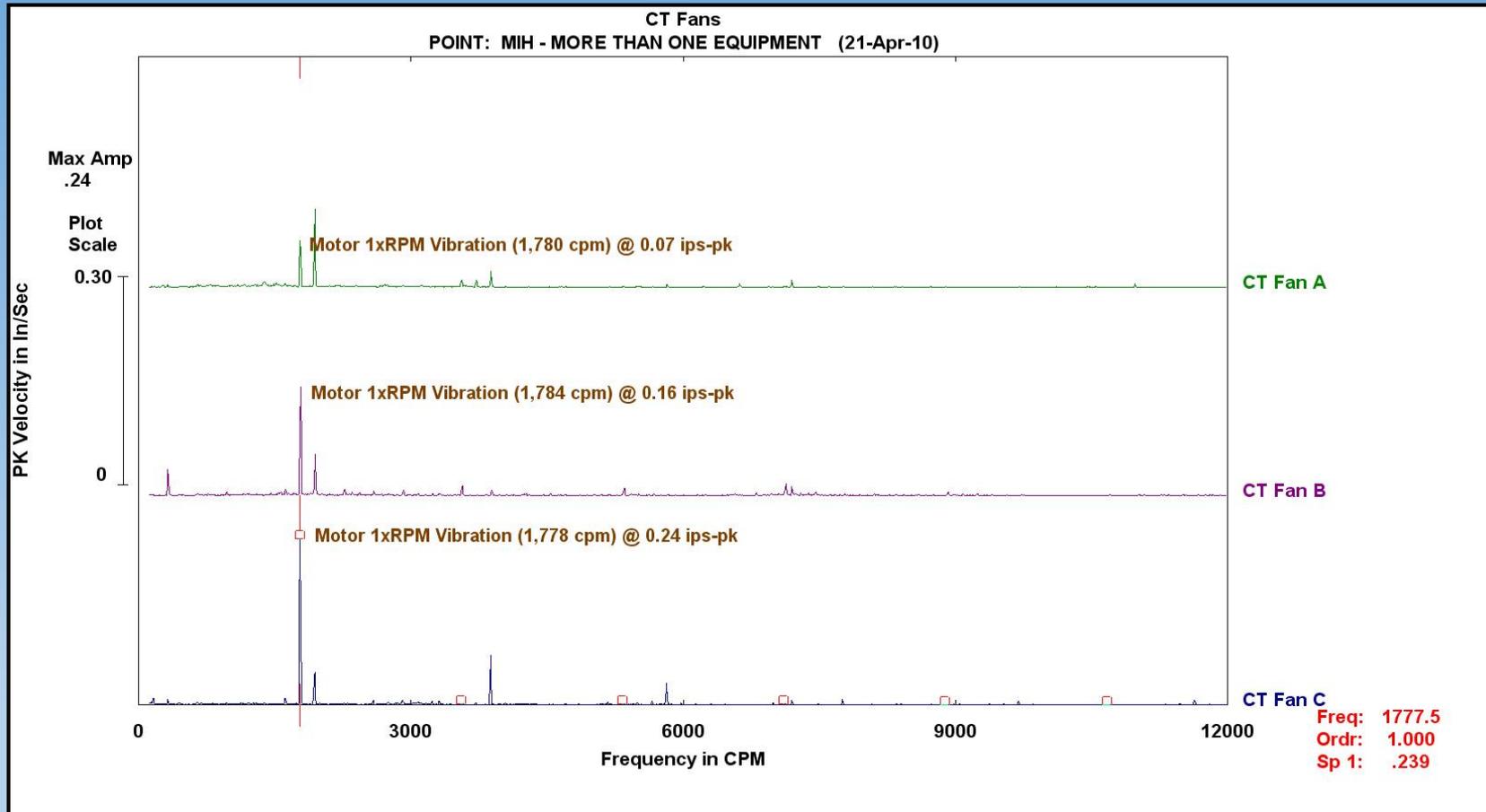
## COOLING TOWER VIBRATION WAVEFORM LEVELS (G'S-PK-PK)

- All waveform levels were < 3 g's-pk-pk (not that bad for gearboxes).
- Gearbox levels at fan "C" were the lowest of the group at ~ 1.2 g's-pk-pk.
- No significant motor or gearbox bearing or gear faults were expected.

# VIBRATION SPECTRAL DATA

- Spectral vibration data was collected from the motor & gearbox of each CT fan and analyzed. This data showed three primary frequencies of vibration at each machine as follows:
  - 1) Motor speed (1x rpm) at approximately 1,788 cpm.
  - 2) Fan blade-pass frequency at approximately 1,950 cpm.
  - 3) Fan speed (1x rpm) at approximately 325 cpm.
- These CT fans had a greater separation between motor speed & blade-pass frequency than is normally experienced by the author (ie:  $1,950 - 1,788 \text{ cpm} = 162 \text{ cpm}$  or  $\sim 9\%$  separation) resulting in less beating vibration than normally experienced by CT fans.
- As a side note, the author remains puzzled as to why many CT fans are designed with  $< 5\%$  separation between motor speed & blade-pass frequency. Due to beating, this small separation of dynamic forces tends to increase vibration levels at the machine and thus reduce its long-term reliability.

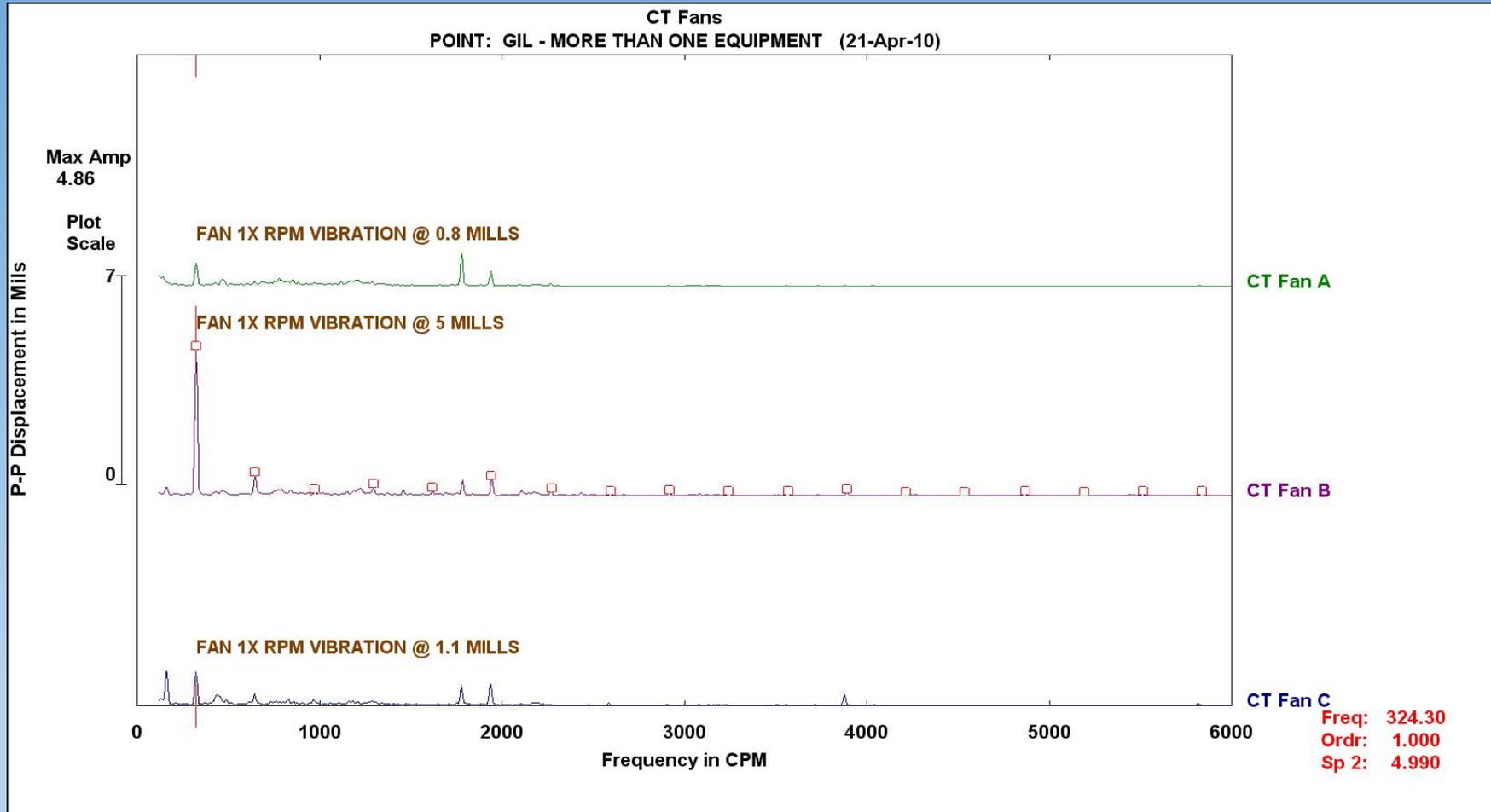
# CT MOTOR SPECTRAL DATA (A, B & C)



- Vibration levels were clearly highest at CT fan “C” motor.
- Dominant vibration at CT fan “C” motor occurred at the motor speed of ~ 1,778 rpm (0.24 ips-pk).
- Potential causes for the higher levels at motor 1x rpm for “C” fan were unbalance at coupling or shaft, misalignment or coupling problems.
- Vibration at blade-pass frequency was low at all motors, but a 2x & 3x blade-pass vibration component were noted at “C” motor.

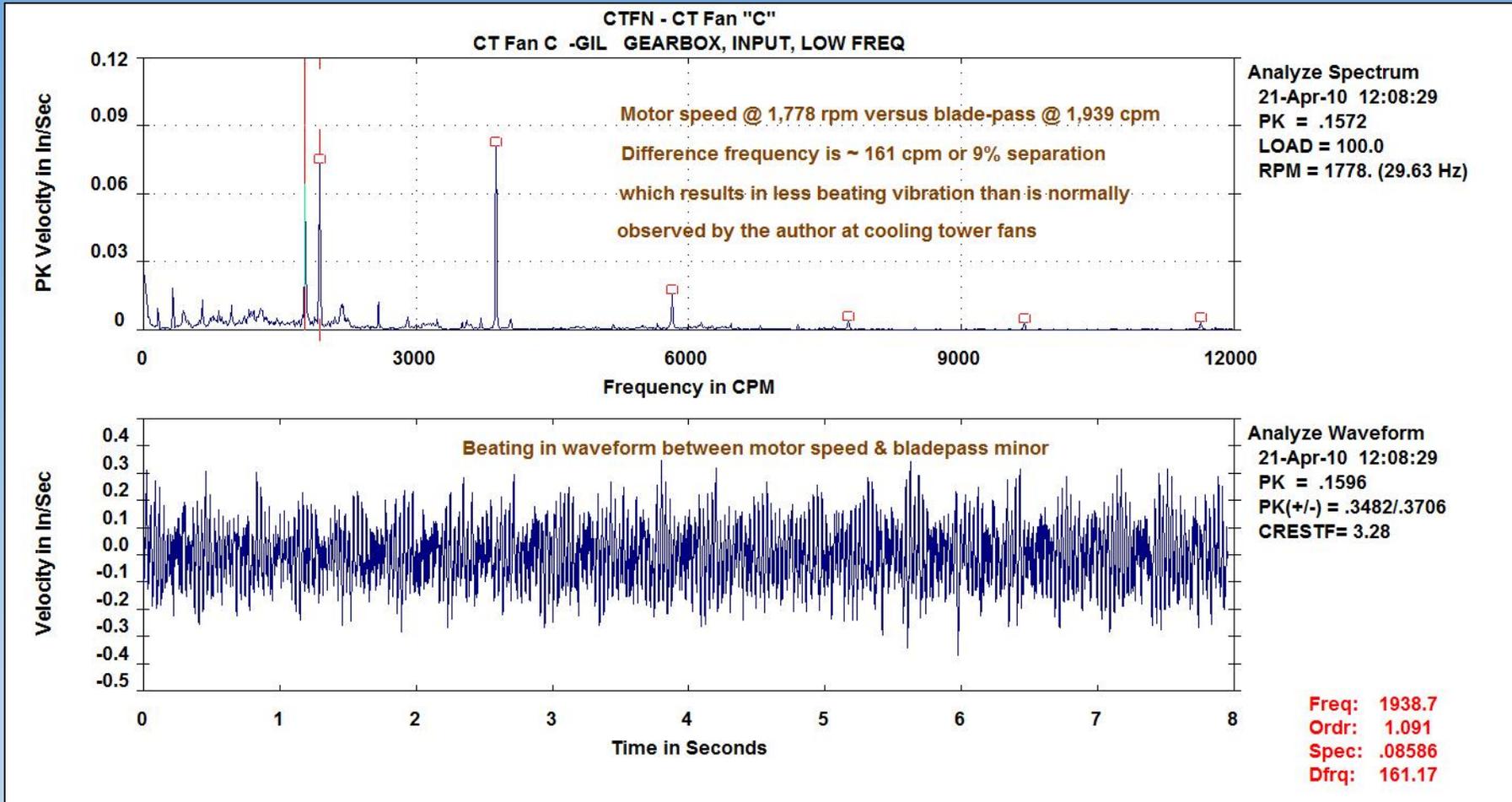


# CT GEARBOX SPECTRAL DATA (DISPLACEMENT)



- By converting our spectral units from velocity to displacement, a **minor** fan balance issue at CT fan “B” becomes clear (5 mills-pk-pk).

# GEARBOX SPECTRAL & WAVEFORM DATA



- From the waveform vibration data below, note how beating vibration is small at CT fan "C" despite the fact that it had the highest levels of vibration at 1x & 2x blade-pass frequency.
- It is the opinion of the author that CT fans with a 10% or greater separation between motor speed & 1x blade-pass frequency would represent one aspect of good design for these machines.

# RUNNING INSPECTION OF CT FAN "C"

- After all vibration data was collected, an **on-site running inspection of CT fan "C"** was performed in an effort to help determine the source of the unusual noise at this fan during operation.
- This running inspection identified a portion of the shroud that was cracked and only visible at certain fan speeds when it apparently resonated and made a terrible noise.



# RUNNING INSPECTION OF CT FAN “C”

- The running inspection found a cracked portion of the fan shroud that was clearly visible from above at the higher fan speeds when it began vibrating excessively coming close to touching the fan blades – this no doubt was the source of the terrible noise heard at this fan.



# CONCLUSIONS & RECOMMENDATIONS (GENERAL)

- 1) All three cooling tower fans could benefit from replacing their rubber oil drain hoses with SS braided types that won't deteriorate overtime and potentially cause a failure of the gearbox due to loss of oil.
- 2) No obvious damage or deterioration of the rubber grommets at the couplings of the jackshafts were noted during this inspection, however, from past experience, it might be a good idea to have these inexpensive grommets replaced every other year or so.
- 3) Lubrication is the lifeblood of rotating equipment. To achieve long life, please ensure that the proper type & quantity of oil is being used in all gearboxes. In my opinion, the oil in both units should be changed every two years or in compliance with OEM guidelines.

## CONCLUSIONS & RECOMMENDATIONS (CT-A & CT-B)

- Cooling Tower Fan A: On-site inspections as well as the vibration data collected showed no signs of significant problems with this fan at this time. Other than the general comments mentioned above for all fans, no specific recommendations are made at this time.
- Cooling Tower Fan B: This fan suffers from a higher level of unbalance when compared to the others (ie: compare fan A (0.8 mills), fan B (5 mills), and fan C (1.1 mills). Having this fan balanced at your next *convenient* opportunity would reduce its vibration levels and likely extend its life.

## CONCLUSIONS & RECOMMENDATIONS (CT-C)

- 1) The highest levels of vibration at both the motor speed of 1,788 cpm and the blade-pass frequency of 1,940 cpm were measured at fan "C".
- 2) As noted earlier, an unusual noise was clearly heard at this fan during operation that simply wasn't heard at the others. Knowing of the high levels at blade-pass frequency and hearing the noise, I decided to do a running inspection of the fan.
- 3) From this inspection, I discovered a portion of the fiberglass shroud cracked and the steel grating covering the top of the fan loose at spots.
- 4) Excessive vibration, noise and visible movement of the shroud itself in the general area of the crack were observed while fan "C" was running at the higher speeds. Similar problems were simply not found at any other part of this fan's shroud or at the shrouds of any of the other fans.
- 5) *In my view, the high vibration at blade-pass frequency at this fan is in large part due to this damaged shroud. Please have this shroud & grating repaired or replaced as needed, and check all bolts holding the shroud to the structure to ensure they are all tight.*
- 6) Consider an alignment check at this fan at your next opportunity.