ISA Delhi Section

Setting the Standard for Automation™

FERTILISER MEET 2016
Machine Condition Monitoring for Fertilizer Plants & its Engineering Interfaces

Sanjay Dehran, PK Midha
Fluor, India

Standards
Certification
Education & Training
Publishing
Conferences & Exhibits

The International Society of Automation Delhi Section

Introduction

- Fertilizer production continues to increase as food producers struggle to keep pace with our ever expanding population.
- There is increased pressure for capacity utilization & in fact incentives to produce beyond.
- To run the plant with zero defects has become an inevitable concept in order to achieve maximum productivity. This is possible, only if the equipment is used to maximum of its efficiency without any break down.
- This brings the focus on having state-of-the-art condition monitoring techniques that can be used in an effective manner to avoid the breakdown of equipment or to predict any possible failure for taking timely preventive action.

Machine Monitoring, Why ?

- Condition monitoring systems have evolved significantly over the last 10 years. They now offer more powerful monitoring functions for earlier fault detection and more reliable diagnostics, and they are also more flexible, intelligent and easier to use. This results in reduced machinery life cycle costs and increased production.
- Machinery condition monitoring of rotating equipments is an important facet in modern maintenance. Avoiding unscheduled downtime of these equipments is critical to maintain corporate competitiveness.
- Fertilizer plants have variety of rotating equipments from Vital, Essential, critical depending upon the criticality in the process. These equipments are mainly spread in Urea, Ammonia, Utilities/Offsite & Captive Power Plant.

Machine Monitoring in a Fertilizer Plant

MCM Pyramid for Rotating Machines in Fertilizer Plant

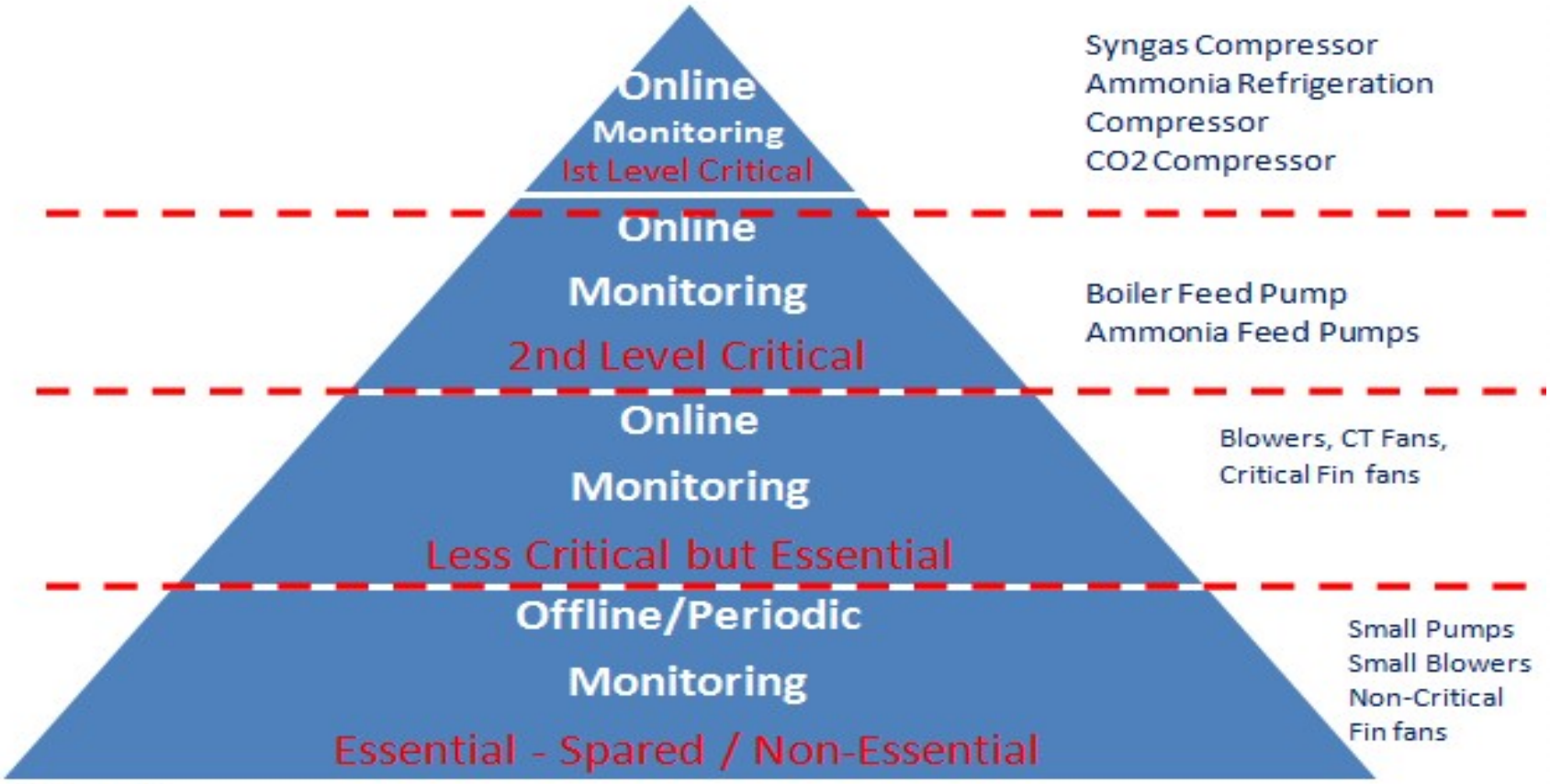
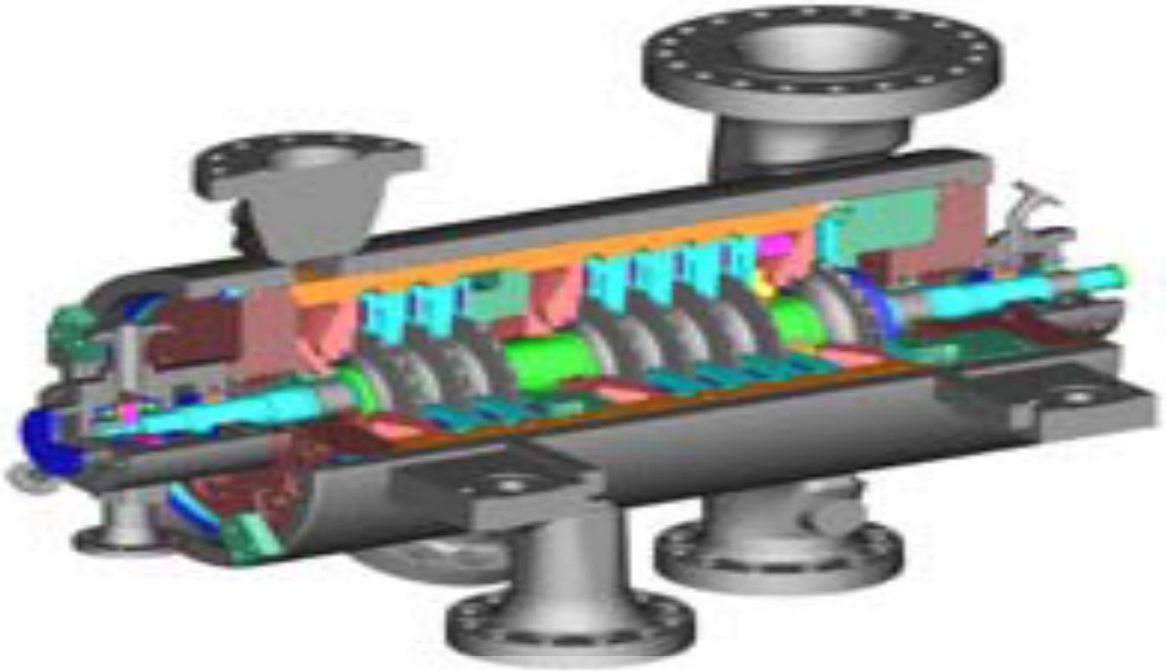


Figure-1

Machine Condition Monitoring Requirements for different Machines

- As discussed above, Fertilizer plants have some big compressors, turbines & critical pumps so the paper will mainly focus on these.
- In compressors, we have mainly Centrifugal, Reciprocating compressors & some integrally geared compressors are used for process air in some cases & condition monitoring for this is not very different from centrifugal compressors.
- Boiler feed pumps & ammonia feed pumps also have similar condition monitoring requirements as that Centrifugal compressors.
- Blowers, CT Fans & Critical Fin fans have fewer sensors for online monitoring & most such equipments are managed offline.

Centrifugal Compressor



In a Centrifugal Compressor, energy is transferred from a set of rotating impeller blades to the gas.

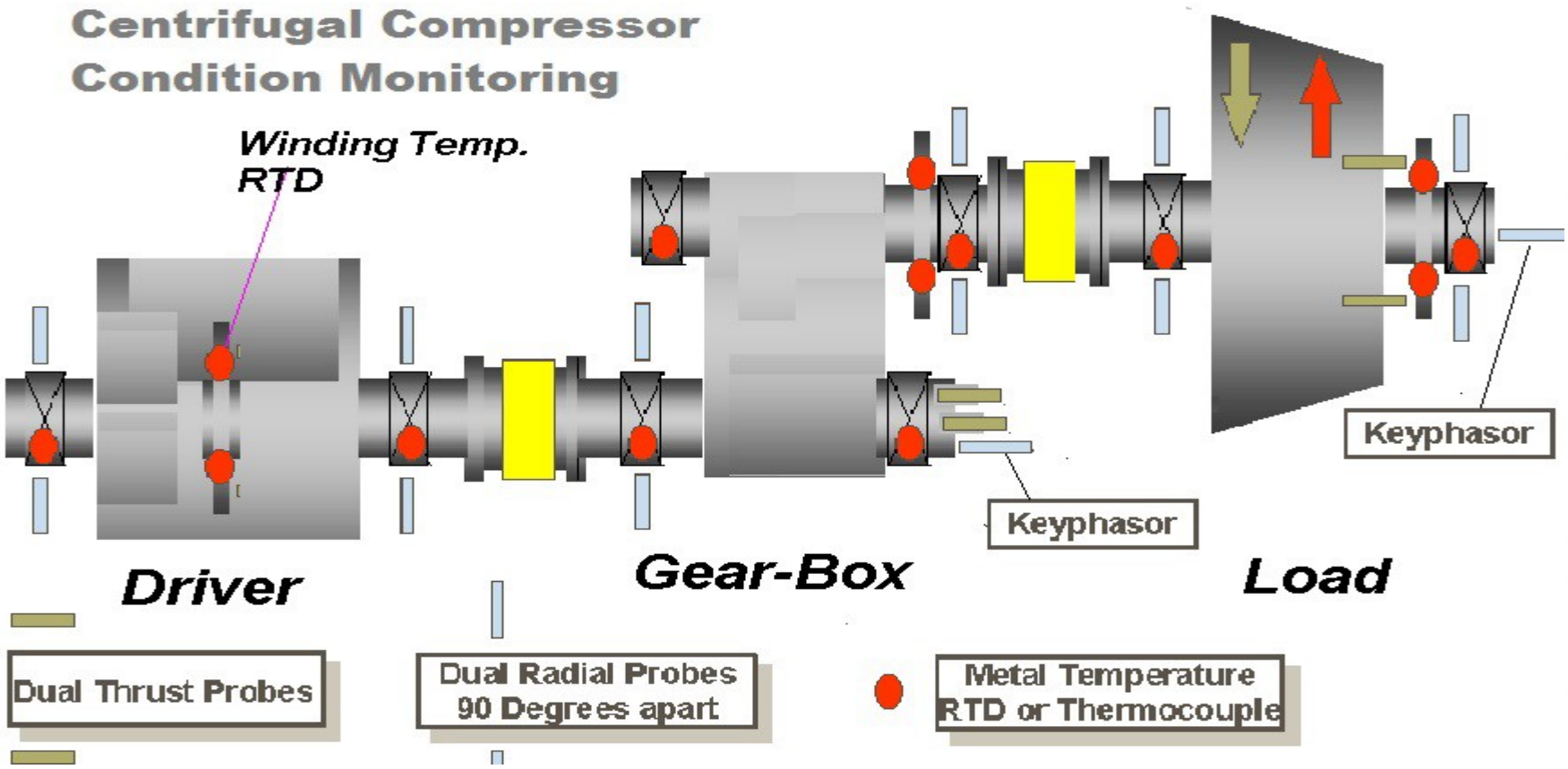
The designation “centrifugal” implies that the gas flow is radial, and the energy transfer is caused from a change in the centrifugal forces acting on the gas. Centrifugal compressors deliver high flow capacity per unit of installed space and weight, have good reliability, and require significantly less maintenance than reciprocating compressors.

Centrifugal Compressor API Standards

- **API 617 standard specifies minimum requirements and gives recommendations for axial** compressors, single-shaft and integrally geared process **centrifugal** compressors, and expander compressors for special purpose applications that handle gas or process air in the petroleum, chemical, and gas industries. Clause 5.5 defines the Controls & Instrumentation part. Clause 5.5.1 & 5.5.2 provide important details for machine condition monitoring.

- **API 670 standard covers the minimum requirements for a machinery protection system (MPS)** measuring radial shaft vibration, casing vibration, shaft axial position, shaft rotational speed, piston rod drop, phase reference, over speed, surge detection, and critical machinery temperatures (such as bearing metal and motor windings). It covers requirements for hardware (transducer and monitor systems), installation, documentation, and testing.

Centrifugal Compressor…
MCM at a Glance



Centrifugal Compressor…
MCM Details

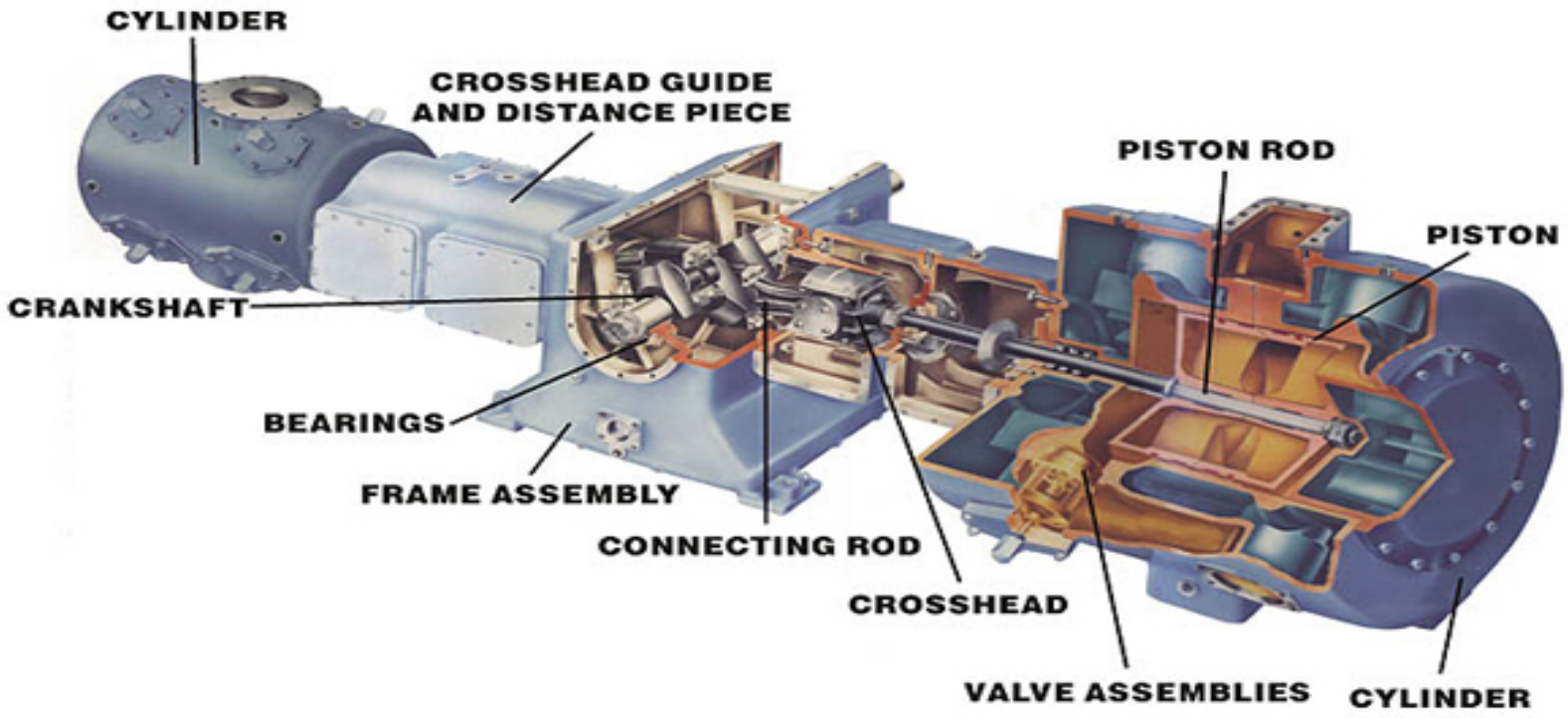
Radial Vibration: It's generally a Proximitor probe connected to the appropriate system hardware e.g. Bently Nevada racks via BN 3500/40M or 42M Proximitor monitor with channels configured for radial vibration. Radial shaft vibration is monitored with orthogonal X/Y paired proximity sensors.
Thrust Position / Axial Displacement: It's generally a Proximitor probe connected to the appropriate system hardware e.g. Bently Nevada racks via BN 3500/40M or 42M Proximitor monitor with channels configured for Thrust position. API 670 Section 7.4.2 covers this consideration in detail. API 670 makes an allowance for end users to choose single logic (one-out-of-two or 1oo2) for axial position shutdown based on needs and preferences.
Main Bearing Temperature: Simple temp. RTD from the bearing connected to the appropriate system hardware e.g. Bently Nevada racks BN temperature monitor. This helps in identifying overload or lubrication problems.
Thrust Bearing Temperature: Simple temp. RTD from the bearing connected to the appropriate system hardware e.g. Bently Nevada racks BN temperature monitor. This helps in identifying overload or lubrication problems.

Centrifugal Compressor…
MCM Details

Keyphasor: It's generally a Proximitor probe connected to the BN racks via appropriate system hardware e.g. Bently Nevada 3500/25 Keyphasor module. This module provides Keyphasor signals to the monitor modules in a 3500 rack. The Keyphasor signal provides a once-per-turn phase reference voltage pulse that is combined with vibration measurements to derive synchronous (1X, 2X, nX, etc.) amplitude and phase angle of vibration values. It is necessary for diagnostics and balancing, and is required by the System 1 condition monitoring platform.

Frame Vibration: It's generally a Velomitor (velocity transducer) connected to the appropriate system hardware e.g. Bently Nevada racks via BN impulse/velocity monitor. This is added generally on gear box cover.

Reciprocating Compressor



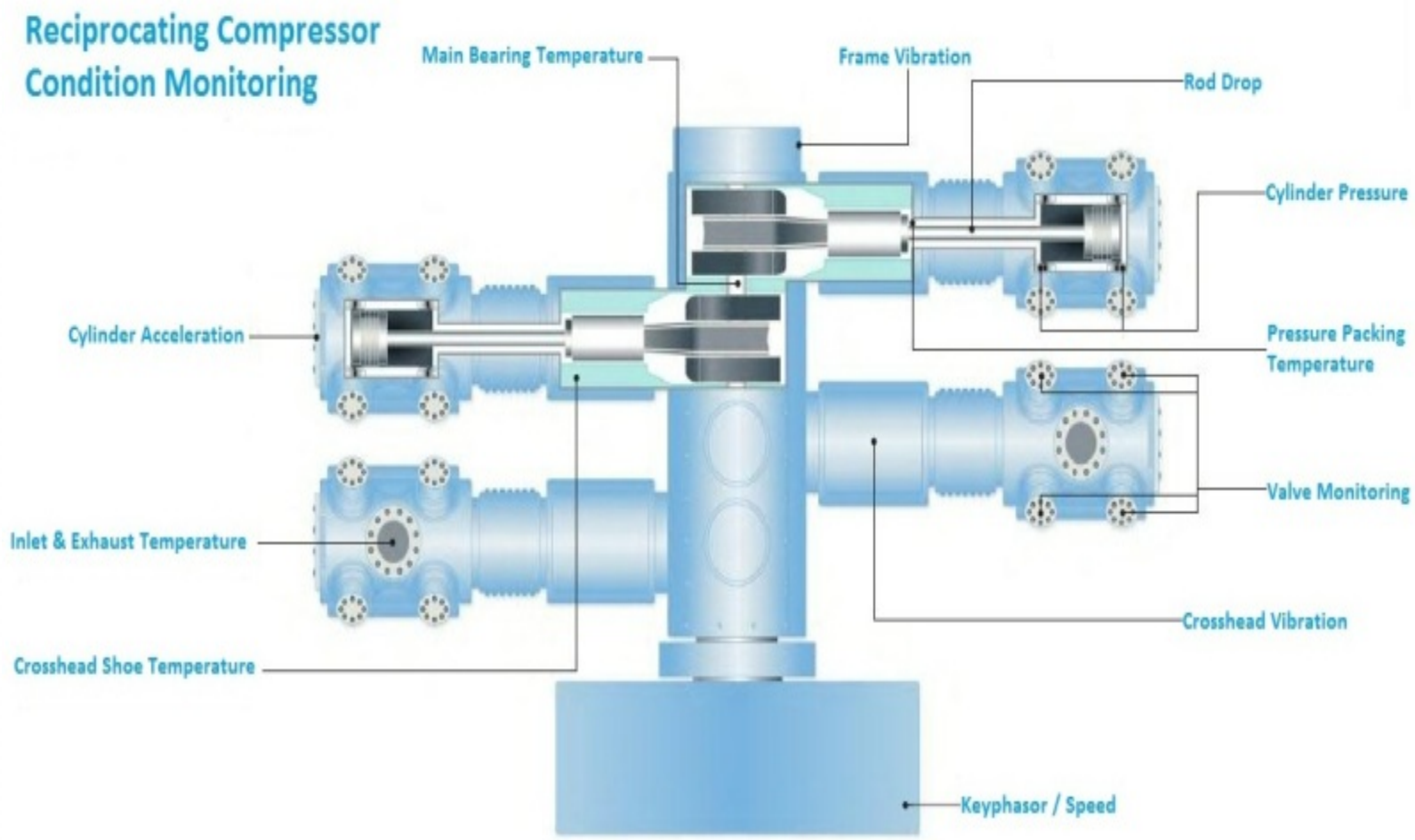
In Reciprocating compressors are positive displacement machines in which the compressing and displacing element is a piston having a reciprocating motion within a cylinder. Reciprocating compressors are often some of the most critical and expensive systems at a production facility, and deserve special attention.

Reciprocating Compressor API Standards

- **API 618 standard** covers the minimum requirements for reciprocating compressors and their drivers for use in petroleum, chemical and gas industry services. Clause 7.6 defines the Controls & Instrumentation part. Clause 7.6.7 & 7.6.8 provide the details for machine condition monitoring.

- **API 670 standard** covers the minimum requirements for a machinery protection system (MPS) measuring radial shaft vibration, casing vibration, shaft axial position, shaft rotational speed, piston rod drop, phase reference, over speed, surge detection, and critical machinery temperatures (such as bearing metal and motor windings). It covers requirements for hardware (transducer and monitor systems), installation, documentation, and testing.

Reciprocating Compressor…
MCM at a Glance



Reciprocating Compressor…
MCM Details

- Frame Vibration: It's generally a Velomitor (velocity transducer) connected to the BN racks via BN impulse/velocity monitor. This helps in identifying gear imbalance or ant foundation/structural looseness.
- Main Bearing Temperature: Simple temp. RTD from the bearing connected to the BN racks BN temperature monitor. This helps in identifying overload or lubrication problems.
- Cylinder Acceleration: This is generally an Accelerometer (acceleration transducer) connected to the BN racks via BN impulse/velocity monitor. This was not very common earlier but recently being used almost on all good size machines particularly helpful where a step-less control is used (hydraulically actuated valves are used & this is also becoming more common now a days).
- Inlet/Exhaust Temperature: Simple temp. RTD generally connected to the DCS/IPS/PLC but also connected to the appropriate system hardware e.g. Bently Nevada racks BN temperature monitor for critical machines. This helps in identifying valve problems.

Reciprocating Compressor…
MCM Details

- Keyphasor: It's generally a Proximitor probe connected to the BN racks via appropriate system hardware e.g. Bently Nevada 3500/25 Keyphasor module. This module provides Keyphasor signals to the monitor modules in a 3500 rack. The Keyphasor signal provides a once-per-turn phase reference voltage pulse that is combined with vibration measurements to derive synchronous (1X, 2X, nX, etc.) amplitude and phase angle of vibration values. It is necessary for diagnostics and balancing, and is required by the System 1 condition monitoring platform.
- Frame Vibration: It's generally a Velomitor (velocity transducer) connected to the appropriate system hardware e.g. Bently Nevada racks via BN impulse/velocity monitor. This is added generally on gear box cover.
- Crosshead Shoe Temperature: Simple temp. RTD connected to the appropriate system hardware e.g. Bently Nevada racks BN temperature monitor. This helps in identifying overload or lubrication problems.
- Crosshead Vibration: This is generally an Accelerometer (acceleration transducer) connected to the appropriate system hardware e.g. Bently Nevada racks via BN impulse/velocity monitor. This helps in identifying excessive clearance, loose nut bolts or similar issues.

Reciprocating Compressor…
MCM Details

- Pressure Packing Temperature: Simple temp. RTD connected to the appropriate system hardware e.g. Bently Nevada racks BN temperature monitor. This helps in identifying packing leak or packing lubrication problems.
- Rod Drop: This is a critical parameter. It's a proximity probe connected to the appropriate system hardware e.g. Bently Nevada racks via BN Rod Position monitor. This helps in monitoring the rider band condition & identifying cross head maintenance or rider band replacement.
- Cylinder Pressure: This is the single most important measurement for condition monitoring of reciprocating compressors is cylinder pressure. Armed with accurate cylinder pressure at each point in the piston's stroke, it helps in developing the famous Pressure-Volume (PV) curve which gives indispensable information for the machine condition. Continues online monitoring of this parameter was not common till few years back due to the reasons mentioned above. Online measurement for this has fewer options in market as it requires special sensors, e.g. special pressure transducer developed by GE(Part no. is 165855) & can be connected to the Bently Nevada racks to BN cylinder pressure monitor (3500/77M).

Engineering Interfaces

- Interface Information is a requirement that associates two distinct entities, either internal or external, that is necessary for an entity to generate its own deliverables.

- Internal Interfaces are generally within various engineering disciplines within a engineering company.
- External Interfaces are with the equipment &/or system vendors who are either the manufacturer of the rotating machine or the condition monitoring systems.

MCM Engineering Interface at a Glance (Internal)

Interface With	Requirements	Responsible for
Control System Engineering Department	Owner of the System & Field Instrumentation	Overall Machine Monitoring System Hardware & Software Engineering & Procurement
Mechanical Engineering Department	Owner of the Equipment	Main Package & Rotating Equipment Engineering
Electrical Engineering Department	Owner of the Equipment Driver(Motor)	Monitoring & Protection requirements for motors & integration with main rotating equipment.
Process Engineering Department	Owner of the Process which is performed by the Equipment.	Criticality rating of machines, integration of shutdown as per process requirements.

MCM Engineering Interface at a Glance (External)

Interface With	Requirements	Responsible for
PUS (Packaged Unit Supplier)	Main Supplier of the Main Mechanical Packages which has this Rotating Equipment.	Engineering Documentation & integration with equipment driver.
OEM (Original Equipment Supplier)	Original manufacturer of the Rotary Equipment or its Driver	Engineering Documentation, logic, alarm/trip set points
SPS (System Package Supplier)	Main manufacturer of the MCM system hardware	System software & hardware configuration & integration with other systems.
TPPS (Third Party Package Supplier)	Main manufacturer of the system hardware required for special requirements	Interface for alarm & trip requirements as vibration, speed & surge are inter-related phenomenon.
MAC (Main Automation Vendor)	Manufacturer/Supplier of the Main Process Control & Safety Shutdown	Operator interface for Machine Control, Alarm & Trip Logic configuration & signal exchange with other systems.

Conclusions

- The idea of condition monitoring is not new. What has changed is that the availability of low cost, low power computing has made scalable condition monitoring systems practicable and viable in a variety of new sectors.
- Condition monitoring provides ongoing observation of and feedback about a system's welfare. It works by continuously monitoring specified system parameters and applying intelligence around the data to infer the condition of the system.
- A condition monitoring system collects data from a machine while it's operating and detects changes in the machine that may cause a component to fail.
  - By flagging problems at an early stage, the program tells the user when to perform maintenance, thus preventing unexpected shutdowns.
  - This helps to cut downtime and parts inventory, boost productivity, improve quality, and ultimately, increase profits.

Conclusions

- Machines that perform secondary or support-type functions generally require only periodic data collection. Examples include CT fans, blowers, fin fans in fertilizer industry. These devices are usually small (less than 50 hp) and often perform redundant functions.

- By integrating vibration measurements and analysis into your maintenance program it is possible to….
  - Avoid unplanned production outages
  - Reduce plant downtime
  - Plan maintenance actions more accurately
  - Schedule your maintenance manpower more efficiently
  - Increase operator safety
  - Reduce insurance premiums

Conclusions

- MCM Engineering Interface
  - Effective exchange of information is crucial to the successful engineering of a condition monitoring system. Early identification of interfaces will help reduce the surprises.
  - Mechanical-Control System interface is one of the most critical internal interface(Internal) for condition monitoring engineering.
  - Condition monitoring system vendor & main automation vendor are the 2 most critical external interfaces.