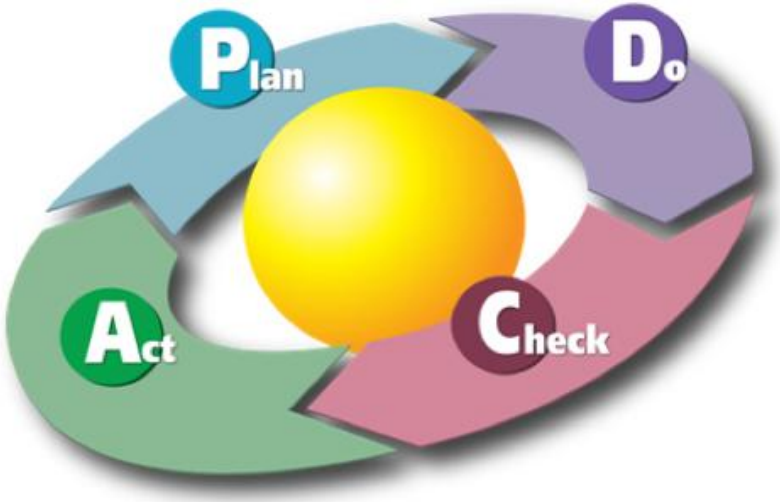
FANUC



Date : 01/ 10 / 2017
Presenter: Vrishabhendra

Ajay Sensors, Bengaluru

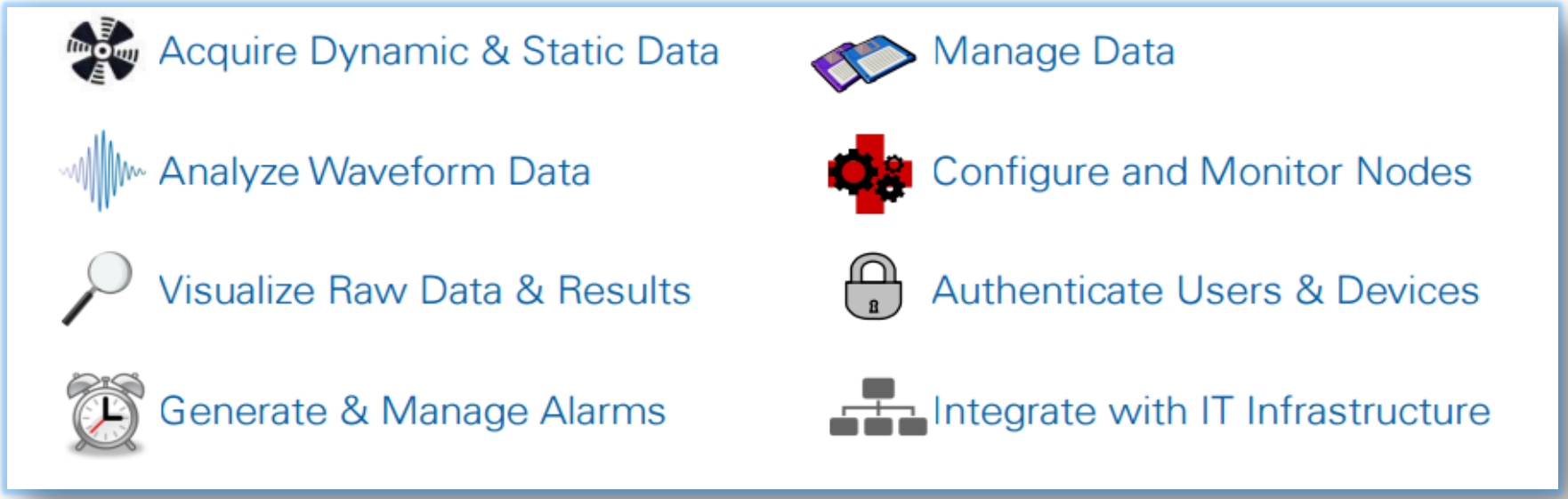
* General / Confidential

"Ajay Sensors" Enterprise software suite

A deployment software solution with tightly integrated hardware options for online condition monitoring that allows companies to gain insight into the health of rotating machinery for operations and maintenance programs.

Condition Monitoring for Industrial and Rotating Equipment

Maintenance, operations, and reliability engineers and technicians rely on condition monitoring and predictive maintenance techniques to ensure critical equipment such as turbines, generators, pumps, compressors, and motors operate more efficiently and last longer. Electrono Enterprise Software platform will help to monitor the health and condition of fleetwide equipment and processes to ensure the reliability and efficient operation of rotating and industrial equipment.



Assess Your Condition Monitoring Needs

- Organizations today are being forced to maintain their assets to improve reliability. Failure to implement a maintenance program that addresses that need increases the possibility of catastrophic failure and production loss. As today's aging assets are being relied on to continue their production output and new technology is becoming more complex, expensive, and difficult to maintain, organizations are looking for a new way forward. Are you ready for the next generation of condition monitoring? Answer these questions to see.

What is your current maintenance mix?

- Organizations today have a multitude of maintenance strategies available from letting the asset fail to performing scheduled maintenance to weaving data and analytics into business intelligence systems in order to predict and handle issues before they become catastrophic. Does the ability to implement a remote, scalable, fleet wide predictive maintenance program seem out of reach for you?

- **Are you analyzing all the asset health data you collect?**

- A study by the International Data Corporation (IDC) showed that only five percent of digital data is actually analyzed. This corresponds with the significant increase in the possibility of missing an important asset health event. Does your condition monitoring solution give you the tools to generate actionable information from your assets when issues are discovered and manage the data you are collecting?

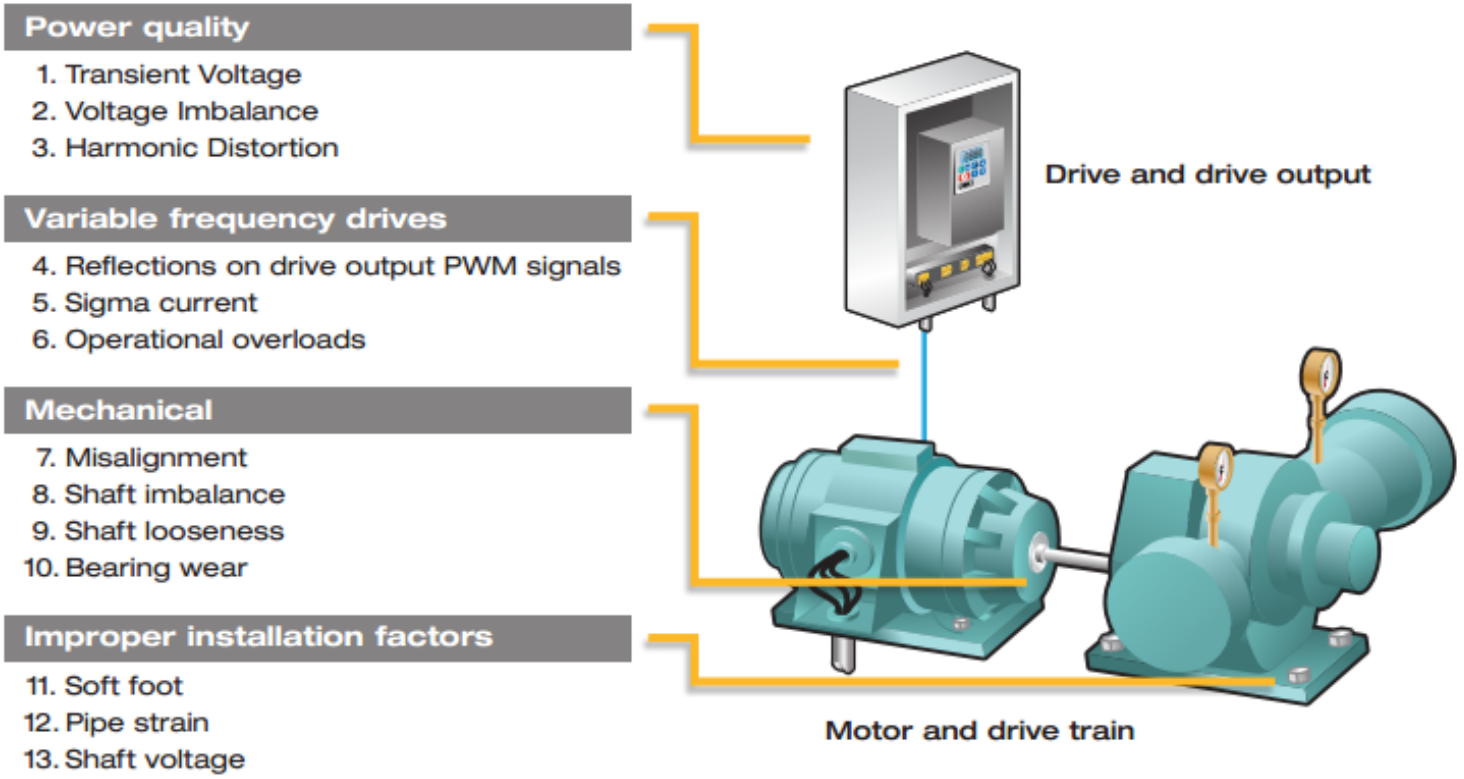
- **Are your maintenance specialists undergoing change?**

- It is becoming increasingly difficult to locate, hire, and train new equipment specialists. On top of that, many equipment specialists are spending upwards of 80 percent of their time collecting condition health data from assets and 20 percent analyzing this data. Do you have a plan in place to provide your equipment specialists with high-value tasks that can have a measurable impact on the organization?

- **As your condition monitoring needs change, can your technology evolve?**

- Organizations add more assets when they are at capacity and need to grow. The condition monitoring technology needs to scale alongside this growth and continue to acquire and provide actionable data. In addition, new assets are becoming more complex and new sensing technologies may be needed to monitor these assets. Does your condition monitoring solution scale and interoperate with new or existing equipment as your business or needs changes?

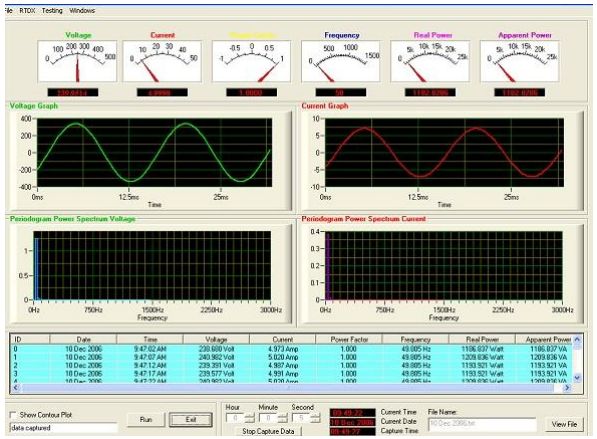
What to look for and how to improve asset uptime Motors are used everywhere in industrial environments and they are becoming increasingly complex and technical, sometimes making it a challenge to keep them running at peak performance. It's important to remember that the causes of motor and drive issues are not confined to a single domain of expertise–both mechanical and electrical issues can lead to motor failure–and being armed with the right knowledge can mean the difference between costly downtime and improved asset uptime. Winding insulation breakdown and bearing wear are the two most common causes of motor failure, but those conditions arise for many different reasons. This article demonstrates how to detect the 13 most common causes of winding insulation and bearing failure in advance



Power Quality

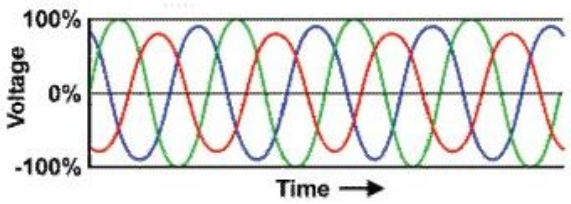
1 Transient voltage

Transient voltages can come from a number of sources either inside or outside of the plant. Adjacent loads turning on or off, power factor correction capacitor banks or even distant weather can generate transient voltages on distribution systems. These transients, which vary in amplitude and frequency, can erode or cause insulation breakdown in motor windings. Finding the source of these transients can be difficult because of the infrequency of the occurrences and the fact that the symptoms can present themselves in different ways. For example, a transient may appear on control cables that don't necessarily cause equipment damage directly, but may disrupt operations



Impact: Motor winding insulation breakdown leads to early motor failure and unplanned downtime
Instrument to measure and diagnose: Electrono Three-Phase Power Quality
Analyzer Criticality: High

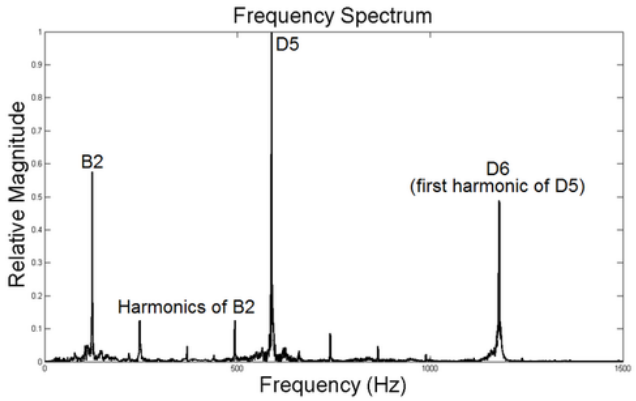
2 Voltage imbalance



Three-phase distribution systems often serve single-phase loads. An imbalance in impedance or load distribution can contribute to imbalance across all three of the phases. Potential faults may be in the cabling to the motor, the terminations at the motor, and potentially the windings themselves. This imbalance can lead to stresses in each of the phase circuits in a three-phase power system. At the simplest level, all three phases of voltage should always have the same magnitude.

Impact: Imbalance creates excessive current flow in one or more phases that then increases operating temperatures–leading to insulation breakdown
Instrument to measure and diagnose: Electrono Three-Phase Power Quality DAQ
Criticality: Medium

3 Harmonic distortion



Simply stated, harmonics are any unwanted additional source of high frequency AC voltages or currents supplying energy to the motor windings. This additional energy is not used to turn the motor shaft but circulates in the windings and ultimately contributes to internal energy losses. These losses dissipate in the form of heat, which, over time, will deteriorate the insulation capability of the windings. Some harmonic distortion of the current is normal on any part of the system serving electronic loads. To start investigating harmonic distortion, use a power quality analyzer to monitor electrical current levels and temperatures at transformers to be sure that they are not overstressed. Each harmonic has a different acceptable level of distortion, which is defined by standards such as IEEE 519-1992.

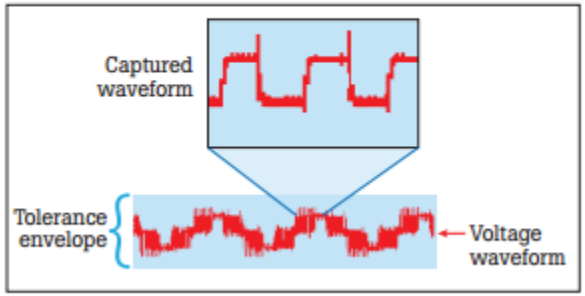
Impact: Decrease in motor efficiency results in added cost and an increase in operating temperatures

Analyzer Criticality: Medium

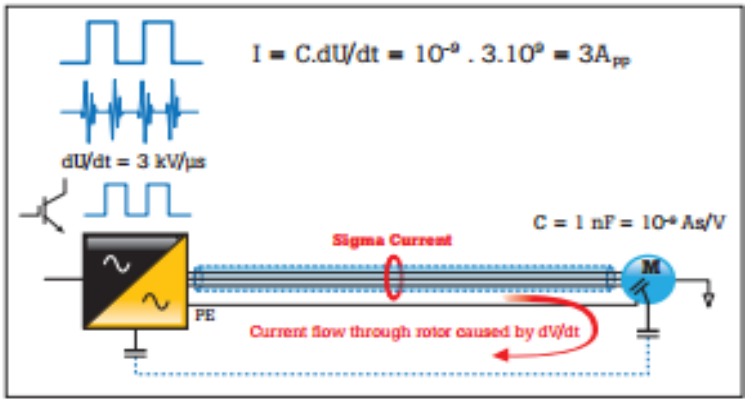
4 Reflections on drive output PWM signals

Variable frequency drives employ a pulse width modulation (PWM) technique to control the output voltage and frequency to a motor. Reflections are generated when there is an impedance mismatch between the source and load. Impedance mismatches can occur as a result of improper installation, improper component selection or equipment degradation over time. In a motor drive circuit, the peak of the reflection could be as high as the DC bus voltage level. Impact: Motor winding insulation breakdown leads to unplanned downtime.

Criticality: High



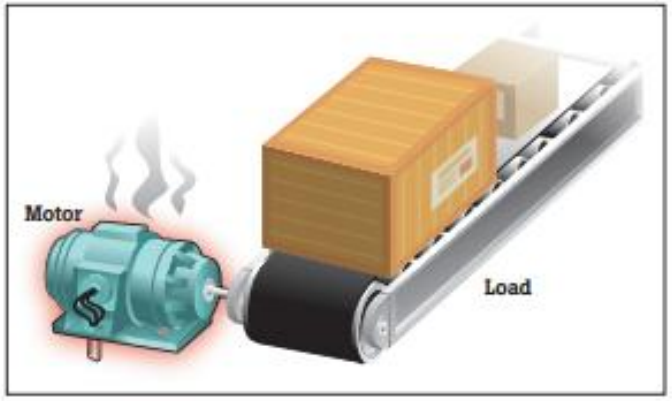
5 Sigma current



Sigma currents are essentially stray currents that circulate in a system. The sigma currents are created as a result of the signal frequency, voltage level, capacitance and inductance in conductors. These circulating currents can find their way through protective earth systems causing nuisance tripping or in some cases excess heat in windings. Sigma current can be found in the motor cabling and is the sum of the current of the three phases at any one point in time. In a perfect situation, the sum of the three currents would equal zero. In other words, the return current from the drive would be equal to the current to the drive. Sigma current can also be understood as asymmetrical signals in multiple conductors that can capacitive couple currents into the ground conductor. Impact: Mysterious circuit trip due to protective earth current flow

6 Operational overloads

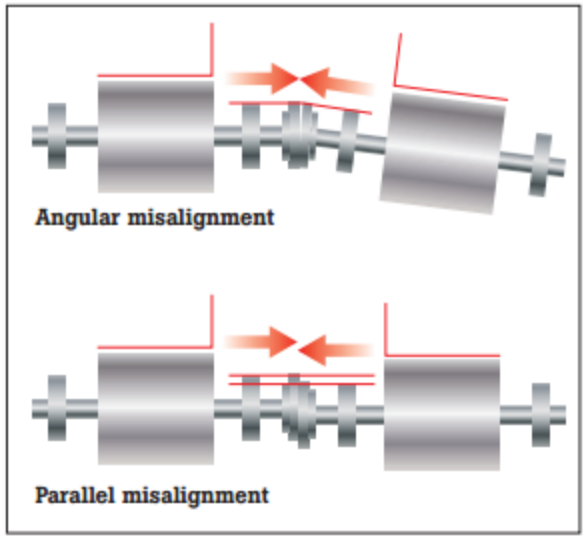
Motor overload occurs when a motor is under excessive load. The primary symptoms that accompany a motor overload are excessive current draw, insufficient torque and overheating. Excessive motor heat is a major cause of motor failure. In the case of an overloaded motor individual motor components including bearings, motor windings, and other components may be working fine, but the motor will continue to run hot. For this reason, it makes sense to begin your troubleshooting by checking for motor overload. Because 30 % of motor failures are caused by overloading, it is important to understand how to measure for and identify motor overloading. Impact: Premature wear on motor electrical and mechanical components leading to permanent failure
Criticality: High



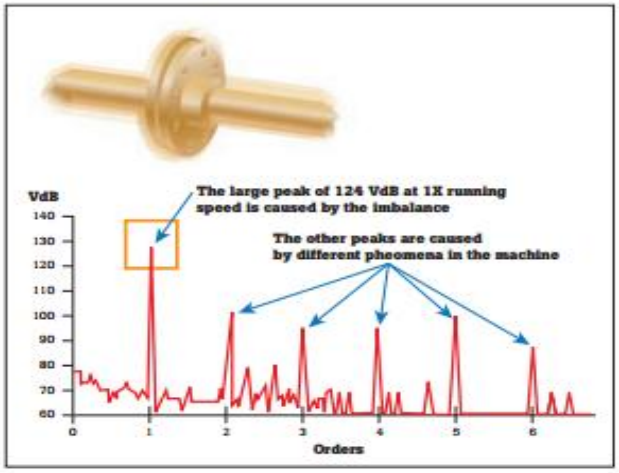
7 Misalignment

Misalignment occurs when the motor drive shaft is not in correct alignment with the load, or the component that couples the motor to the load is misaligned. Many professionals believe that a flexible coupling eliminates and compensates for misalignment, but a flexible coupling only protects the coupling from misalignment. Even with a flexible coupling, a misaligned shaft will transmit damaging cyclical forces along the shaft and into the motor, leading to excess wear on the motor and increasing the apparent mechanical load. In addition, misalignment may feed vibration into both the load and the motor drive shaft. There a few types of misalignment: • Angular misalignment: shaft centrelines intersect but are not parallel • Parallel misalignment: shaft centrelines are parallel but not concentric • Compound misalignment: a combination of parallel and angular misalignment. (Note: almost all misalignment is compound misalignment, but practitioners talk about misalignment as the two separate types because it is easier to correct a misalignment by addressing the angular and parallel components separately.) Impact: Premature wear in mechanical drive components that leads to premature failures

Criticality: High



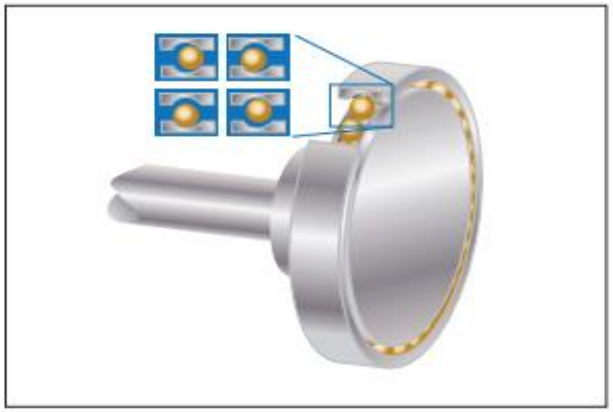
8 Shaft imbalance



Imbalance is a condition of a rotating part where the centre of mass does not lie on the axis of rotation. In other words, there is a "heavy spot" somewhere on the rotor. Although you can never completely eliminate motor imbalance, you can identify when it is out of normal range, and take action to rectify the problem. Imbalance can be caused by numerous factors, including: • Dirt accumulation • Missing balance weights • Manufacturing variations • Uneven mass in motor windings and other wear-related factors. A vibration tester or analyzer can help you determine whether or not a rotating machine is in balance. Impact: Premature wear in mechanical drive components that leads to premature failures

Criticality: High

9 Shaft looseness



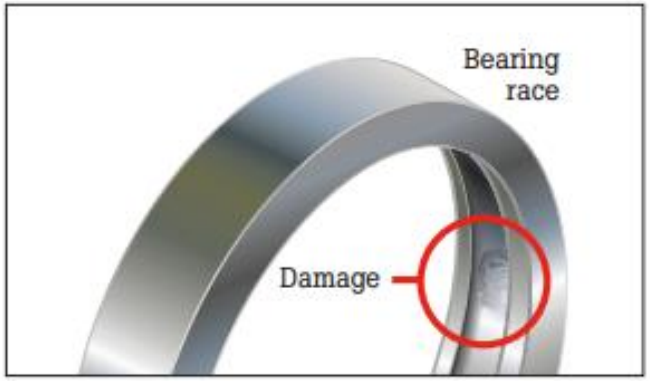
Looseness occurs when there is excessive clearance between parts. Looseness can occur in several places: • Rotating looseness is caused by excessive clearance between rotating and stationary elements of the machine, such as in a bearing. • Non-rotating looseness happens between two normally stationary parts, such as a foot and a foundation, or a bearing housing and a machine. As with all other sources of vibration, it is important to know how to identify looseness and resolve the issue to avoid losing money. A vibration tester or analyzer can determine whether or not a rotating machine is suffering from looseness. Impact: Accelerated wear on rotating components resulting in mechanical

Criticality: High

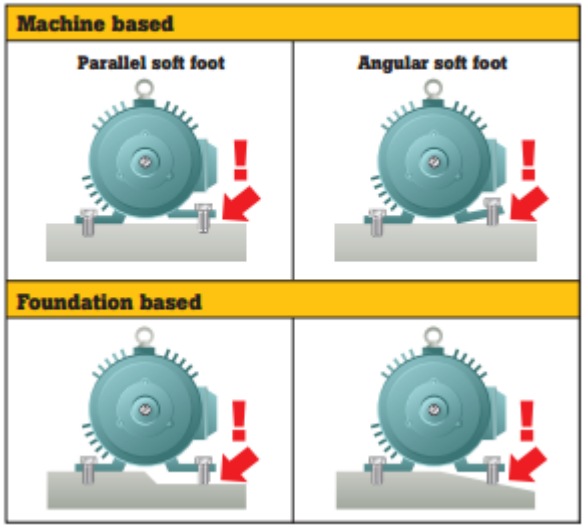
10 Bearing wear

- A failed bearing has increased drag, emits more heat, and has lower efficiency because of a mechanical, lubrication, or wear problem. Bearing failure can be caused by several things: A heavier load than designed for Inadequate or incorrect lubrication Ineffective bearing sealing • Shaft misalignment • Incorrect fit • Normal wear • Induced shaft voltages Once bearing failure begins, it also creates a cascade effect that accelerates motor failure. 13 % of motor failures are caused by bearing failure, and more than 60 % of the mechanical failures in a facility are caused by bearing wear, so learning how to troubleshoot this potential problem is important. Impact: Accelerated wear on rotating components resulting in bearing failure

Criticality: High



11 Soft foot

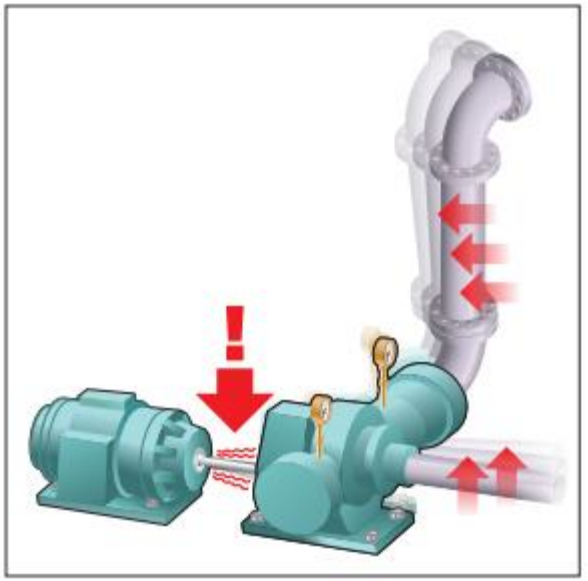


Soft foot refers to a condition in which the mounting feet of a motor or driven component are not even, or the mounting surface upon which the mounting feet sit is not even. This condition can create a frustrating situation in which tightening the mounting bolts on the feet actually introduces new strains and misalignment. Soft foot is often manifested between two diagonally positioned mounting bolts, similar to the way that an uneven chair or table tends to rock in a diagonal direction. There are two kinds of soft foot: • Parallel soft foot—parallel soft foot occurs when one of the mounting feet sits higher than the other three • Angular soft foot—angular soft foot occurs when one of the mounting feet is not parallel or "normal" to the mounting surface. In both cases, soft foot can be caused either by an irregularity in the machine mounting feet, or in the mounting foundation upon which the feet rest. In either case, any soft foot condition must be discovered and remedied before proper shaft alignment can be achieved. A quality laser alignment tool can typically determine whether or not there is a soft foot problem on a particular rotating machine. Impact: Misalignment of mechanical unit

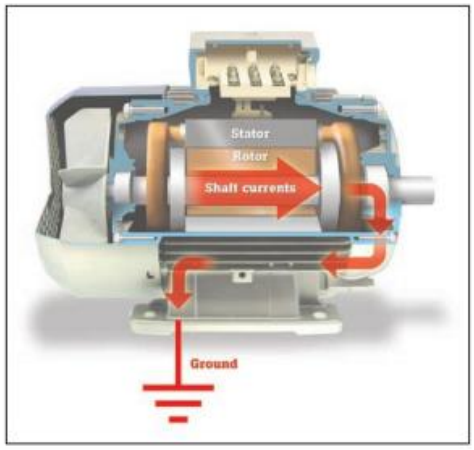
Criticality: Medium

12 Pipe strain

- Pipe strain refers to the condition in which new stresses, strains, and forces, acting on the rest of the equipment and infrastructure transfer backward onto the motor and drive to induce a misalignment condition. The most common example of this is in simple motor/pump combinations, where something applies force to the pipeworks such as: • A shift in the foundation • A newly installed valve or other component • An object striking, bending, or simply pressing on a pipe • Broken or lack-of pipe hangers or wall-mounting hardware Those forces can put an angular or offset force on the pump, which in turn causes the motor/pump shaft to be misaligned. For this reason it is important to check machine alignment more than just at the time of installation–precision alignment is a temporary condition that can change over time. Impact: Shaft misalignment and subsequent stresses on rotating components, leading the premature failures. Instrument to measure and diagnose:
- **Criticality: Low**



13 Shaft voltage



When motor shaft voltages exceed the insulating capability of the bearing grease, flashover currents to the outer bearing will occur, thereby causing pitting and grooving to the bearing races. The first signs of this problem will be noise and overheating as the bearings begin to lose their original shape and metal fragments mix with the grease and increase bearing friction. This can lead to bearing destruction within a few months of motor operation. Bearing failure is an expensive problem both in terms of motor repair and downtime, so helping to prevent this by measuring shaft voltage and bearing current is an important diagnostic step. Shaft voltage is only present while the motor is energized and rotating. A carbon brush probe attachment allows you to measure shaft voltage while a motor is rotating. Impact: Arcing across bearing surfaces create pitting and fluting resulting in excessive vibration and eventual bearing failure Instrument to measure and diagnose:

Criticality: High

Four strategies for success Motor control systems are being utilized in critical processes throughout manufacturing plants. Equipment failure can result in high monetary losses both from potential motor, or parts, replacement and from equipment downtime for the system the motor powers. Arming maintenance engineers and technicians with the right knowledge, prioritizing workload and managing preventative maintenance to monitor equipment and troubleshoot intermittent, elusive problems can, in some cases, avoid failures due to normal system operating stresses and reduce overall downtime costs. There are four key strategies that you can undertake to restore or prevent premature failures in motor drive and rotating component: 1. Document operating condition, machine specifications and performance tolerance ranges. 2. Capture and document critical measurements at installation, before and after maintenance and on a routine basis. 3. Create an archive reference of measurements to facilitate trend analysis and identify change of state conditions. 4. Plot individual measurements to establish a baseline trend. Any change in trend line of more than +/- 10 % to 20 % (or any other % determined, based on your system performance or criticality) should be investigated to root cause to understand why the issue is occurring.

Preventive/Predictive Maintenance

Industrial Manufacturing Condition Monitoring

- Solutions for process and discrete manufacturing
- Steel mills, semiconductor fabs, consumer goods, and chemicals
- Platforms for portable and distributed monitoring and factory test

Heavy Equipment Condition Monitoring

- Solutions for mining, construction, and agriculture equipment
- Increased asset reliability to manage industry profitability constraints
- Monitoring of shovels, trucks, and other equipment

Transportation Condition Monitoring

- Solutions for rail, marine, and aerospace
- Distributed remote monitoring for mobile assets
- Integration of vibration and electrical power monitoring

Oil and Gas Condition Monitoring

- Solutions for extraction, pipelines, and refining
- Easy integration with a variety of sensors for turbomachinery monitoring
- Advanced software that provides powerful analysis functions such as order analysis and envelope detection

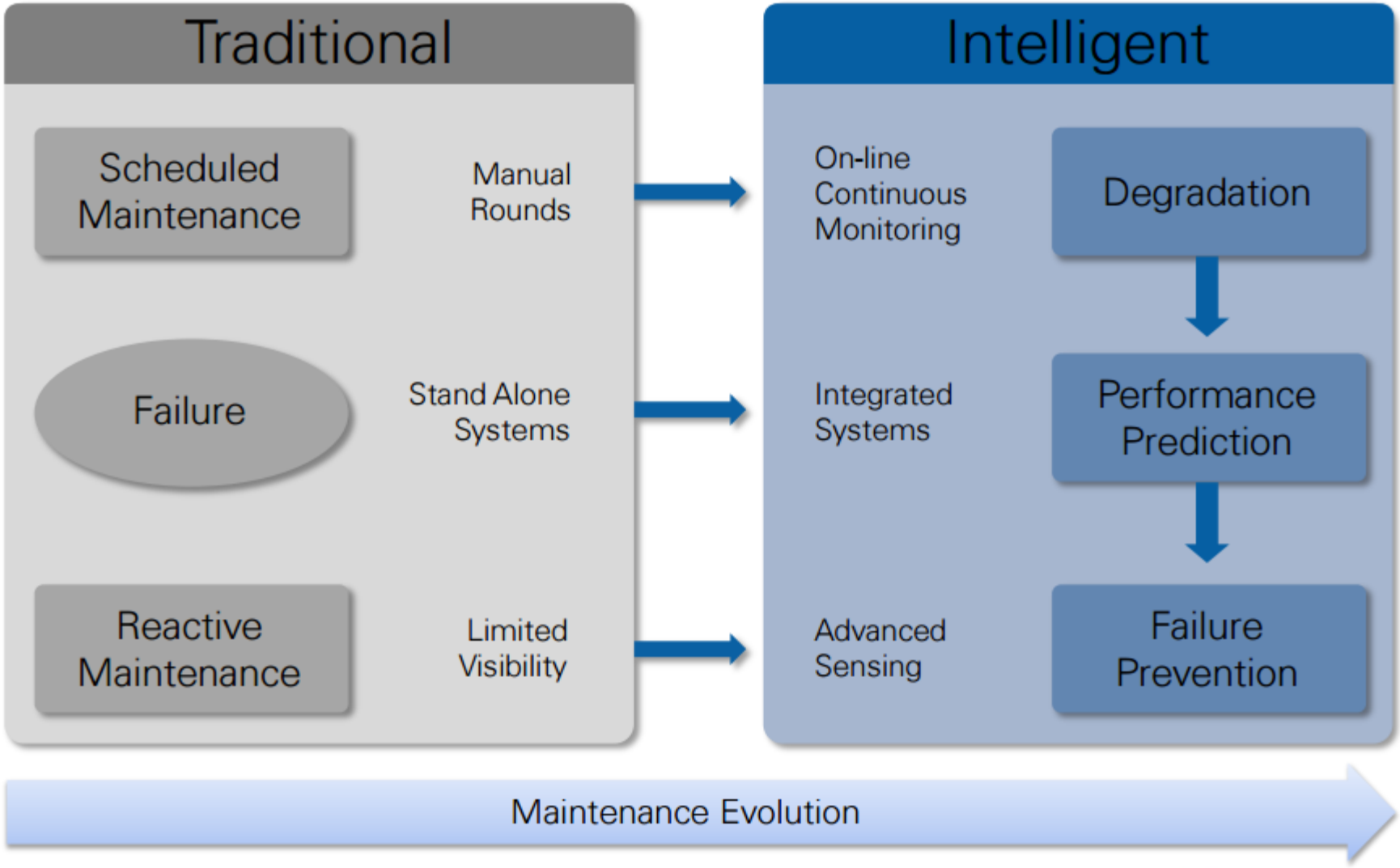
Wind Condition Monitoring

- Low cost of entry for up-tower, embedded, and online monitoring
- High-performance, high-channel-count systems for efficient dynamometer and factory assurance testing
- Embedded processing for real-time signal analysis, data logging, and control

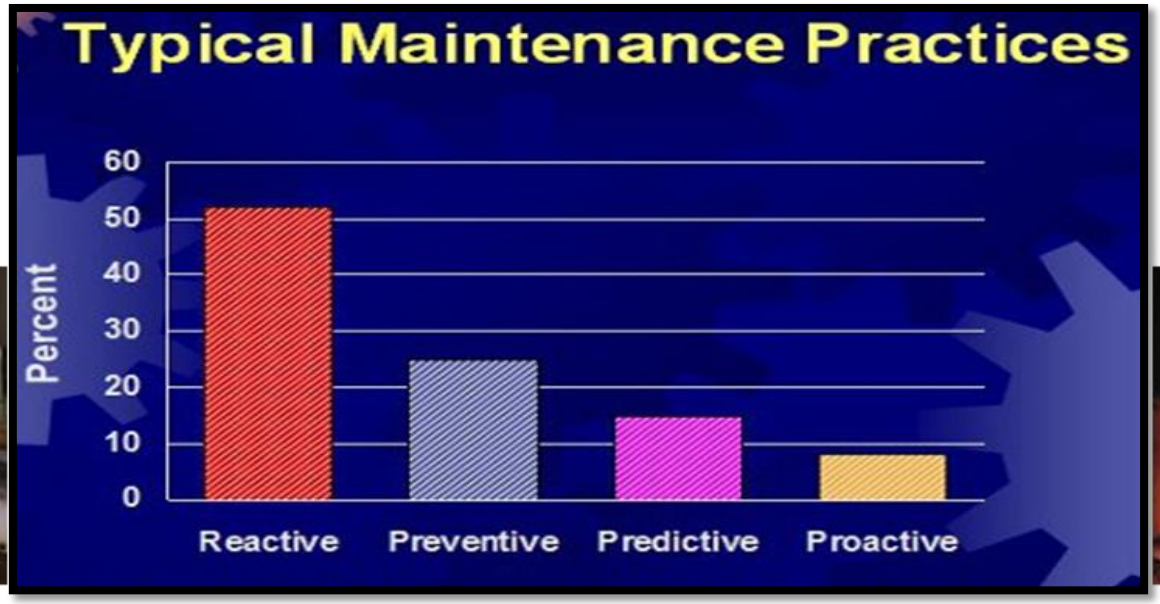
Power Generation

- Solutions for fossil, nuclear, and hydro power plants
- Monitoring for critical equipment and balance-of-plant assets
- Fleetwide diagnostics such as vibration to meet increasing reliability demands

Intelligent Maintenance Systems



Standard Approach to Machinery Diagnostics



60,000 rounds/month

Traditional Approach

- Labor intensive and inefficient
- Shrinking workforce
- People being sent into hazardous locations

Technical Features :

- **Description of features provided with Customized Software:**
- **MACHINE RUNNING STATUS :**
- Machine running status would be displayed for all the interconnected machines
- Layout of the production unit would be displayed as user friendly screen
- Option to print & export the report would be provided
- **OVERALL EQUIPMENT EFFICIENCY :**
- Report would be generated based on the last month, quarter, last 6 month or
- 1 year report.
- Option for capturing for the downtime would be provided
- Option to print & export the report would be provided
- **PM CHECK SCHEDULE VS STATUS:**
- Machine running hours report would be generated
- Report would be generated on monthly & yearly basis
- Option for capturing the Man-hrs based on configuration would be provided
- Activities(check points) for next 6 months should be arrived based on
- no.of.cycles/running hrs per day
- Option to print & export the report would be made available
- **CNC & PLC PARAMETER MONITORING:**
- Standard critical parameters that the MTB offers would be monitored & displayed
- Option to print & export the report would be made available

Enterprise software runs on Windows-based servers

Systems Management

- System health & status monitoring
- Deployment image management for large system counts
- Device Configuration

Security

- Secure communication
- User and device authentication
- User profile management

Data Analytics

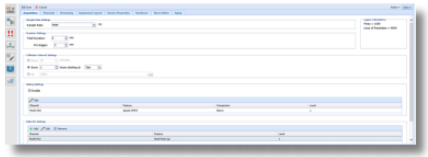
- specific data analytics & algorithms

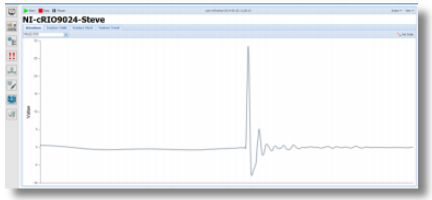
Data Management

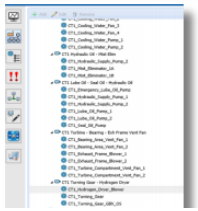
- Alarming
- Integration into 3rd party historians
- Data aging and storage rules

Systems Management Features

- Web Based Acquisition Node Configuration
  - Automatic module discovery
  - Template based configuration
- Web based test panels for commissioning support
- Equipment Layout definition page

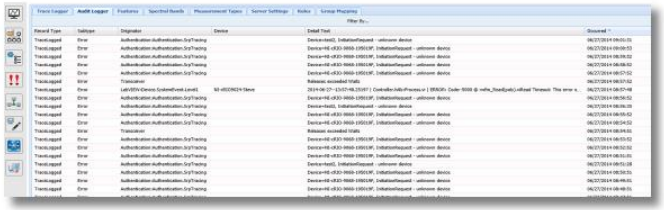


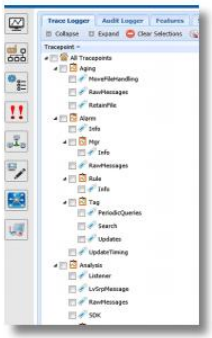




Systems Management Features

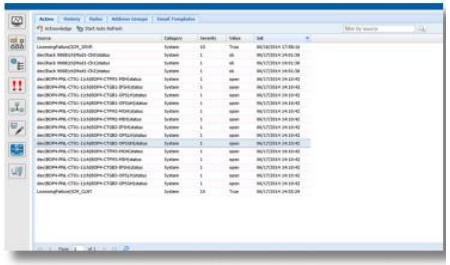
- Remotely update acquisition systems when enhanced capabilities are released
- Configuration management for firmware revisions
- IT system console
  - Logging of errors, messages, tracepoints
  - System configuration
  - Historian management

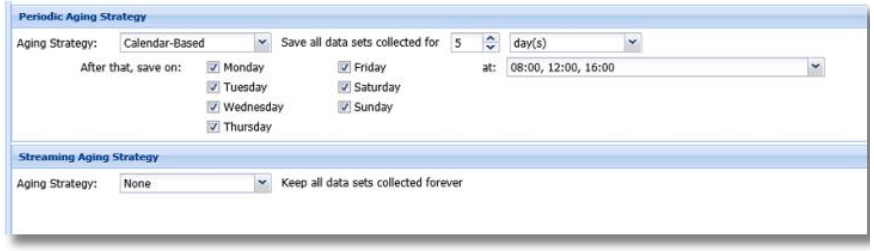




Data Management & Analytics Features

- Alarming Dashboard
- Data Historian Integration
- Aging of data to automatically reduce data





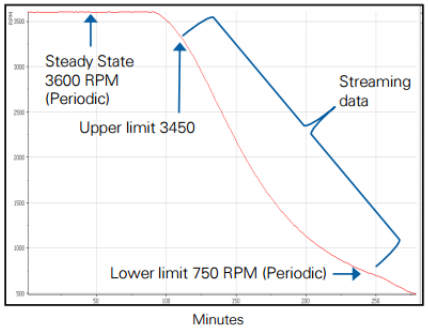
Monitoring Systems Functionality

Periodic & Event Recording

- Continuous monitoring with intelligent logging
- Various Triggering Modes: User Initiated, Time, and Operating conditions
- Gated Acquisition ensures collect data only when machine is in known state
- On board buffering to capture events leading up to event

Transient, Periodic & Event Recording

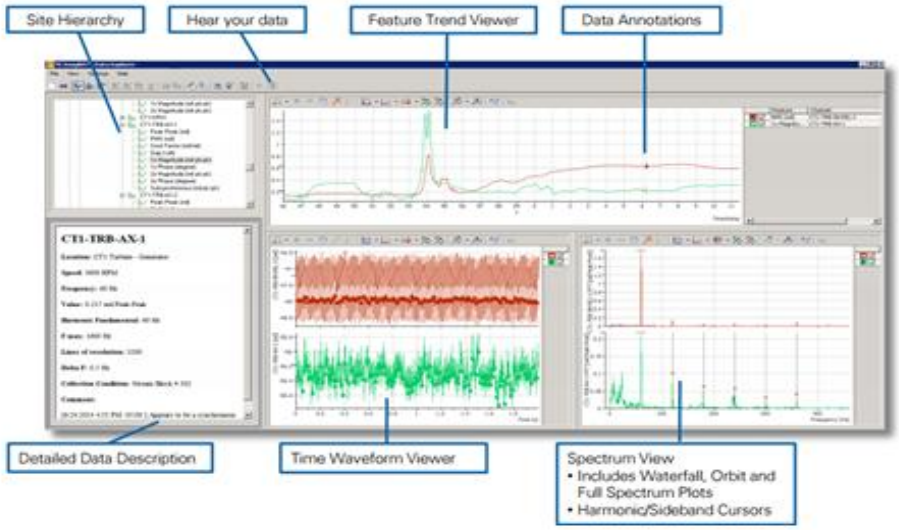
- Periodic & Event Recording functionality + automatic streaming of data



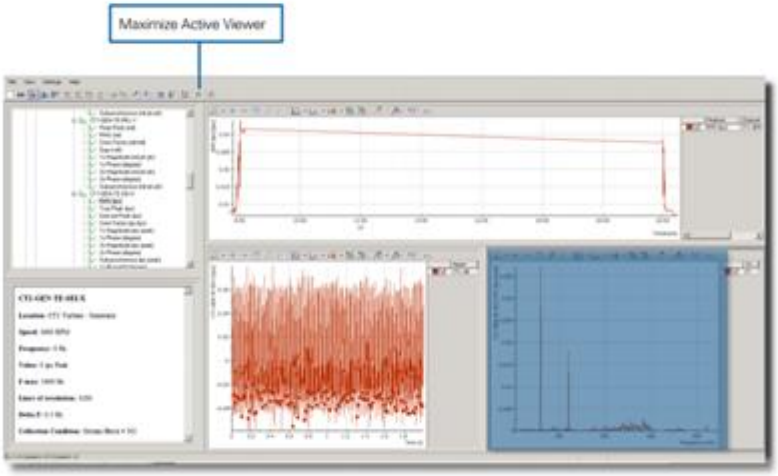
Gathering conclusions out of your data

Periodic Data Mode

Data Explorer



Gathering conclusions out of your data

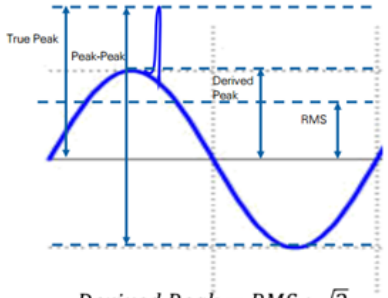


Common Causes Of Motor Failure

Pump Example

Analysis Features

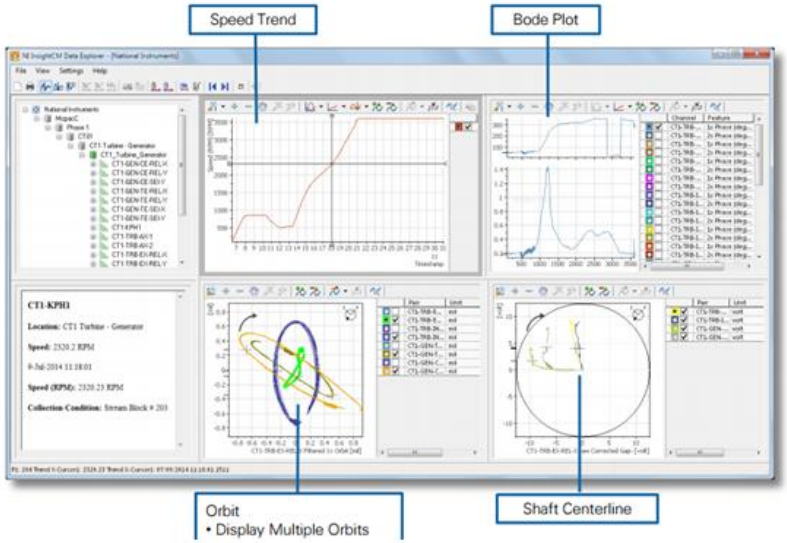
- RMS, Peak-Peak, True Peak, Derived Peak,
- DC Gap, Crest Factor
- Spectral Bands
  - 1x Mag/Phase
  - 2x Mag/Phase
  - High Frequency (1kHz→Fmax)
  - Subsynchronous (.2→.8 Orders)
  - Custom: Good for defining bearing fault frequencies (BPFO, BPFI, etc.)
- Integration/Differentiation
- English and Metric unit support

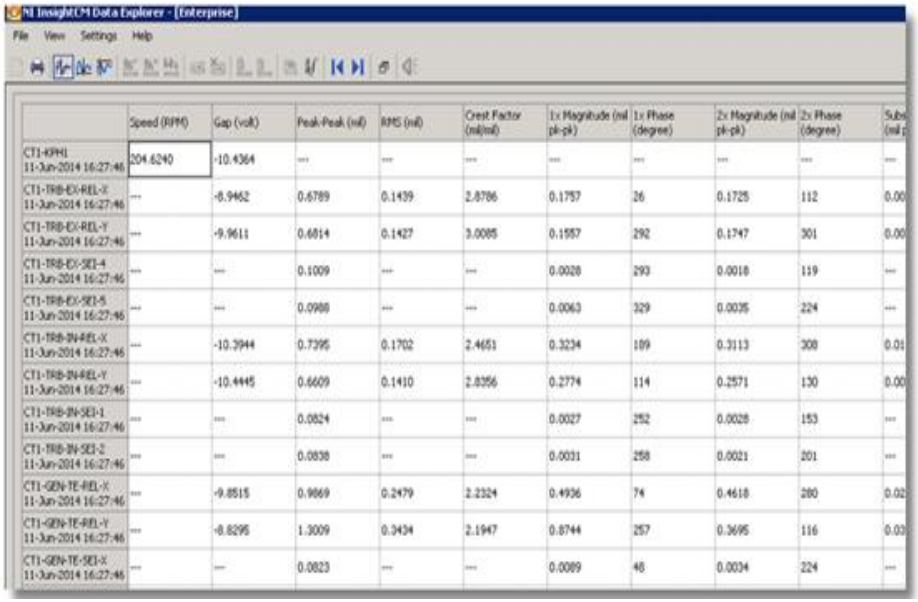


$$Derived\ Peak = RMS * \sqrt{2}$$

Gathering conclusions out of your data:

Data Explorer





Requirements

1) How CNC and PLC data could be integrated
2) How different FANUC controllers would be integrated – 0i, 35i, 31i
3) About screens – Monitoring screens – Custom screens with parameter details Temperature, Pressure, Load, etc
4) SAP integration about machine breakdowns
5) Graphs plotting for the data
6) Sitting in the existing line, data can be monitored for the New line too such as part count and production details

How CNC and PLC data could be integrated

- CNC data would be captured into the Machine Health Monitoring platform through CNC IoT tools such as MTLinki etc.
- Advanced PLCs that have communication feature and tools could be integrated into the Machine Health Monitoring platform accordingly
- PLCs with no communication features would be integrated at the Physical I/O layer into the Machine Health Monitoring platform
- The integration and collation of all these data from different sources would be done at the Machine Health Monitoring platform layer

How different FANUC controllers would be integrated – 0i, 35i, 31i

- For 0i F and 0i D model controllers

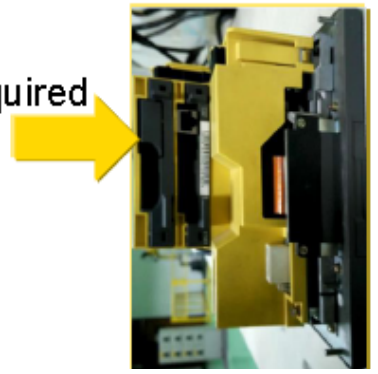
Hardware requirement in CNC side

0i-F – Machine Remote diagnostics is standard with Embedded Ethernet
0i-D – Machine Remote diagnostics is standard with Embedded Ethernet with below embedded Ethernet software version

In case of Series 0i-MODEL D

Software	Series	Edition
Embedded Ethernet software (Both are necessary.)	658E 658F	Edition 07 or later Edition 06 or later

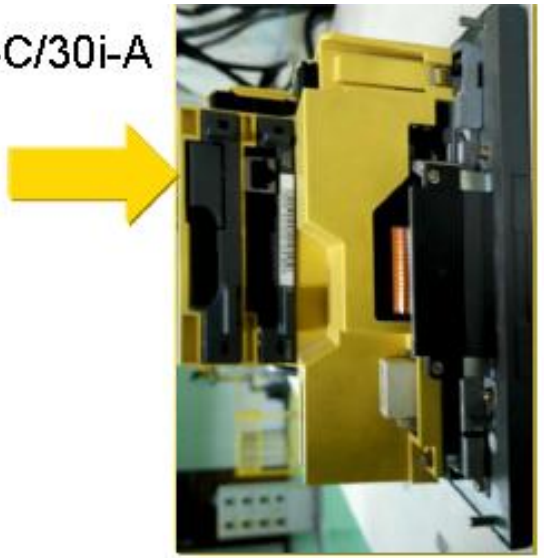
0i-B/C – Fast Ethernet Board is required and CNC with 2 slot is required



How different FANUC controllers would be integrated – 0i, 35i, 31i

- For 0i F and 0i D model controllers
  - Embedded Ethernet – Standard in 0i-F/0i-TD/0i-MD
  - FOCAS2 CD (A02B-0207-K737) for one time purchase which contain Library files

CNC with 2slot & Fast Ethernet is required for the 0i-B/0i-C/30i-A FS16i/18i/21i-A/B



- CNC with 2 slot
- Fast Ethernet Board
- Control software for Fast Ethernet
- Ethernet function (S707)

How different FANUC controllers would be integrated – 0i, 35i, 31i

- For 31i and 35i controllers

Connectable CNCs

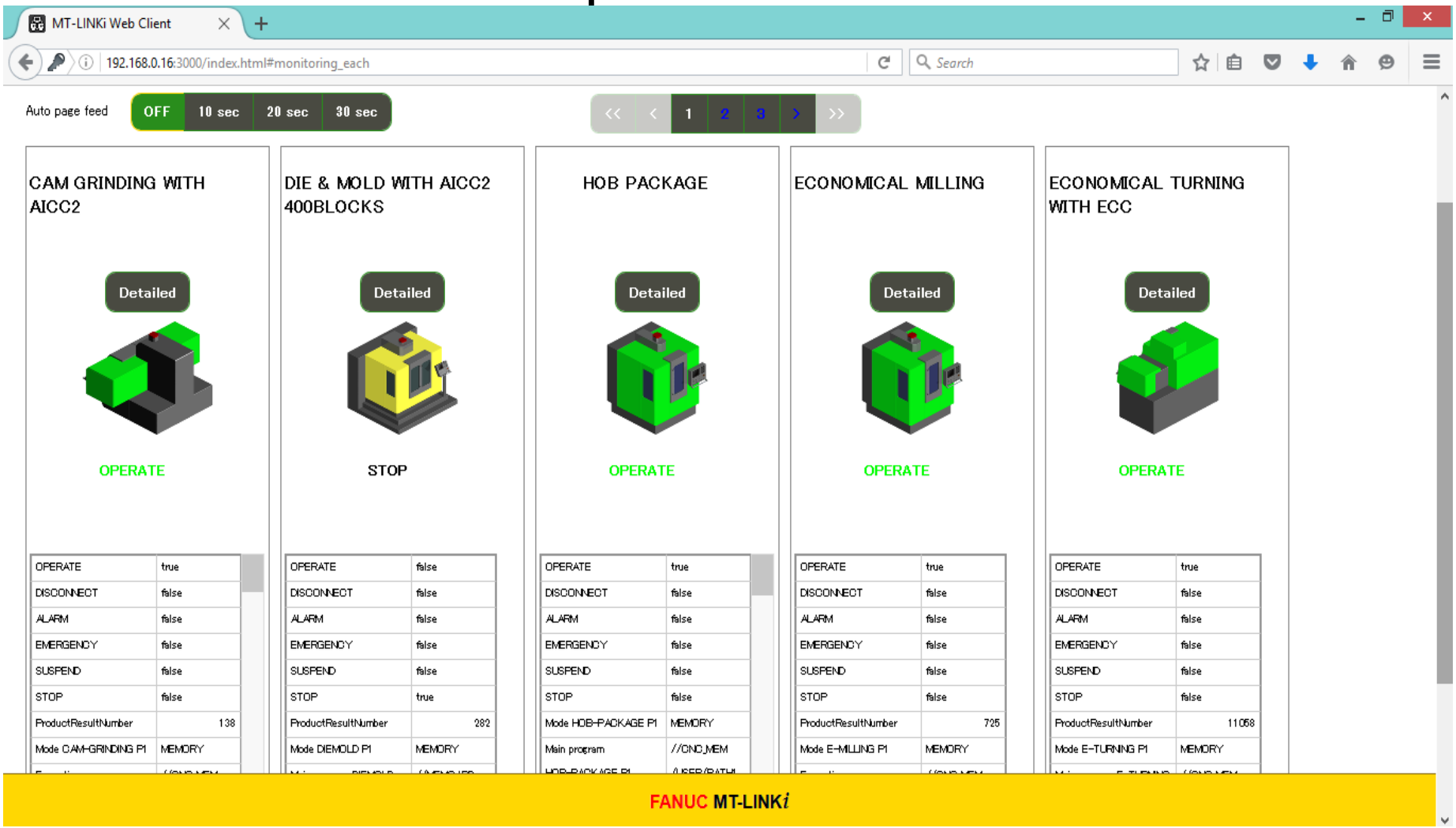
The following are connectable machines.

- CNC type
  - (1) FANUC Series 30*i* /31*i* /32*i* /35*i*-MODEL B
  - (2) FANUC Series 30*i* /31*i* /32*i*-MODEL A
  - (3) FANUC Power Motion *i*-MODEL A
  - (4) FANUC Series 0*i*-MODEL F
  - (5) FANUC Series 0*i*-MODEL D

One of these Ethernet is required.

- Ethernet type
  - (1) Embedded Ethernet by embedded Ethernet port (called "Embedded Ethernet" hereafter)
  - (2) Multifunctional Ethernet, Fast Ethernet board (called "Fast Ethernet" hereafter)

Monitoring screens – Custom screens with parameter details



Monitoring screens – Custom screens with parameter details

Monitoring screens – Custom screens with parameter details

Monitoring screens – Custom screens with parameter details

- Customized screens would be developed to address the specific requirements of the users
- Custom screens could include parametric information, production details, preventive maintenance related information and so on

SAP integration about machine breakdowns

- Data from the Machine Health Monitoring platform would be integrated into the SAP
- User to provide access to SAP platform accordingly

Report Generation

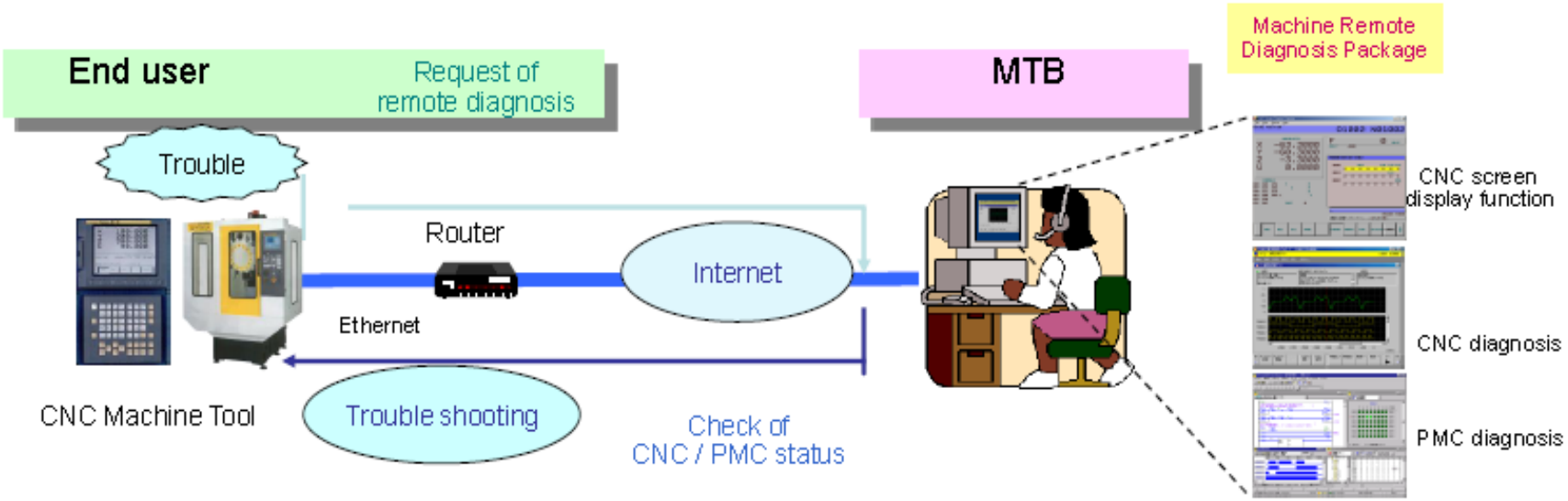
- Several report templates would be provided as default
- Further, user could define custom templates and the same would be built and provided to the user accordingly
- Report would consist of graphs, tables and notes
- Specific representations, if any, is required to be defined at the requirements stage and would be addressed accordingly

Machine Remote Monitoring and Diagnosis

- As in the case specified, the user could monitor a distant plant infrastructure from a centralized location
- The Remote monitoring and diagnosis feature helps the user to assess the status of each of the machines in distant locations and prepare themselves accordingly

Machine Remote Diagnosis

- Tool supporting remote diagnosis of machine by Machine Tool Builders
- Checking CNC/PMC status by remote operation for trouble-shooting of machine



Possible to check exact situation of machine by remote operation for trouble-shooting without visiting end users

- Reduces time to recover
- Allows MTB efficient field service activities

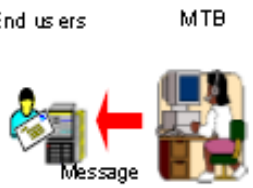
Machine Remote Diagnosis

Features

- **Enhanced diagnosis function**
  - CNC Dual screen display function (option)
  - Message transmitting function
  - Enhanced waveform diagnosis function
  - Improved operability of PMC diagnosis
- **Supports various network protocol**
  - Supports DNS (Domain Name System), DHCP (Dynamic Host Configuration Protocol)
  - Supports high-speed internet (ADSL,ISDN)
- **Supports diversity of CNC**
  - Series 30*i*/31*i*/32*i*-B, 0*i*-D, 0*i*-F

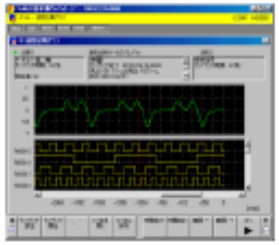
CNC screen display function

Message transmitting function



- Sends Max. 10 lines (400 characters)
- Receives 4 kinds of answers

Waveform diagnosis function



- Simultaneous sampling of servo-wave and machine signals
- Variable sampling cycle
- Max. 2 hours of sampling

Web Server and Status Notification

Machine troubles can be found early by using Intranet with free communication expenses

Patent pending

CNC Status Notification function

CNC Status (alarm, number of machined parts) is notified with e-mail

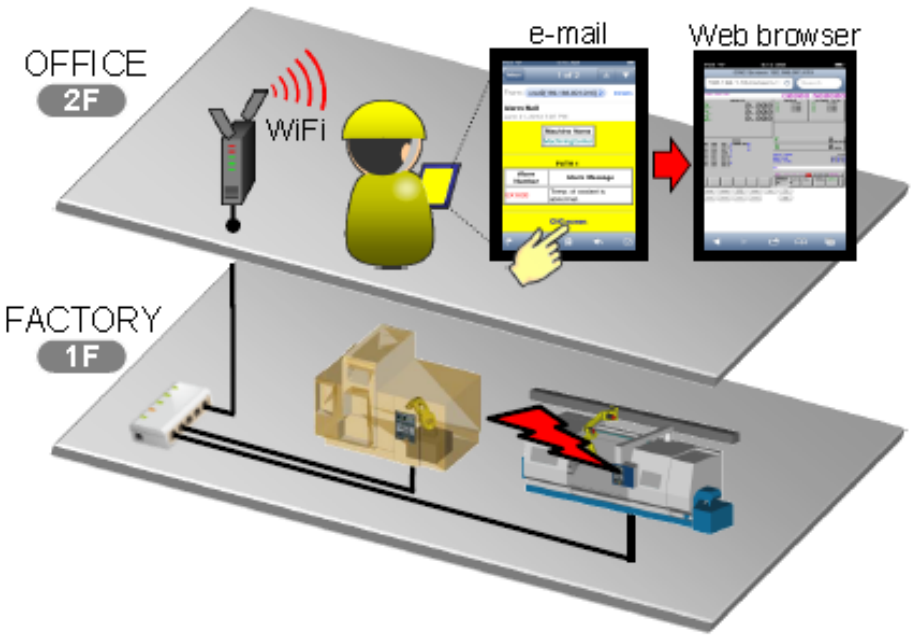
(CNC option : A02B-03xx-R975)

Patented

CNC Screen Web server function

The CNC screen can be displayed on the Web browser of Tablet-type device

(CNC option : A02B-03xx-R728)



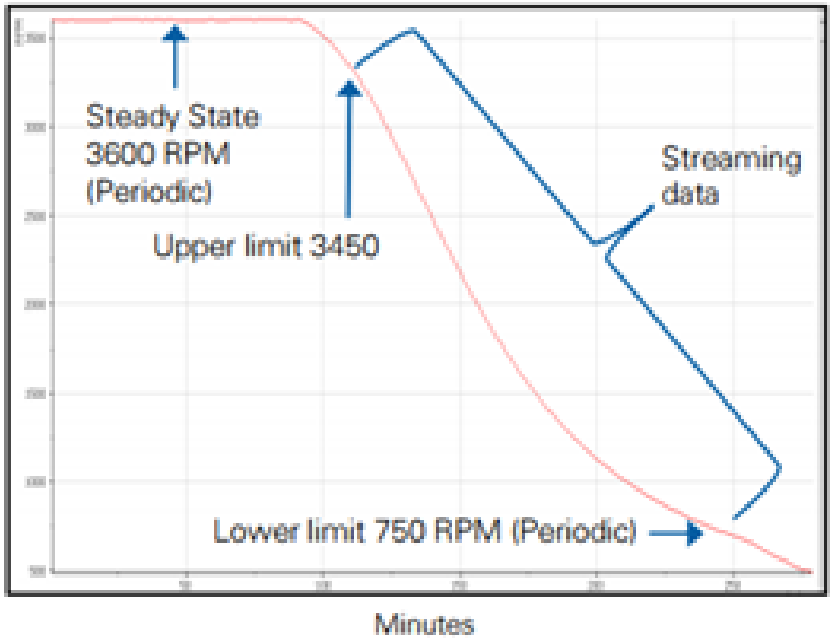
MT Link i features page

MT Link i Alarm monitoring

EquipmentName	Date of occurrence	Time of occurrence	Alarm level	Alarm number	Alarm type	Alarm message	Machine name
MULTIPATH31iModel-B	19-07-2016	08:30:43	4	197	PS	PATH2 C-AXIS COMMANDED IN SPINDLE MODE	FS31I-BMULTIPATH

Transient, Periodic & Event Recording Systems

- Periodic & Event Recording System + Transient Capabilities
- Support for accelerometers, velocity, and proximity probe (including up to 3 Keyphasor®) sensors
- Can utilize Buffered Outputs from common protection systems
- Larger on-board hard-drive for locally storing transient/streaming events



Thank You

* General / Confidential