FLUKE®
Reliability

Understanding condition-based maintenance tools that impact the P-F curve

John Bernet
Gregory Perry
Dries Van Loon

Accelix™
Webinar Series

Meet the Speakers

John Bernet, CMRP

- Mechanical Reliability Application Specialist at Fluke Corp. (8 years)
- Previously worked at Azima DLI for 18 years
- Served 12 years in U.S. Navy on cruiser & aircraft carrier as electrical technician
- Has 30+ years of experience in preventive and predictive maintenance
- Written many technical articles for global trade publications and recently completed a 240-page vibration training program

Certified Maintenance & Reliability Professional (CMRP)

Thermal/Infrared Thermography Level I certified

Vibration Analysis Level 2 certified

Meet the Speakers

Dries Van Loon, CRL

Sales and Project Manager, Online Condition Monitoring | Fluke Reliability

- 10 years of experience in predictive maintenance
- Joined Pruftechnik (acquired by Fluke) as an Application Engineer in 2012
- Established Pruftechnik Inc.'s Condition Monitoring Dept. in 2014
- Certified as an ISO CAT 4 analyst since 2017

✓ **Certified Reliability Leader (CRL)**

✓ **Ultrasound Level I certified**

✓ **Vibration Analysis Level 4 certified**

Meet the Speakers

Gregory Perry, CMRP, CRL

Capacity Assurance Consultant | Fluke Reliability

- Former maintenance practitioner (healthcare), with more than 20 years of maintenance & reliability experience – especially within CMMS realms
- Extensive background in maintenance & reliability concepts
- Proficiently focused on CMMS implementation initiatives with 300+ CMMS implementations under his belt
- Fluke Reliability subject-matter expert presenting at leading industry conferences; content provider for leading industry periodicals and magazines

Certified Maintenance & Reliability Professional (CMRP)

Certified Reliability Leader (CRL)

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POLL QUESTION No. 1

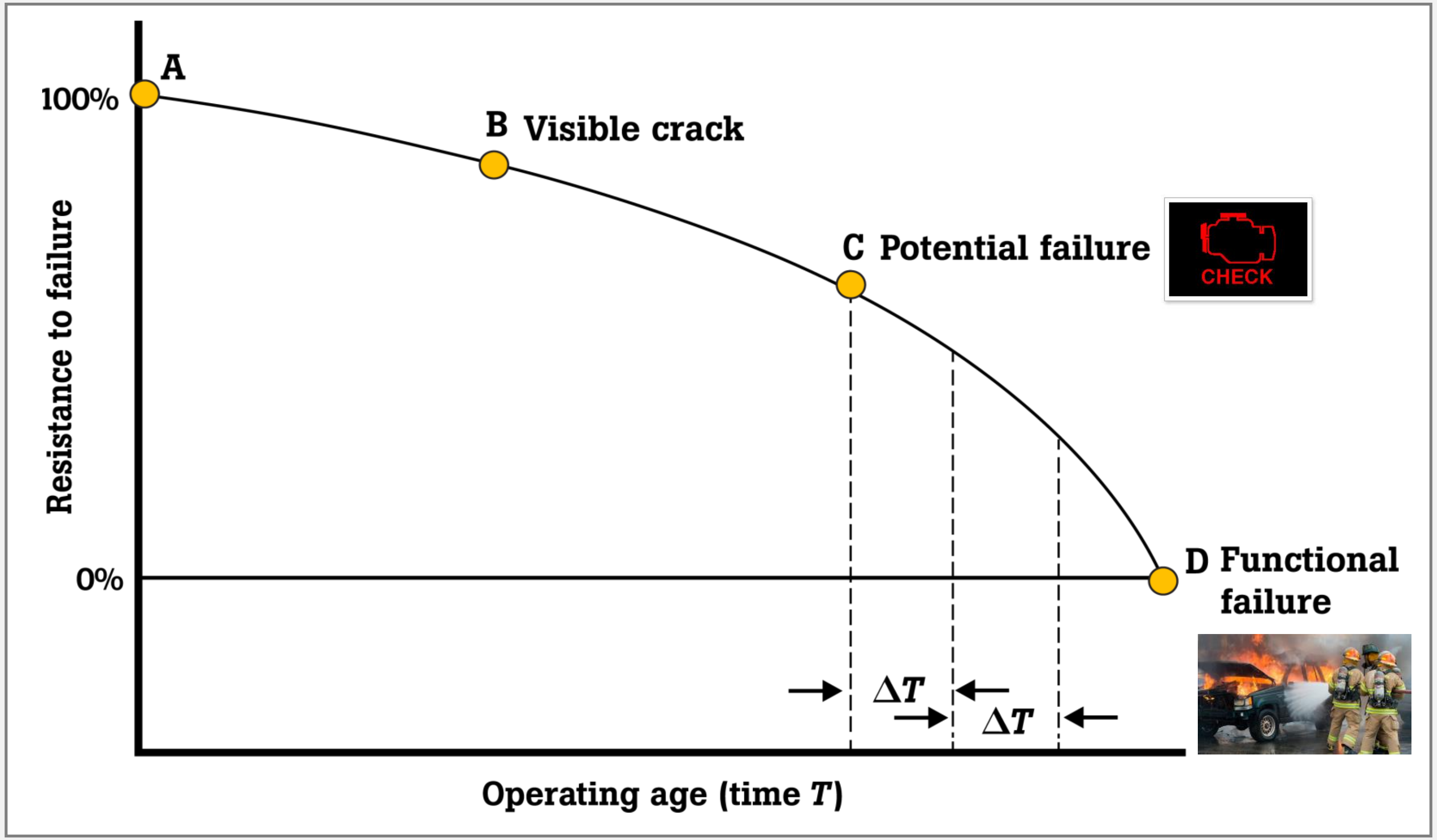
What level of condition-based maintenance have you adopted in your current job plans? **(Click only one answer)**

- More than 35%
- 25-35%
- 15-25%
- 0-15%
- Not sure

P-F Curve

P-F Curve: the basics

Stanley Nowlan & Howard Heap's P-F Curve



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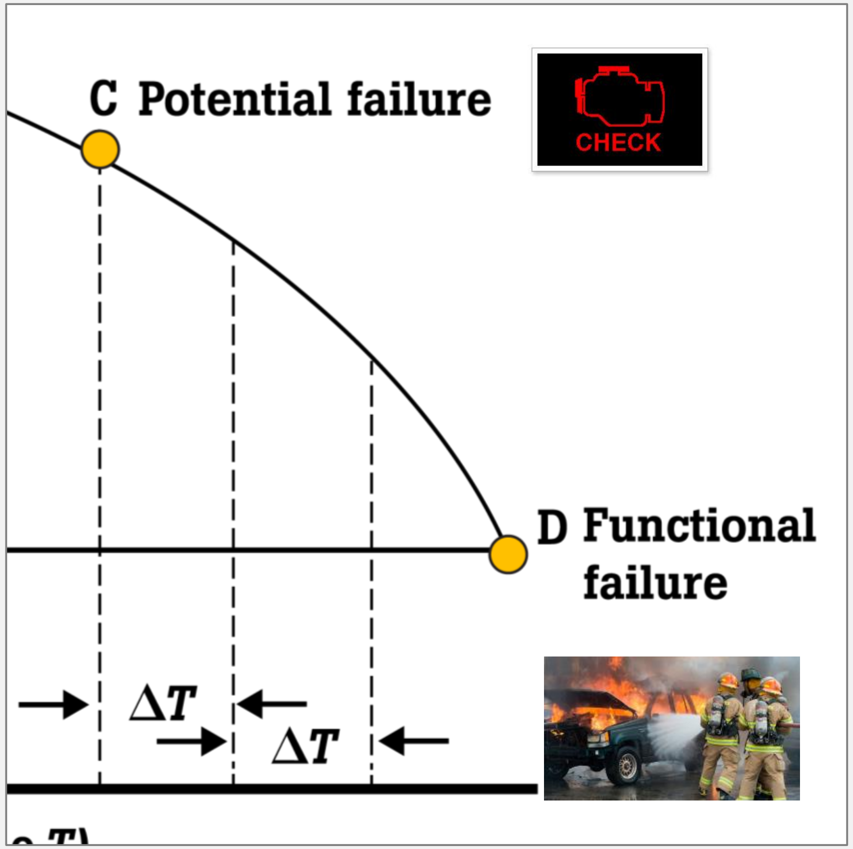
Nowlan & Heap P-F Curve: simple

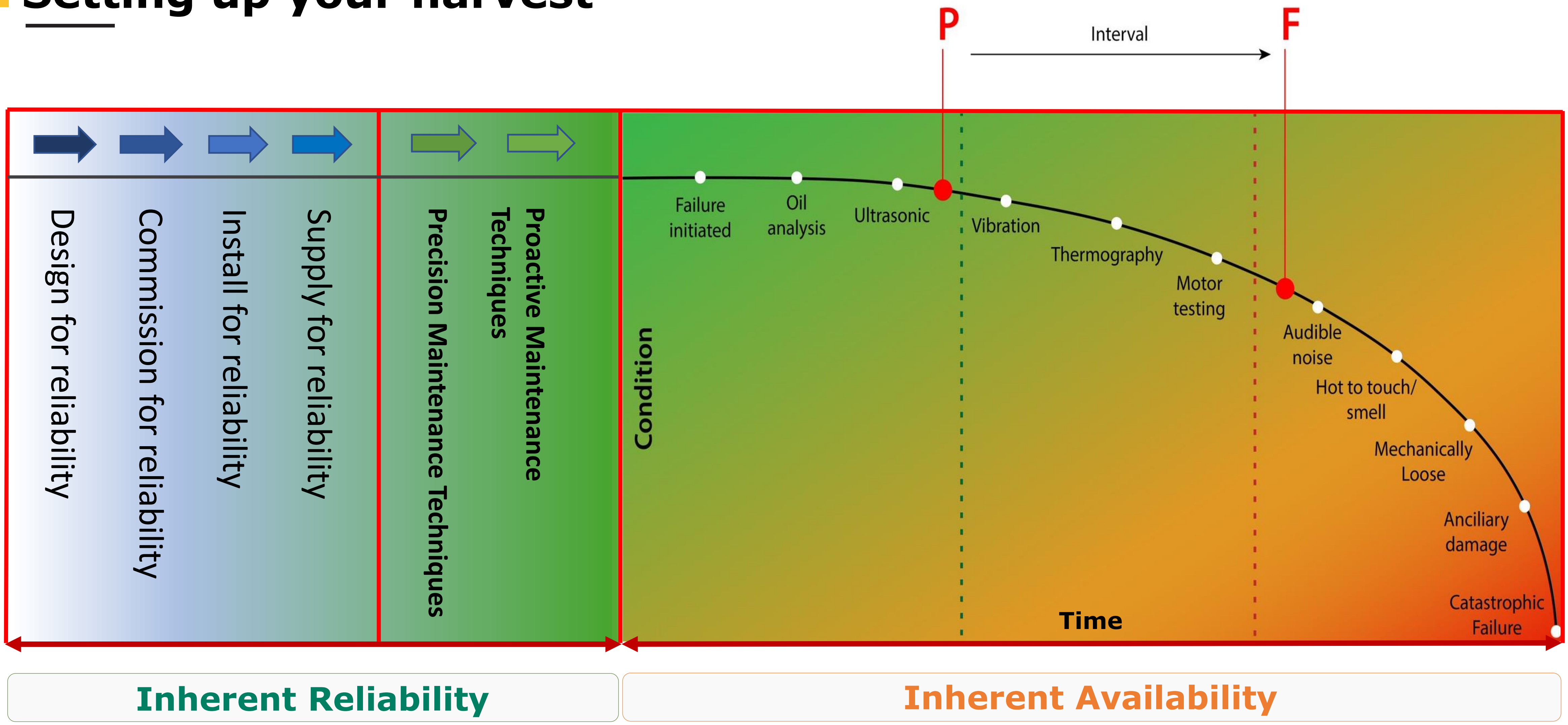


Point P = Potential Failure:
An identifiable physical condition that indicates functional failure is imminent.

Point F = Functional Failure:
The inability for an item (or the equipment containing it) to meet a specified performance standard.

P-F Interval:
The time it takes for an item to functionally fail once a potential failure has been detected.

Setting up your harvest



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Inherent Reliability

... *maximum "Attainability"*

Inherent reliability is a measure of the overall "robustness" of a system or piece of equipment. It provides an upper limit to the reliability (attainability) that can be achieved through proper design, commission, installation (precision maintenance), and supplied for reliability.

If you operate, maintain, and inspect a device as well as possible, you will be able to harvest all the inherent reliability.

In other words, no matter how much inspection or maintenance you perform, you will never exceed the inherent availability as defined by the maximum attainability.

On the other hand, if there are gaps in your operating, maintenance, or inspection practices, you will harvest only some of the inherent reliability – but not all.

Inherent Availability

… *maximum "Maintainability"*

In reliability theory and reliability engineering, the term ***availability*** *has the following meanings:*

The degree to which a system, subsystem, or equipment is in a specified operable and committable state at the start of a mission, when the mission is called for at an unknown, i.e. a random, time.

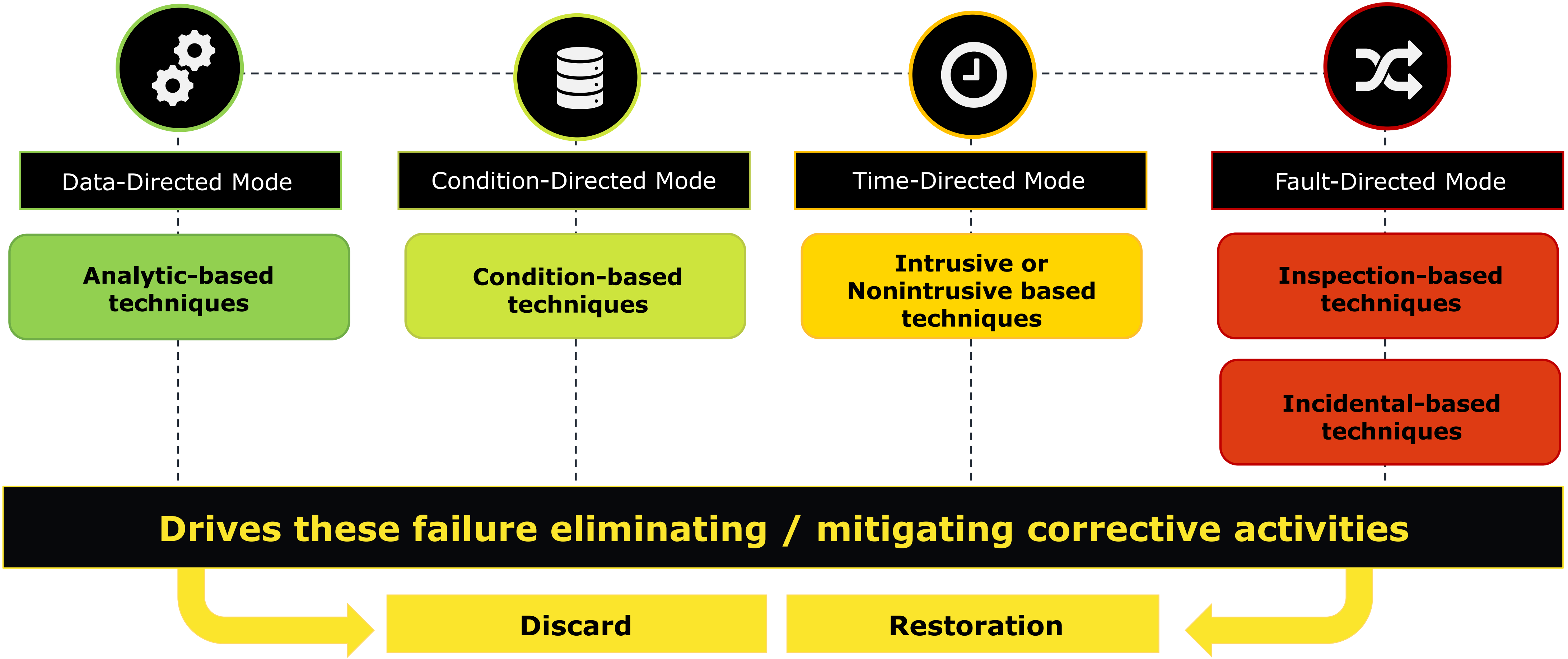
Availability *is an important metric used to assess the performance of repairable equipment—whether a component or system— accounting for both reliability and maintainability properties.*

Inherent availability *is the "steady state availability", when considering only the corrective maintenance (CM) downtime of the system.*

Source: www.Weibull.com

1- Elsayed, E., Reliability Engineering, Addison Wesley, Reading, MA, 1996.

Inherent Availability: tasks and techniques on the P-F Curve



Moving towards being asset heath-centric (condition-based)

Reactive	Time-Directed	Condition-Based
Corrective work orders after failure	**Calendar & meter based scheduling**	**Work orders from real-time asset data**
☒ Can be expensive	☑ Increased efficiency	☑ Increased uptime
☒ Shorter asset life	☑ Less downtime	☑ More productivity
☑ Appropriate for some assets	☒ Can perform too much / too little maintenance	☑ Data-driven maintenance decisions

Maintenance-centric → **Asset Health-centric**

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Matching failure modes to measurement methods on the P-F Curve

Data-Directed Mode

Analytic-based techniques

Condition-Directed Mode

Condition-based techniques

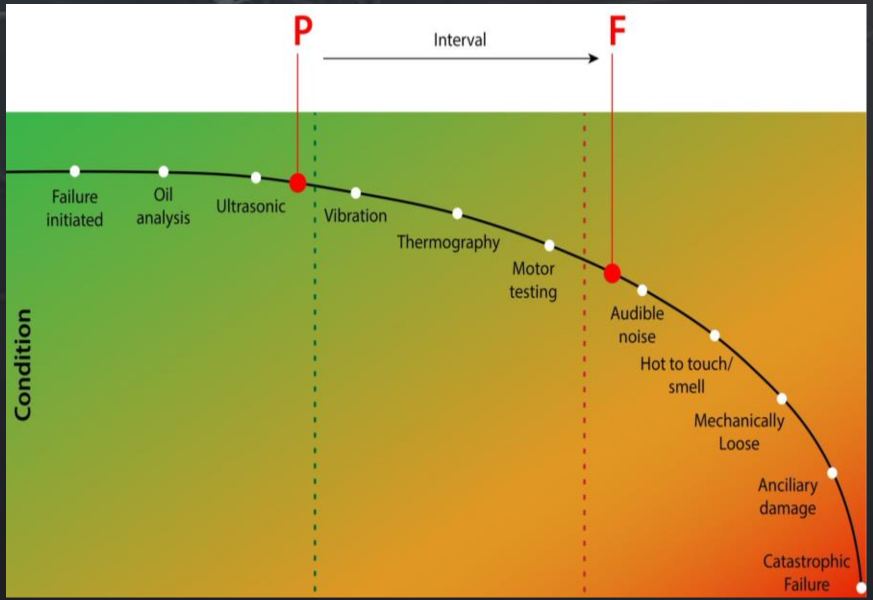
Time-Directed Mode

Intrusive or Nonintrusive based techniques

Fault-Directed Mode

Inspection-based techniques

Incidental-based techniques



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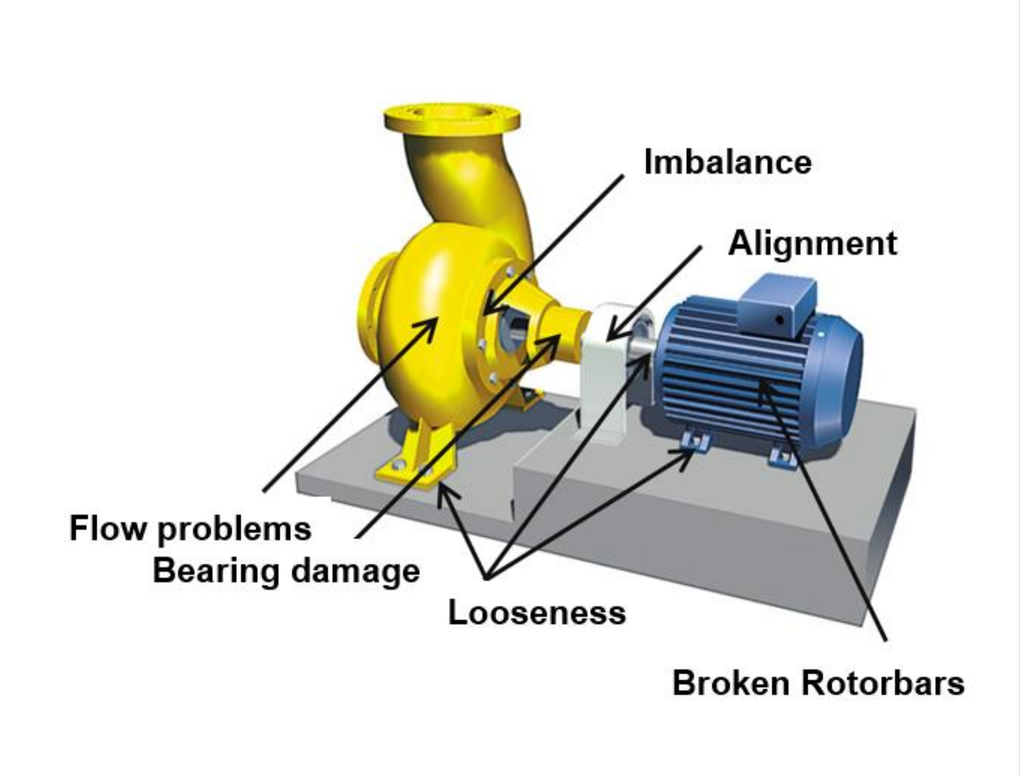
Vibration: failure modes

- Condition monitoring and root cause analysis
- Rotating equipment
  - Machine failures
    - Imbalance, misalignment, looseness
  - Bearings failures
    - From very early stage on …
  - Electrical failures
    - Rotor bars, stator slots, VFD induced
  - Process issues
    - Flow, pressure



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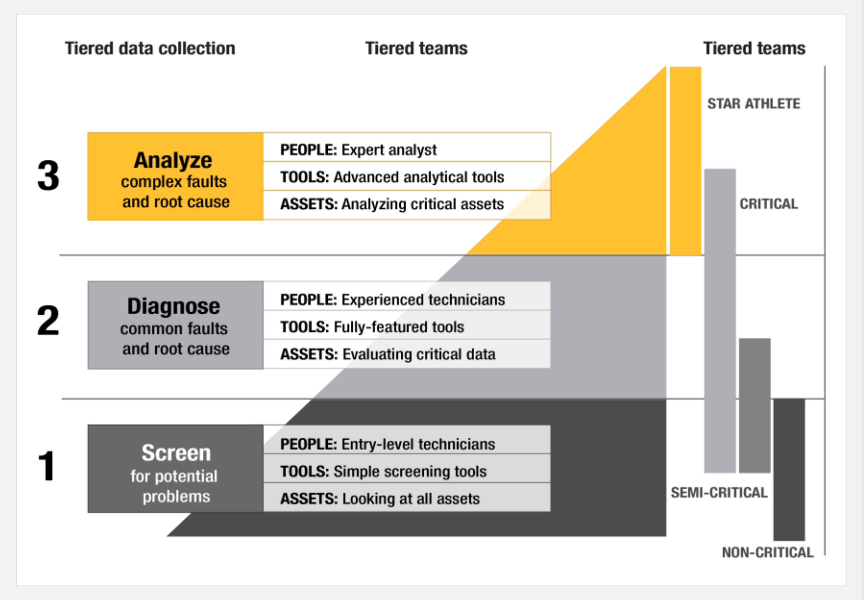
Vibration: measurement methods

- Used method depending on **asset criticality and failure modes**
- Methods

Analyze	- continuous online monitoring	*Level 3-4 training + experience²*
Diagnosis	- advanced handheld monitoring - advanced wireless system	*Level 2 training + experience*
Screen	- basic wireless system - basic handheld system	*Minimal training and experience*



805 FC Vibration Meter

810 Vibration Tester

VIBSCANNER 2

VIBXPERT II

VIBGUARD

Wireless 3561

Oil analysis: failure modes

- **Condition monitoring and root cause analysis**
- **Rotating equipment**
  - Gearboxes
    - Bearings failures, gear wear, broken tooth
  - Sleeve bearing
    - Bearing wear
  - Recip engines and compressors
    - Bearing failures, gear failures, cylinder wear, overload
- **Hydraulic systems**
  - Hydraulic components
    - Wear + overload

**Image source: www.machinerylubrication.com*

Oil analysis: measurement methods

- Used method depending on **asset criticality and failure modes**
- Methods

Analyze	- advanced online monitoring (wear particles, ferrous, non-ferrous, viscosity, humidity) - advanced lab analysis
Diagnosis	- basic online monitoring (overall wear, viscosity, humidity, temperature) - basic lab analysis
Screen	- oil sight glass - oil temperature

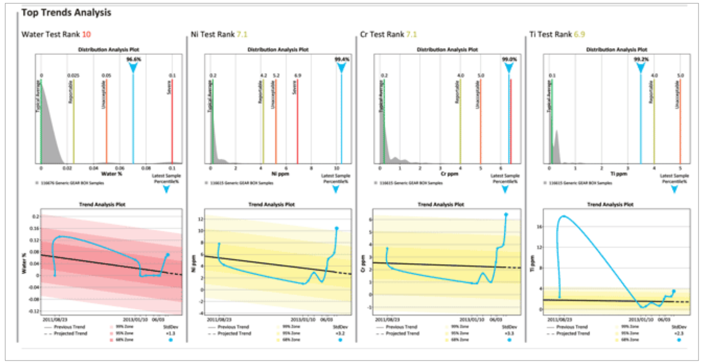


Image source: www.machinerylubrication.com

Expected failure modes: best practices for each technology

Hints & tips from successful users:

#1 Problem: Use one tool to measure everything

Solution:
Focus on the expected failure modes and match the right tools based on best practice

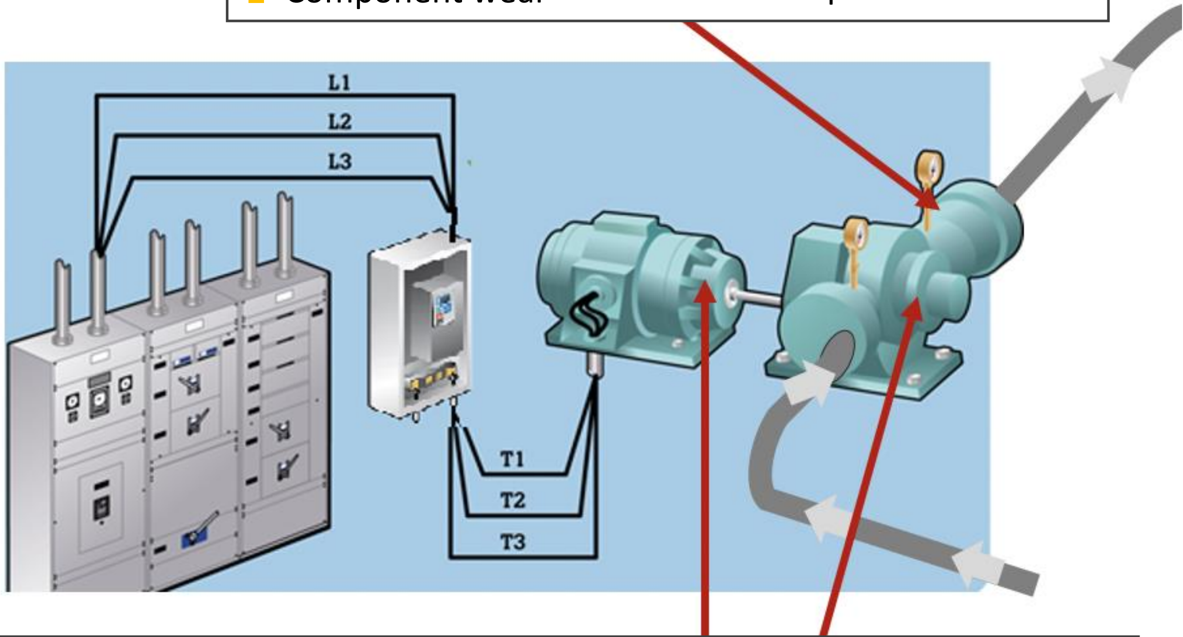
Think about your assets holistically:

- Electricity in and work out
- Every link in the chain is a potential failure and some links lie outside the physical "machine"

Smart tools protect each link in the chain

Oil – best for faults on oil-cooled components

- Lubrication breakdown
- Component wear
- Overheating
- Wear particles



Vibration – best for mechanical faults on rotating machines

- Misalignment
- Resonance/structure
- Component faults
- Gear / belt faults
- Shaft imbalance
- Cavitation / turbulence
- Looseness
- Balancer
- Bad bearings
- Laser shaft alignment
- Laser belt alignment
- Speed / timing issues

Motor testing: failure modes

Electrical condition monitoring to prolong the life of motors
Motor testing is divided into two categories

1 Energized – operating

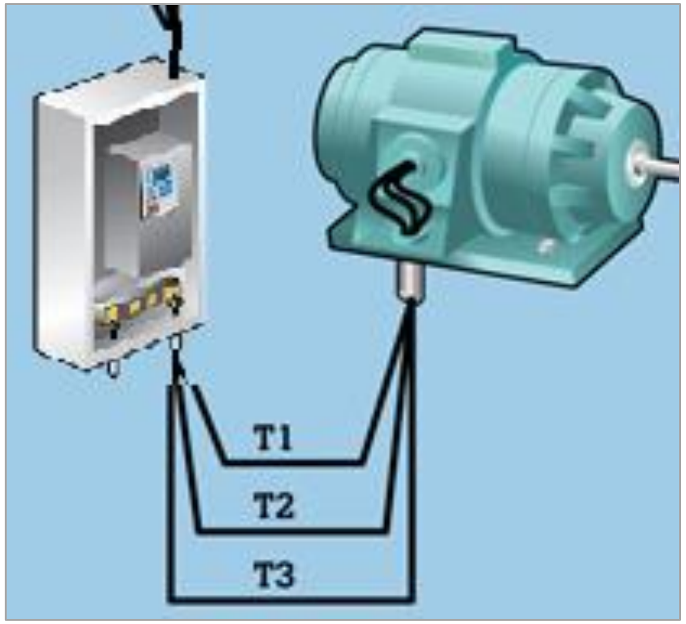
Tests may include:

- Insulation testing
- Motor current / starting current
- Motor circuit spectrum analysis
- Power factor
- Harmonic distortion

2 De-energized – circuit is de-energized

Tests may include:

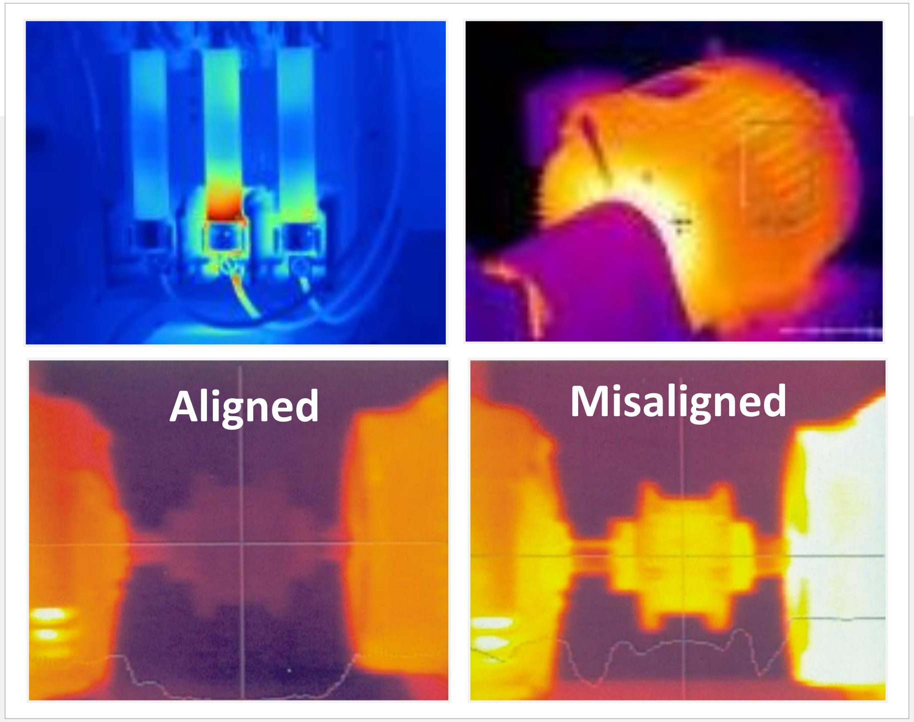
- Surge testing
- Hi pot testing
- Megohmmeter
- Motor circuit analysis

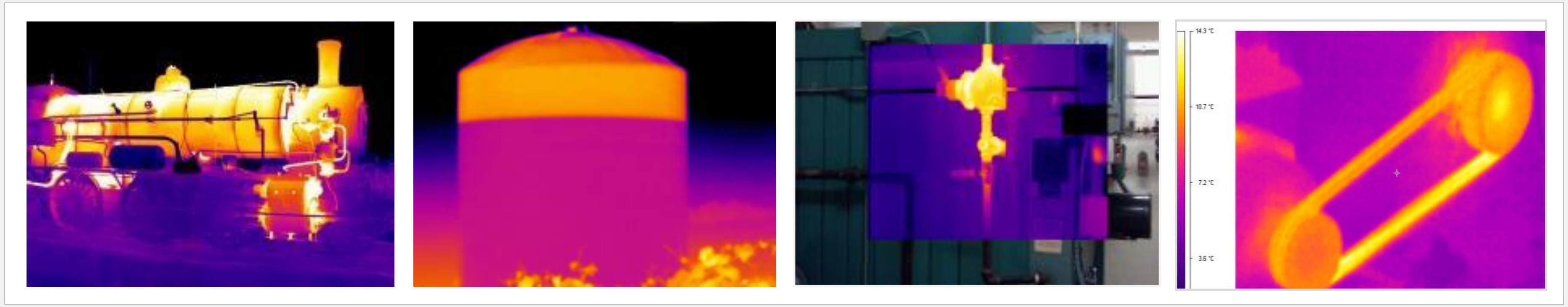


Thermography: failure modes

Best for finding electrical hots spots and supports severe mechanical faults

- Electrical – faulty connections in panels, fuses, motors
- Mechanical – shafts, components
- Process – tanks, pipes, steam traps
- Other – anything

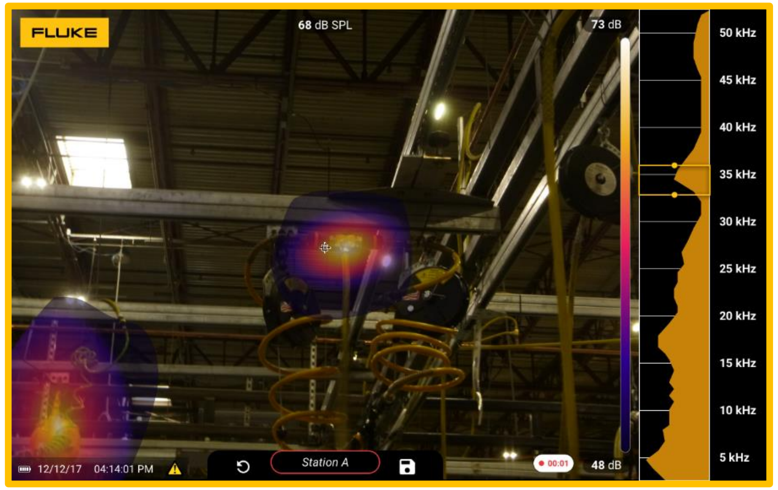




Ultrasound: failure modes

Need to find root cause of the problem – fix the root cause don't just fix the symptom

- Keeping air compressors running for important systems is critical to production
- Maintenance teams spend far too much time working and worrying about air systems
- Most teams just repair the compressors because finding leaks takes too much time
- Compressed air is expensive – largest source of energy waste in manufacturing



1. Find leaks – air, refrigerant, gas, ammonia
2. Valve actuator problems
3. Steam trap problems
4. Find bearings that need lubrications (too early for bearing replacement)
5. Electrical safety hazards – is it safe to open a panel
6. Tank tightness checks

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Expected failure modes: best practices for each technology

Summary

Match the best tool / technology to the expected failure mode

Think about your assets holistically - power in and work out

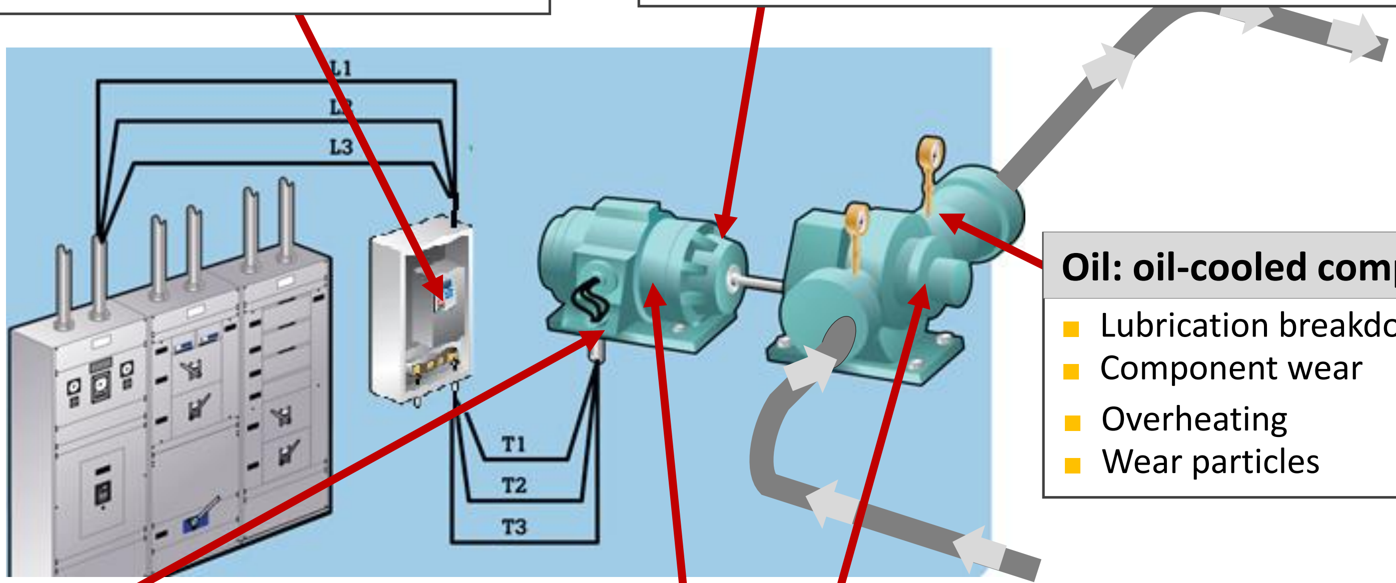
Combine technologies to protect each link in the chain

Thermography – high temp

- Find electrical hot spots
- Process / operations issues
- Support serious mech faults

Ultrasound – air leaks, lubrication

- Find leaks
- Valve actuator problems
- Bearings need lubrication
- Stem trap problems
- Tank tightness
- Electrical safety hazards



Oil: oil-cooled components

- Lubrication breakdown
- Component wear
- Overheating
- Wear particles

Motor testing: motor problems

Energized:
- Current testing / MCSA /
- PF and Harmonic Distortion

De-energized:
- Motor insulation degradation
- Hi Pot, Surge, Megohmmeter

Vibration: best for mechanical faults on rotating machines

- Misalignment
- Resonance/structure
- Component faults
- Gear / belt faults
- Shaft imbalance
- Cavitation / turbulence
- Looseness
- Balancer
- Bad bearings
- Laser shaft alignment
- Laser belt alignment
- Speed / timing issues

POLL QUESTION No. 2

What measurement methods are you using?

(Click as many as apply)

- Vibration monitoring/analysis
- Ultrasound
- Thermography
- Oil analysis
- Electrical testing

Questions

Questions

QUESTIONS?

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Thank you!

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Next webinar Oct. 14: Actually implementing a change

BEST PRACTICE WEBINAR | Wednesday, Oct. 14, 11 a.m. ET

Actually implementing a change

Lean management, Six Sigma, process reengineering, root cause analysis, and other disciplines all provide methods for identifying changes required to move a business forward. But the biggest challenge has long been implementing those improvements identified. Organizations continue to struggle with this. Implementation comes down to individual leaders influencing their direct reports at each level to infuse essential changes.

In this webinar, leadership expert **Tom Moriarty**, an author and longtime Plant Services magazine columnist, outlines three proven steps for executives to successfully implement needed change at their organization.

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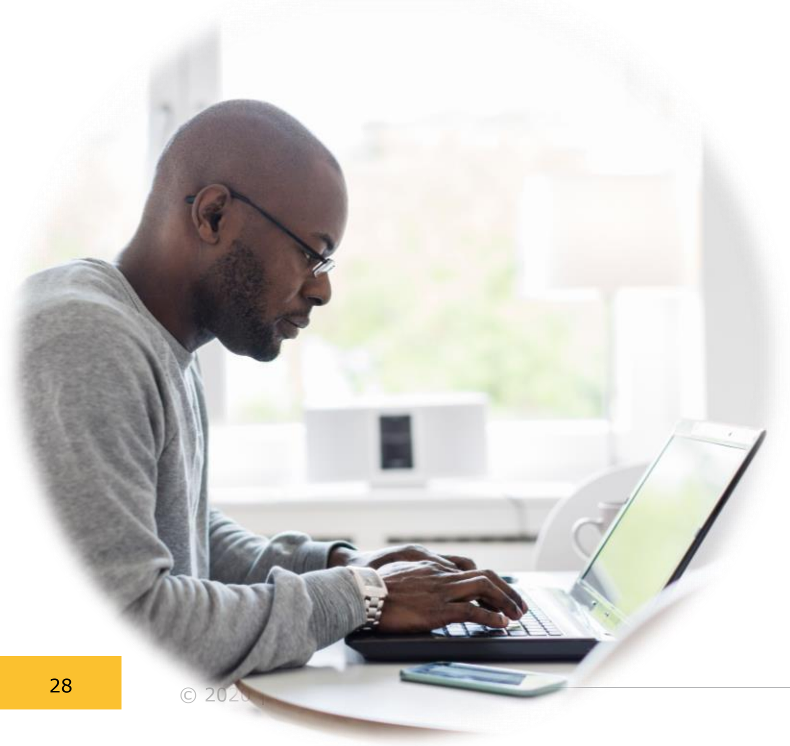

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