GE Energy

Energy Harvesting used for Wireless Condition Monitoring

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Bently Nevada* Asset Condition Monitoring

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Agenda

1. Bently Nevada Asset Condition Monitoring
    - Who we are – Mission Vision
2. CM in general
    - Size of CM market
    - RCM approach
    - Data types and freq (p/f curve)
3. Role of wireless in CM
    - Sweet spot for use - case studies
    - Haz Area use in plant (Z0)
    - Power usage leads into battery issues lead-in to E-Harvesting
4. Energy harvesting in support of wireless nodes
    - Vibration Energy scavenging
    - Solar, Line emf scavenging, thermopile
    - Direct line
5. Product Demonstration

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GE's Bently Nevada Product Line

A Leader in Machinery Protection and Condition Monitoring

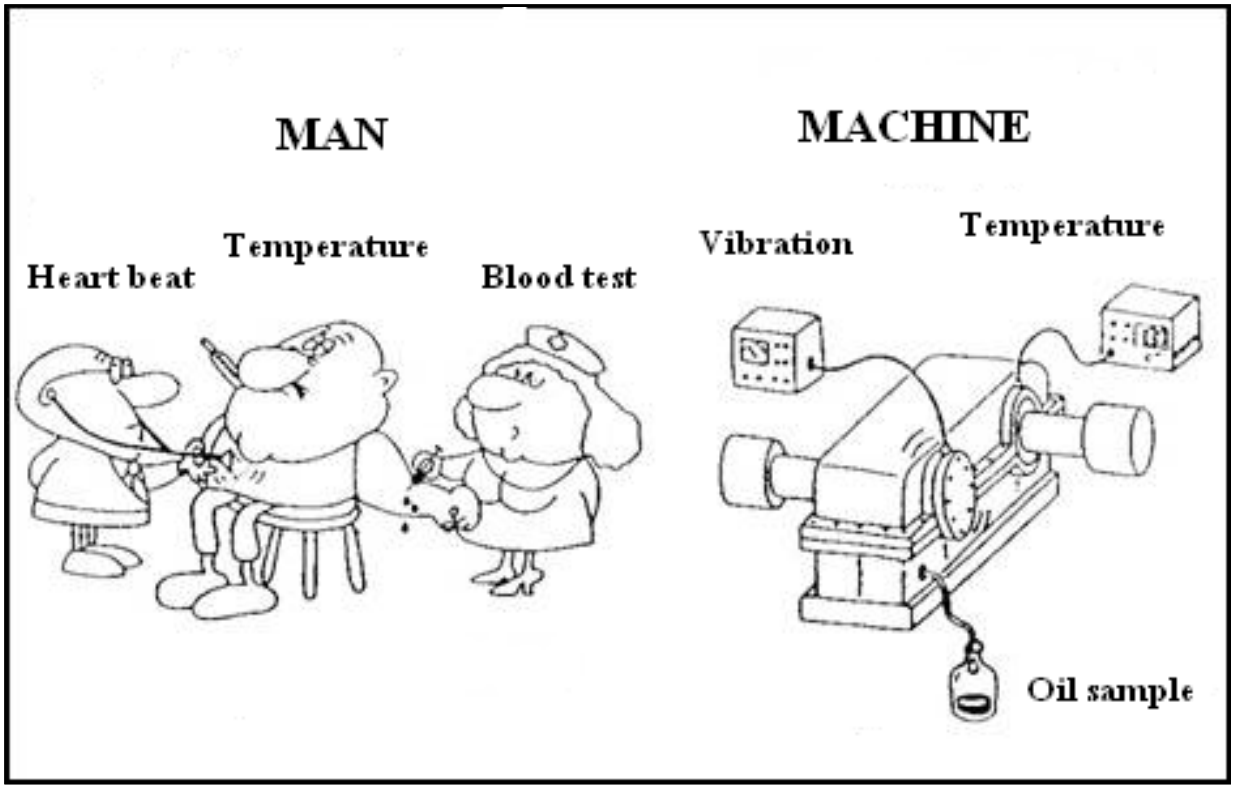
The Bently Nevada name has been synonymous with machinery protection and condition monitoring for over 50 years. Our expertise delivers you advanced, high-quality machinery monitoring solutions for optimum plant safety, uptime and efficiency.

Industry spend on condition monitoring is ~$1.8B annually
GE provides technology leadership for the industry

Our Mission

"To be our customers' **partner** *for* **innovation** *that* **enhances** *their business* **performance**.”

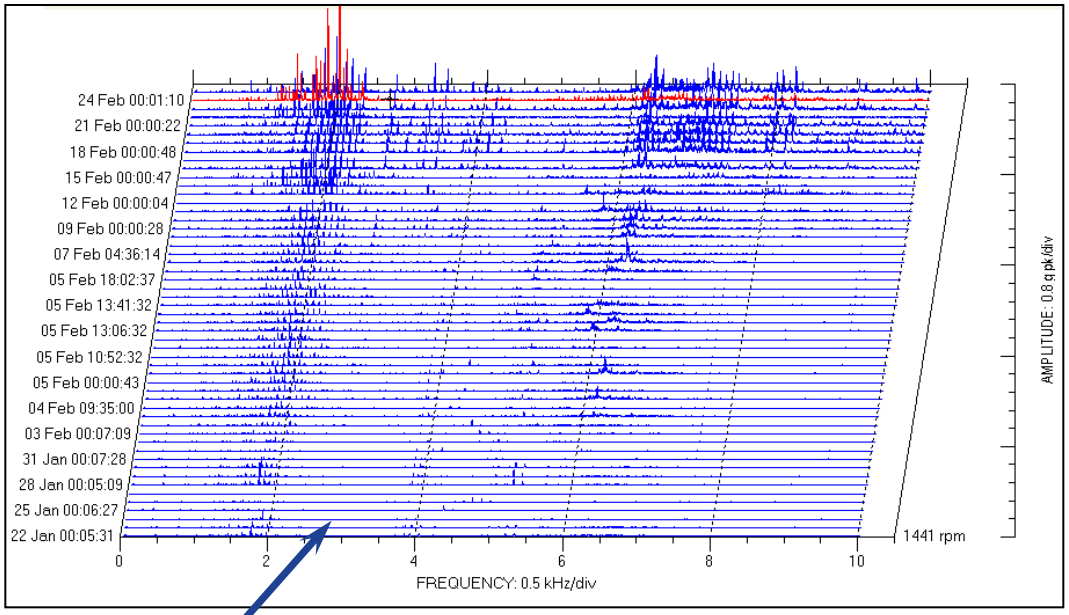
What is Condition Monitoring ?

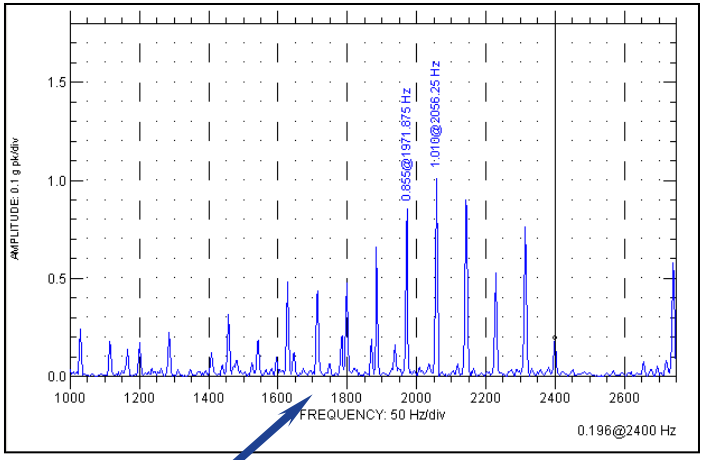


CM:

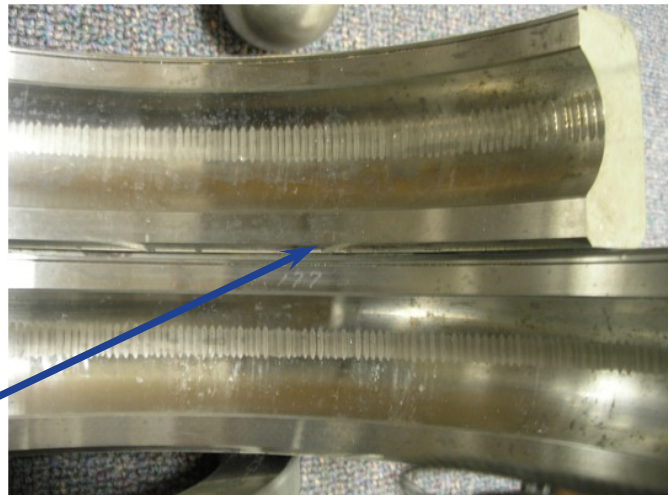
- Determines an assets' operating condition
- Predicts the development of this operating stage
- Then, determines possible failure, required maintenance and/or repair times.

Condition Monitoring example





1. Historical data shows increasing vibration on higher frequencies.
2. Spectral analysis pinpoints a bearing outer ring failure
3. Physical inspection verifies diagnostics



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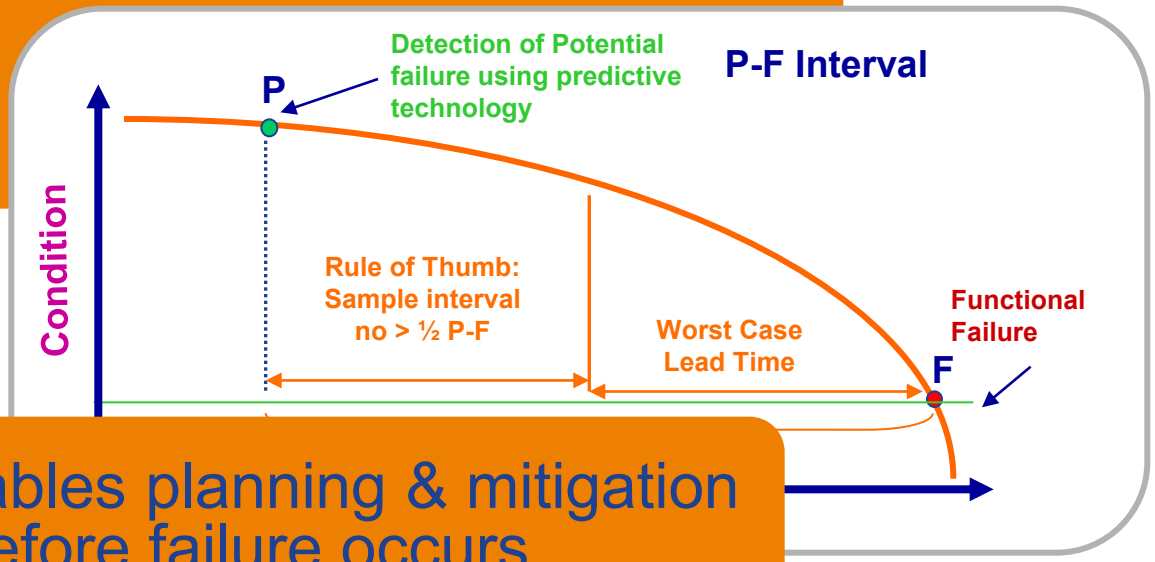
Reliability Centered Maintenance (RCM)

RCM Risk Mitigation Approach

Risk = ρ failure x R consequence of failure
Early detection of equipment failure modes
Modeling software using key inputs:
Vibration
Temperature/IR thermography
Tribology
Ultrasonic
Corrosion



RCM enables planning & mitigation before failure occurs

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Condition Monitoring

Online (wired):

Protection is needed

Every sensor has its own processor

Centralized or distributed systems

Data collected continuously

Scanning (wired & wireless):

P-F not suitable for PDC

One processor covers serveral sensors

Centralized or distributed systems

Data collection rate 0.2 ... 120 minutes

PDC:

Most common way to collect CM data

Data typically collected once / month

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Role of Wireless in CM

Wireless enables:

- Overall RCM plan covering the 70% o the mid- to low-criticality equipment t augment PDCs and wired solutions.
- Monitoring where manpower, cost, or hazardous areas constraints make traditional methods impractical.

Application scenarios:

Wireless usage is best suited where failure mode for:

- ½ P-F life is 15 minutes to 30 days
- Detection being done using
  - ✓ Case vibration
  - ✓ Temperature

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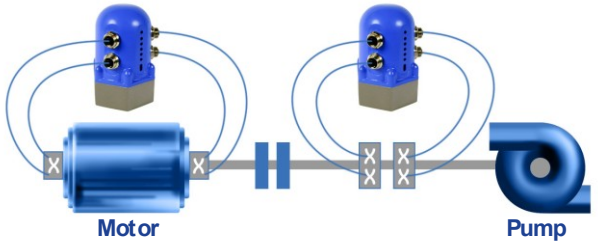
Application Solution: **Tank Farm Pumps**

Current Practice:
Walk-arounds @3 week intervals

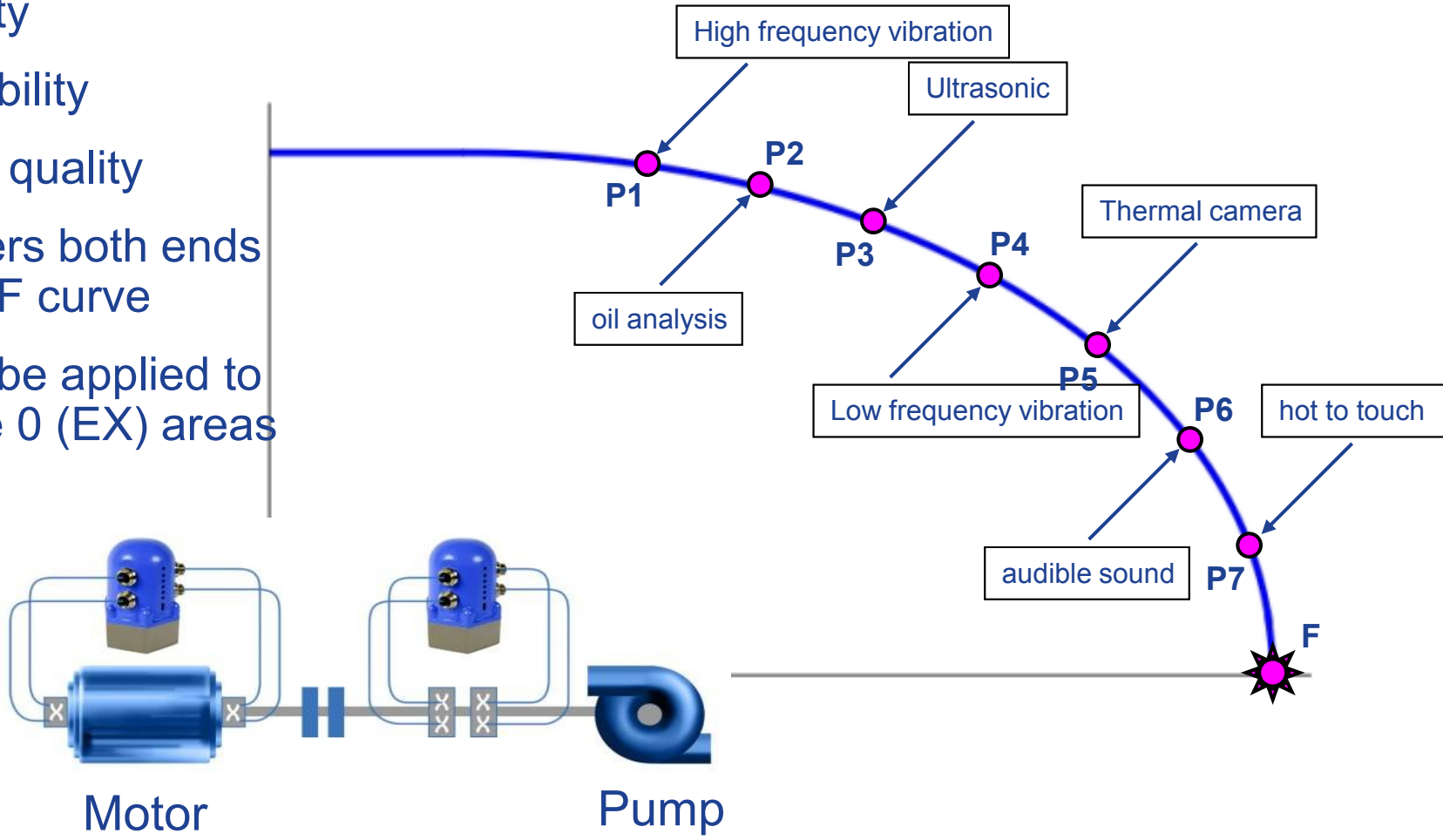
Failure Modes:
Undetected Failure occurs between rounds.

Our solution:
System 1 Monitoring of vibration at key points several times per day with Essential Insight .mesh

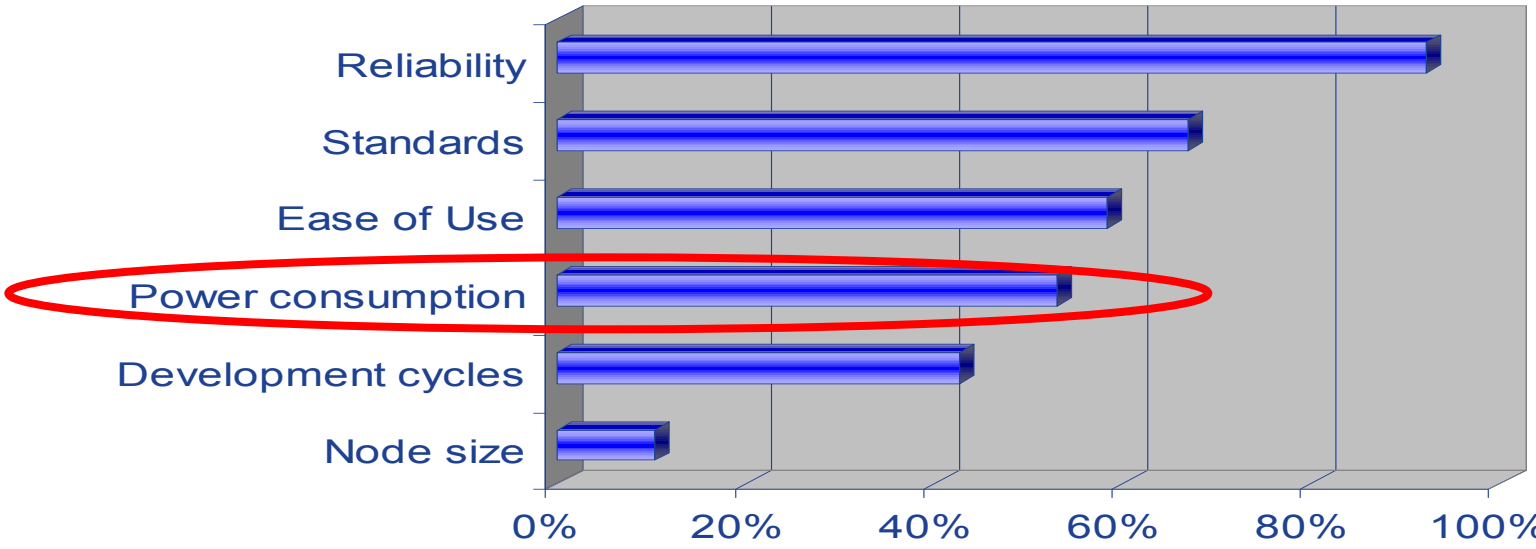


Drivers for Wireless systems

- Installation cost of Wired systems
- Installation time of Wired systems
- Safety
- Flexibility
- Data quality
- Covers both ends of P-F curve
- Can be applied to Zone 0 (EX) areas

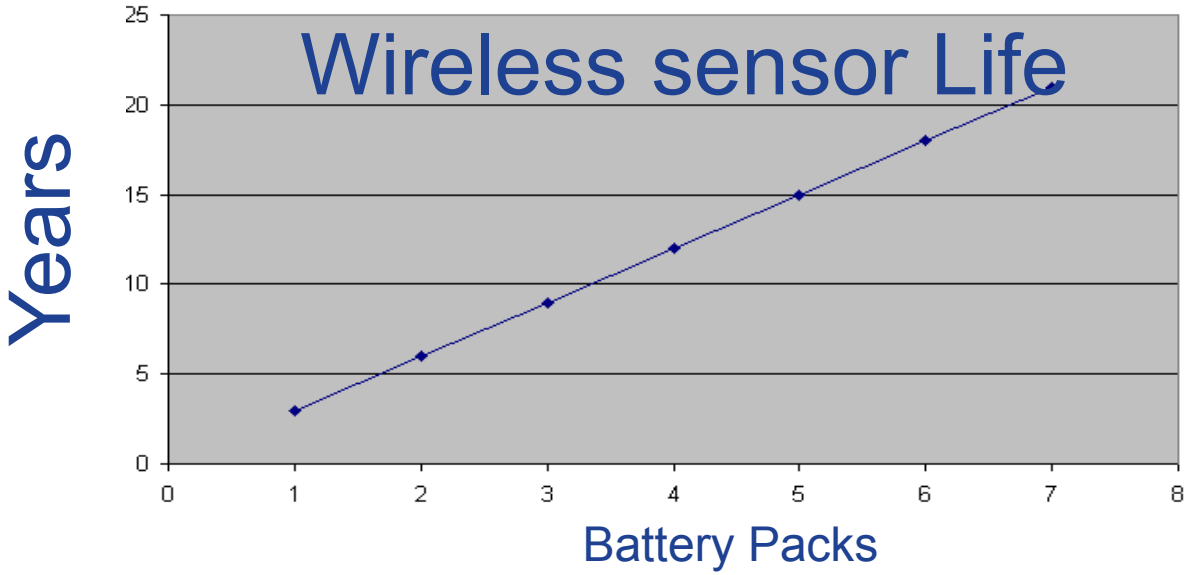


Barriers for Wireless Adoption



Source: OnWorld 2005

Typical vibration sensor life of 3 years per battery pack.



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Typical Power Source Capacity

Lithium Thionyl Chloride Battery packs @ 19,000 mA-hour

Vibration Energy Harvester (VEH)

- Delivers 0.5mA average @ 3.6V for 4 years
- Variations in environment, duty cycle, and configuration causes uncertainty to begin at 2-3 years.
- **Unpredictable maintenance logistics.**

- Delivers at least 0.5mA @ 3.6V indefinite
- **Fit it and forget it – Life Cycle Independ**

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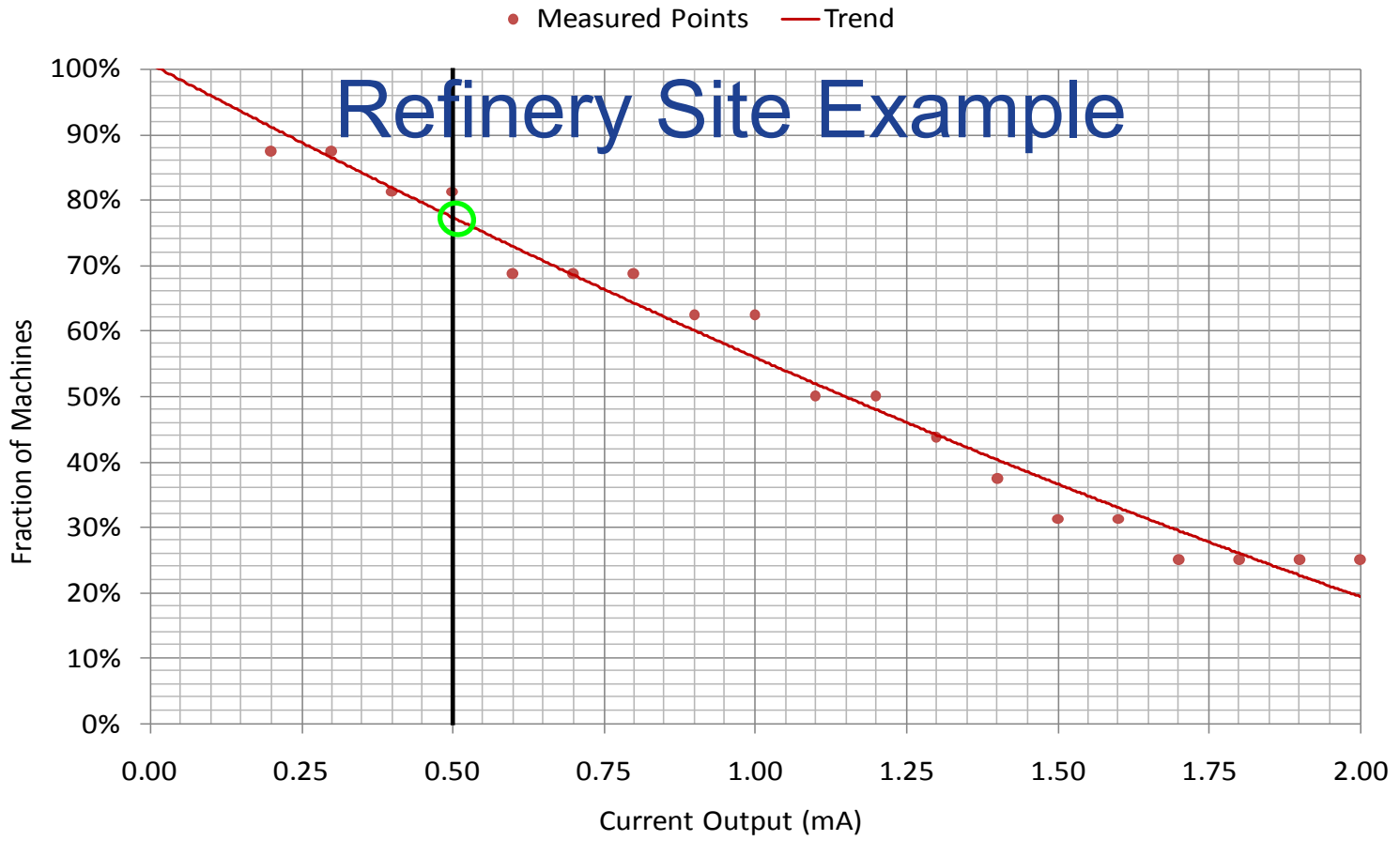
Motors available to Harvest vibration

Test show 100mg must be available from motor vibration on a 50 Hz, 60Hz, 100Hz, 120Hz horizontal AC motor with REBs (harvester was casing, pedestal, or machine mounted)

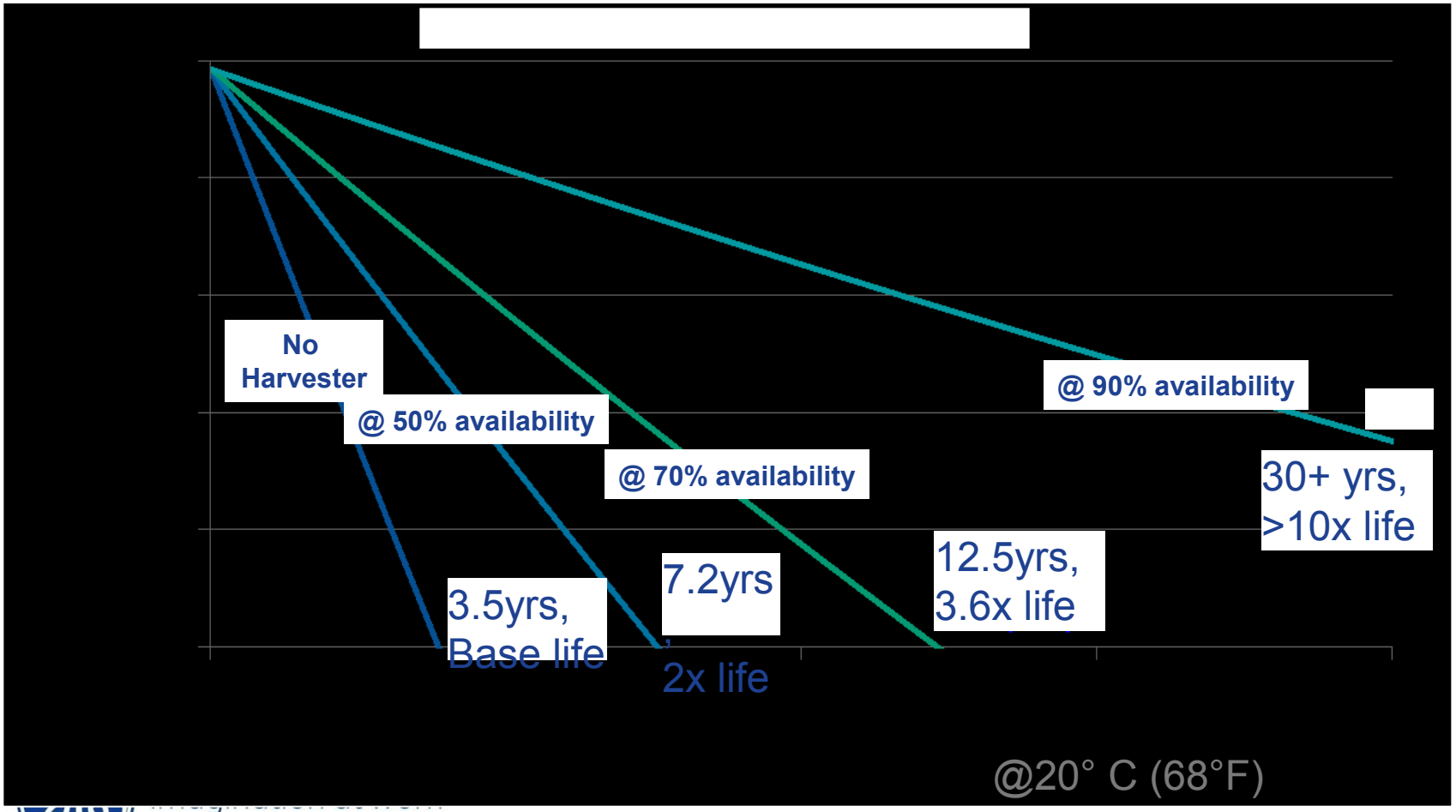


50%-75% motors produced 0.5+mA across 3 user sites

Data collected across 4 user sites (refining and power Generation)

Power Harvester assisted battery life

Battery life @ 2mW constant power consumption and 1%/yr self-discharge.
Graphs show varying degrees of harvester usage/availability.



Drivers for Energy Harvesting

Available (battery) Power limits:

- Wireless transmission rates
- Sampling rates
- Data processing
- Temperature extremes shorten battery life

Hazardous material:

- Depleted lithium thionyl chloride batteries are hazardous material and creates a potential disposal issue (cost and logistics)

Maintenance cost

- Battery changes require scheduling, disposal, and labor expense

Logistics

- Even NEW lithium thionyl chloride batteries are regulated material that can NOT be transported on passenger airplanes
  -> Causes shipping delays and creates logistical issues

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These issues ultimately limit wireless deployment applications

Energy Harvesting in Wireless CM

GE Bently Nevada's harvesting solution is designed to accommodate a full range of harvesting technologies (5VDC, 0.5mA input):

- Solar
- Thermopile
- Vibration
- emf

… as well as accommodate External Line Power to enable:

- Higher level functions
- Optimal reporting rates without battery depletion worries

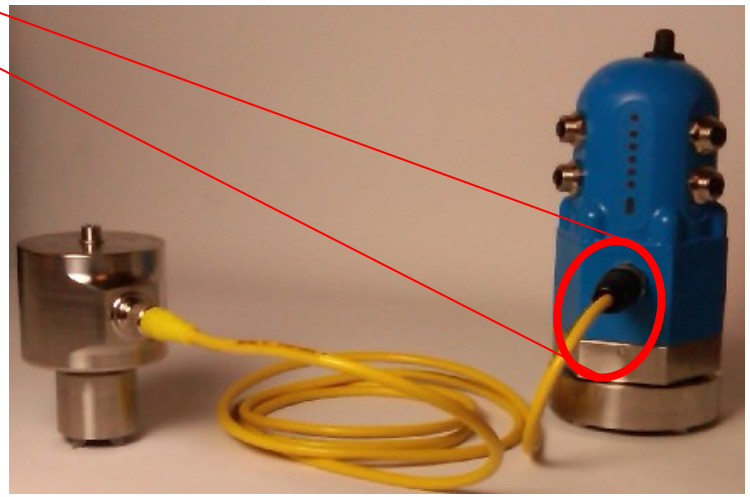

Figure: VEH with wSIM

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Harvesting enables deployments without requiring an electrician

Deployment Guidelines

1. Mount the VEH at the optimum location to provide current required (e.g. 0.5mA). using the supplied magnetic mounting hardware.

2. Locate the optimized location for the Wireless Sensor Interface Module (wSIM).

3. Attach the VEH to the wSIM (using the supplied cable)

4. Power up the wSIM & start monitoring.

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BACK-
UP

Drivers for Energy Harvesting

- Available (battery) Power limits:
  - Wireless transmission rates
  - Sampling rates
  - Data processing
- Depleted lithium thionyl chloride batteries are hazardous material
  -> Disposal and shipping is onerous
- Lithium Thionyl Chloride batteries cannot be transported on passenger airplanes
  -> Causes shipping delays and creates logistical issues
- Temperature extremes shortens battery life
  -> Causes frequent battery replacement

These issues limit wireless deployment applications

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