"Field Analysis and Balancing Tools"

Needs and Solutions

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A Look at Industry Today

- The Economic Driving Forces
  - Improving operating efficiency
  - Minimizing downtime
  - Immediate problem resolution
- Key Elements to Problem Resolution
  - Detection
  - Analysis
  - Correction
  - Verification
- Pressure on Maintenance Personnel
  - Need to be readily available, and at a moment's notice
  - Need to have all required tools in place

Evolution on PdM Equipment

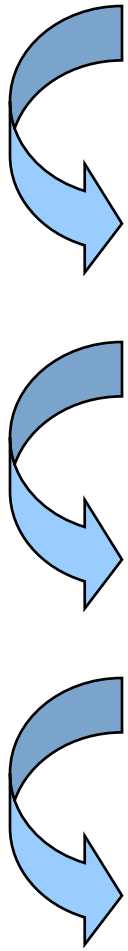
- The Evolution:
  - Human senses (and a wooden-handle screwdriver)
  - Vibration transducer
  - Portable meters for detecting (and quantifying) a problem
  - Portable data collector for storing historical information
  - Portable analyzer for storing, recalling, and examining data (amplitude, frequency, and phase)
  - Portable collector, analyzer, and correction tool in one lightweight, integrated package
- Key Emphasis:
  - Portability
  - Completeness

Maintaining Assets

- Wants and Needs of Plant (and Management) Personnel:
  - Advanced, but proven technology
  - Right set of tools
  - Dependability and repeatability
  - Cost-effective solution
  - Trained and skilled workforce
  - Early problem detection
  - Quick root-cause analysis
  - Effective resolution, with high confidence
- The Fundamental Focus for Maintenance:
  - Detection
  - Analysis
  - Correction
  - Verification

The 4 Key Elements

Field Service and Repair



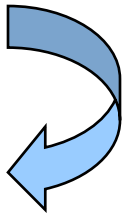
- Addressing the problem
  - Discovery
  - Assessment
- Diagnosis
  - Data gathering
  - Root-cause analysis
- Correction
  - Examining alternatives
  - Selecting the best path for the solution
  - Resolving the problem
- Verification

Key Elements of Service

- Quality Detection
  - Accurate, repeatable sensing device
  - Accurate, repeatable measuring instrument
- Right Interpretation (Analysis)
  - What is vibrating?
  - How much, what level (Amplitude)?
  - What frequency (1X, 2X, etc. relative to running speed)?
  - Under what conditions?
  - Relative behavior to other machine components (Phase)?
- Resolution of Problem (Correction)
  - What seems to be the matter?
  - What should be tried?

Correction

- Common Methods for Correcting a Vibration Problem …
  - Balancing
  - Alignment
  - Tightening of loose parts
  - Cleaning
  - Replacing failed components, such as bearings
  - Stiffening, damping, and isolation of vibrating components
  - Active cancellation of vibration
- Common Sense Routine Maintenance
  - Thorough inspection
  - Checking machine components for looseness
  - Cleaning of blades, vanes, etc.



The “Big 5” Faults …
- Balancing
- Alignment
- Looseness
- Rolling Element Bearings
- Resonance

Unbalance – The Major Problem

- Unbalance Is a Major Culprit In Rotating Equipment
  - 40% of all vibration problems can be attributed to an unbalance condition
  - Unbalance is characterized by a significant vibration at 1X running speed
  - Typically resolved by adjusting mass distribution – i.e., shifting, adding, or removing weight on the rotor

Balancing

- ANSI S2.19-1999
  - "…process of attempting to improve the mass distribution of a body so that it rotates in its bearings without unbalanced centrifugal forces…"

  Reducing these influences to the lowest limit possible.

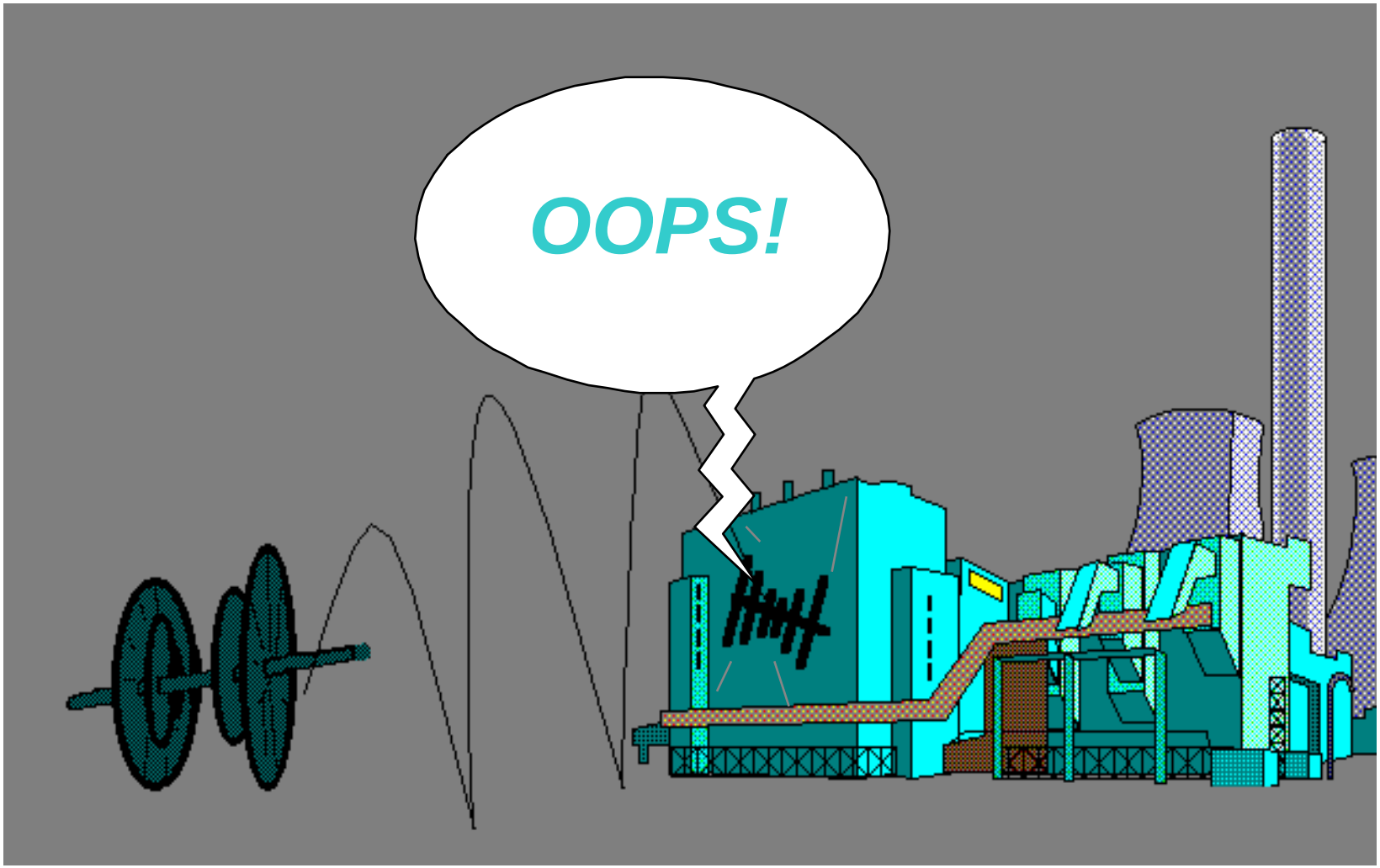
Way back when …

- Even early man had unbalance problems !

Why Balance?

- Benefits of Balancing
  - Minimize noise
  - Increase bearing life
  - Decrease operating stress
  - Consume less energy
  - Improve product quality
  - Decrease operator fatigue
  - Improve personnel safety
  - Eliminate fatigue of support structure

No Balancing Could Be Bad!



Causes of Unbalance

- Source of Problem in Manufacturing *(Production)*
  - Design errors
  - Material variation
  - Form, fit, assembly variation
- Source of Problem in Operations *(Field)*
  - Deposits buildup
  - Erosion
  - Shifting of weights or components
  - Gradual relief of residual stresses

"Production" versus "Field" Balancing

The Challenge in the Field

- What Are Possible Causes of a Vibration Problem?
  - Unbalance
  - Misalignment
  - Resonance
  - Eccentricity
  - Influences from other machine components
- We Must Get a Good Reading of the Situation
  - The amount of vibration
  - The frequency of the influence (looking for a significant 1X component)
  - The direction (phase) of the influential forces

Fundamental Requirements for the Tool

- Small, lightweight, and preferably a hand-held package
- Proven hardware platform – reputable supplier
- Accurate, reliable instrument
- Functionally independent in the field (no dependence on host)
- Easy to use, intuitive – not requiring lots of training
- Complete package – including key accessories
- On-board data storage and recall
- Chart and report capture
- Built-in analysis – for qualifying and quantifying
- Incorporates a correction technique, like balancing

plus … Low Cost

Ability to function independently and without "lifelines"!

Field Implementation

- Simple Menu Structure
  - Instrument Setup
  - Measurement
  - Analysis
  - Balancing
- Analysis
  - Quick measurement
  - Simple, fundamental measurements
  - Speed of machine
  - Amplitude and frequency of vibration

Remember, if it is unbalance, we are looking for significant 1X component at running speed.

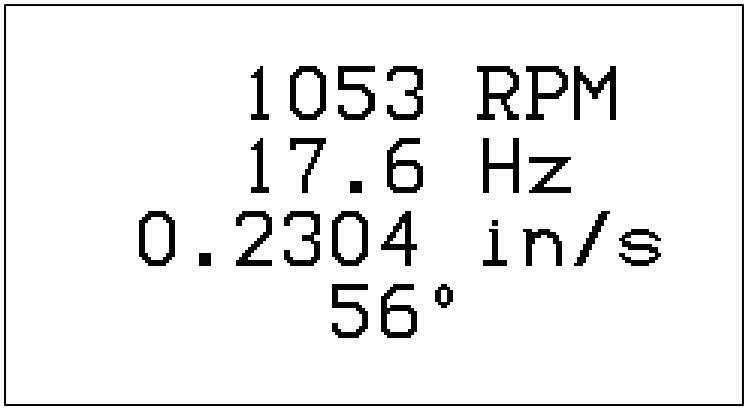
Provisions for Balancing

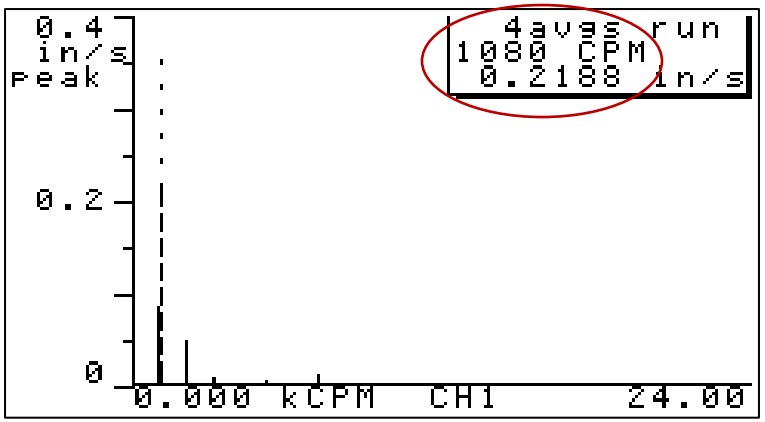
- Inclusion of all required components – vibration transducers, phase measuring device, instrument cables, etc.
- Abilities for two-plane measurement, continuous or fixed rotor positions, direction orientation, adding or removing weight, combining weights, additional trimming
- Guidance and prompting through fundamental steps
  - Initial run
  - Introduction of trial weight *(The Calibration)*
  - Correction run
  - Trim run

All with clear and concise numeric and graphical screens.

A Field Example

- Equipment is reported as running roughly
- Running speed is 1050 RPM
- Speed of shaft measured via photo tachometer (laser) and verified to be 1053 RPM
- Overall and FFT (frequency) measurements taken





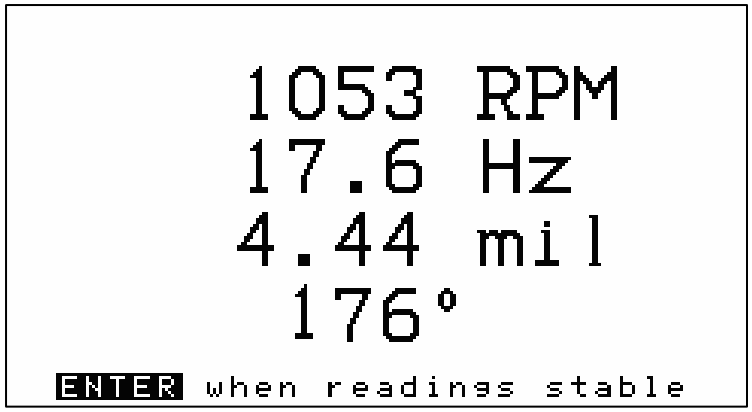
Field Example (cont.)

- Overall at 0.230 IPS (inches per second 0-pk), with majority of contribution (0.219 IPS) at running speed (1050 RPM)
- Verified as “rough” from Severity Chart

Vibration Velocity (IPS – Peak)	Vibration Velocity (mm/s – Peak)	Severity Level for Machine
.001	0.025	Extremely Smooth
.002	0.051	Very Smooth
.004	0.102	Smooth
.008	0.203	Very Good
.016	0.406	Good
.032	0.813	Fair
.064	1.626	Slightly Rough
.128	3.251	Rough

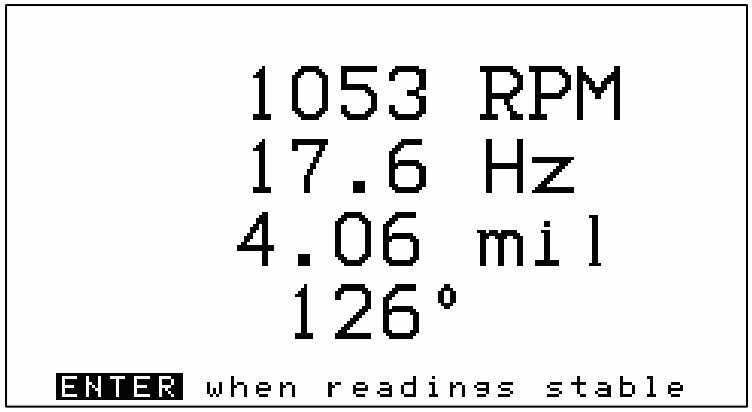
Field Example (cont.)

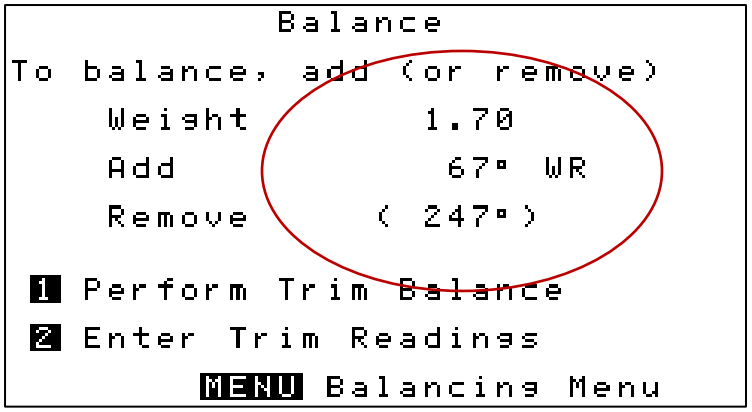
- Attach transducer
- Make an initial balancing run measurement on one plane
- Display speed, magnitude, and relative phase



Field Example (cont.)

- Stop rotor
- Attach trial weight plane 1
- Bring up to speed
- Instrument measures unbalance and performs calculation for correction

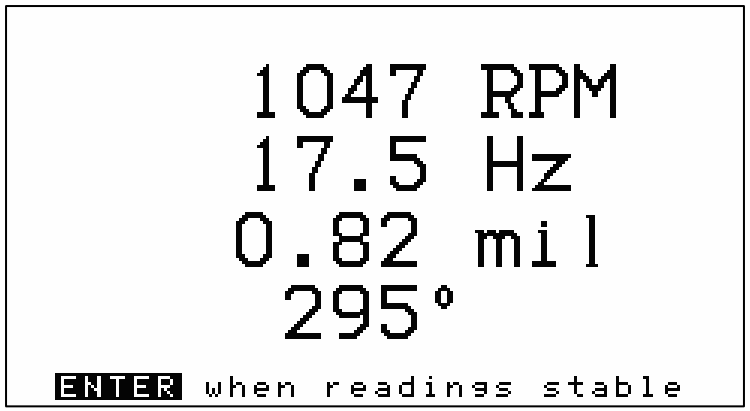




Remember the 30/30 rule.

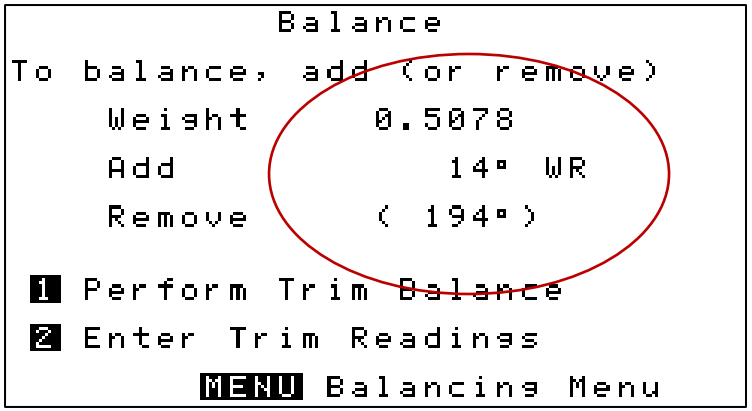
Field Example (cont.)

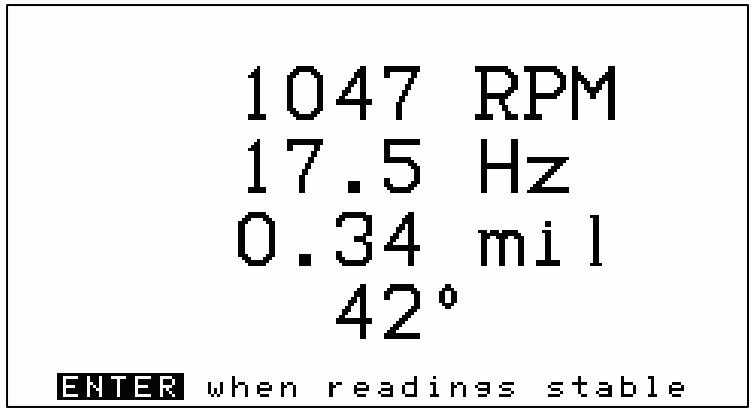
- Correction weight is placed at recommended position
- Machine is brought up to running speed
- Speed, magnitude and phase measurements are taken



Field Example (cont.)

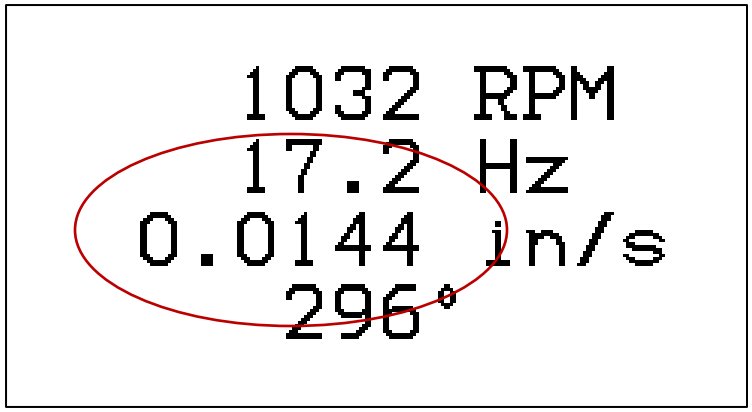
- It is decided to perform a trim
- A new weight callout is specified
- The machine is stopped, the weight is applied, and it brought back up to running speed
- Speed, magnitude and phase measurements are taken

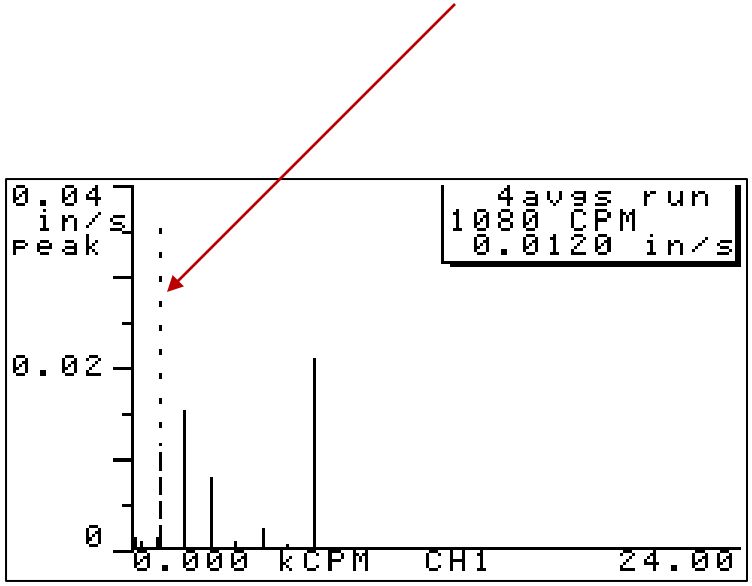




Field Example (cont.)

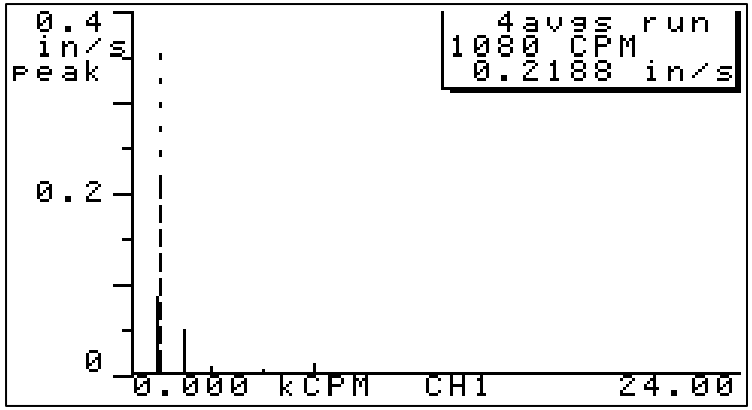
- Overall and spectral readings are once again taken
- Certain progress is noted

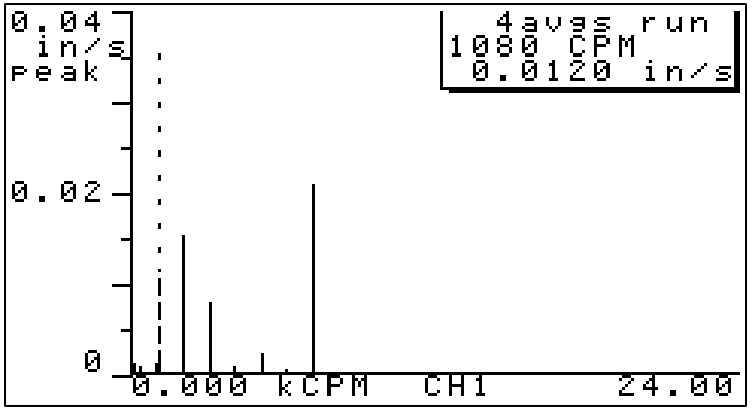


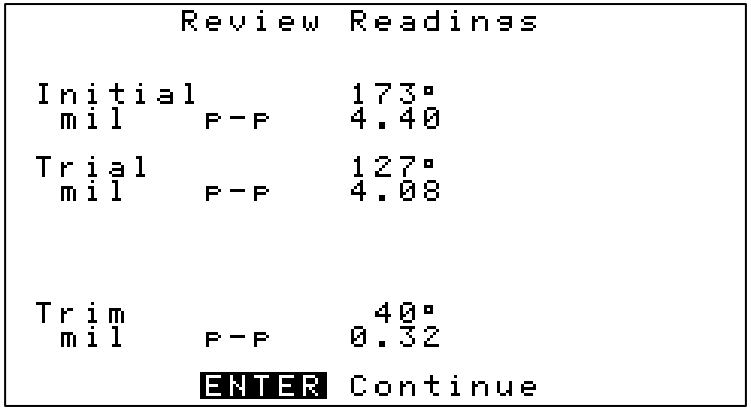


Field Example (cont.)

- Data is compared in the instrument for a conclusive ‘before’ and ‘after’ comparison. (Certain improvement is noted.)







General Procedure in Review

- Determine 1X running speed
- Take overall and spectral information
- Verify significant 1X component
- Initiate balancing procedure – initial, trial, correction, trim
- Check vibration levels
- Check spectrum display
- Trim more, if necessary
- Verify success
- Document
- End job

Conclusions:

- Time Is Money in Field Work
  - Be prepared
  - Travel lightly (with a single trip)
  - Work efficiently
- Have All Required Components in Your Tool Box
- Keep the Process Simple
- Maintain Some Independence
- Document (Record) Your Work

This has been an example of a specific implementation.

What does it take?

- PEOPLE
- EQUIPMENT
- TRAINING
- COMMITMENT

Case History Example

A belt-driven air handler

- Run until the shaft breaks
  - Primary and secondary damages
  - $18,000 in parts and $4500 labor
- Run until bearing failure
  - No secondary damages
  - $600 in parts and $300 labor
- Vibration analysis - early warning – calls for grease
  - 3 cents in material and $6.00 labor

Not even counting downtime, a savings of $22,493.97!

Governmental Studies

Take a look the web site:

http://www.eere.energy.gov/femp/operations_maintenance/strategies/strat_predictive.cfm

- Return on investment: 10 times
- Reduction in maintenance costs: 25% to 30%
- Elimination of breakdowns: 70% to 75%
- Reduction in downtime: 35% to 45%
- Increase in production: 20% to 25%

Lean Manufacturing and PdM

- Commonly used “buzz words” in manufacturing today:
  - Lean initiative
  - Visual factory
  - Pull scheduling
  - Value stream mapping
  - Six Sigma
  - Cell design
  - Asset management
  - Kaizen blitz
- As Predictive Maintenance folks, where do we fit into the scheme of things?

Eight Steps in the Scientific Method

PdM follows 8 steps:

1. Determine the basic problem
2. Collect data to define scope and severity
3. Decide a possible method for correction
4. Choose tools to address the problem
5. Try to correct the problem
6. Test the “fix”
7. Reassess the situation
8. Institute a change or remedy for going forward.

Asset Care and the Lean Initiative

- Industrial revolution put machines at core of the new model of manufacturing capability and capacity.
- Maintenance and reliability programs make machines and facilities reliable and available.
- Lean manufacturing emphasis places asset care as a crucial element of the toolbox.
- Predictive Maintenance methods (comprised of detection, analysis, correction, and verification) are essential to asset management.
- Balancing is a key correction tool for “field” work.

Questions & Follow-on Discussion