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Quality Control and Assurance in Maintenance in Fertilizer Industry Workshop

Papers

Muscat - Sultanate Oman

23-25 November 2015

Arab Fertilizer Association

Since 1975

OMIFCO

Quality Control and Assurance in Maintenance in Fertilizer Industry Workshop

Day 1

Monday : Nov. 23, 2015

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23-25 November 2015

Total Productive Maintenance

Engr. Muhammad Sajid
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الإتحاد العربي للأسمدة
Arab Fertilizers Association

Lecturer
University of Gujrat

UNIVERSITY OF GUJRAT
A WORLD CLASS UNIVERSITY

Maintenance Engineering
Health, Safety & Environment
Engineering Management
Reaction Engineering

M.SC Chemical Engineering

PM-Faras Fertilizer Company

فارس

Faras Fertilizer
Company (Pvt) Ltd.

فارس کی شان خوشحال کسان

Process Engineer -Agritech limited

Outline

- Overview of TPM
- TPM Foundation
- TPM tools
- TPM Pillars
- Equipment loss & OEE
- 8 pillars of TPM
- TPM Implementation
- Critical success factors
- TPM benifits

Introduction

❖**Total productive maintenance (TPM)** originated in Japan in 1971 as a method for improved machine availability through better utilization of maintenance and production resources.

❖TPM is a maintenance process developed for improving productivity by making processes more reliable and less wasteful. TPM is an extension of TQM (Total Quality Management).

What is TPM?

- A **philosophy** to permeate throughout an operating company touching people of all levels
- **A collection of techniques and practices**

  aimed at maximizing the effectiveness (best possible return) of business facilities and processes

- TPM is a plant improvement **methodology** which enables continuous and rapid improvement of the manufacturing process through use of employee involvement, employee empowerment, and closed-loop measurement of results.

Meanings of TPM

T-TOTAL	P-PRODUCTIVE	M-MAINTENANCE
• Total efficiency • Total life cycle of production system • Total manpower coverage	• Productivity maximization by; • Zero accident • Zero defect • Zero break down	• Maintenance overs life cycle of production system • Individual processes • Plant • Product Manag. system

Why TPM ?

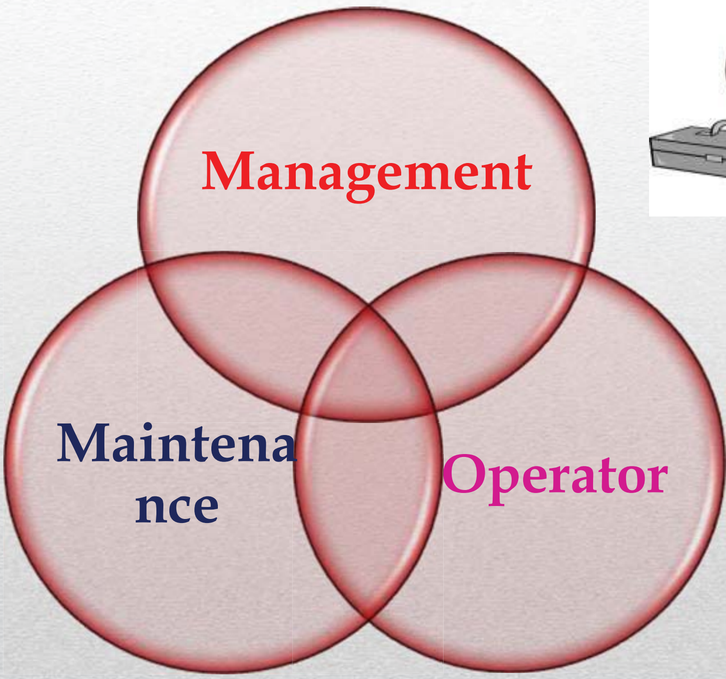
We want following system charachteristics

- Avoid wastage in a quickly changing economic environment.
- Producing goods without reducing product quality.
- Reduce cost.
- Produce a low batch quantity at the earliest possible time.
- Goods send to the customers must be non defective.

TPM

- Proactive
- Preventive
- Predictive
- Planned

TPM



TPM is Planned, Predictive, & Preventive

- Starts with 5S / Visual Factory
- Builds a comprehensive downtime data base by cause, frequency, and duration
- Predicts and prevents downtime by PM system
- Expands role of Operator as first point of early warning and prevention
- Professional Maintenance

What TPM is NOT

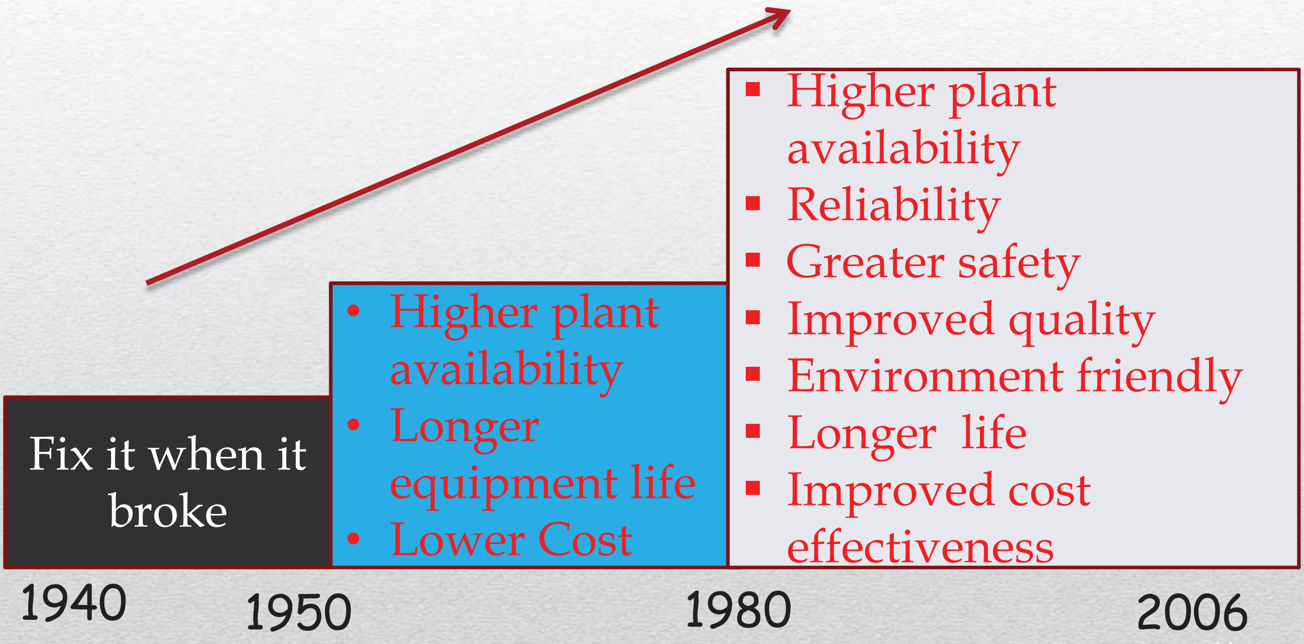
- A maintenance department program
- Just a workshop or event
- A way to eliminate skilled traders (maintenance staff, technicians, etc.)
- Making operators and office staff into skilled tradesman

HISTORY

History

- This is an innovative Japanese concept.
- Developed in 1951.
- Nippondenso was the 1st company that implemented TPM in 1960.
- Based on these developments Nippondenso was awarded the distinguished plant prize for developing and implementing TPM, by the Japanese Institute of Plant Engineers (JIPE).
- This Nippondenso became the first company to obtain the TPM certifications.

Growing Expectation



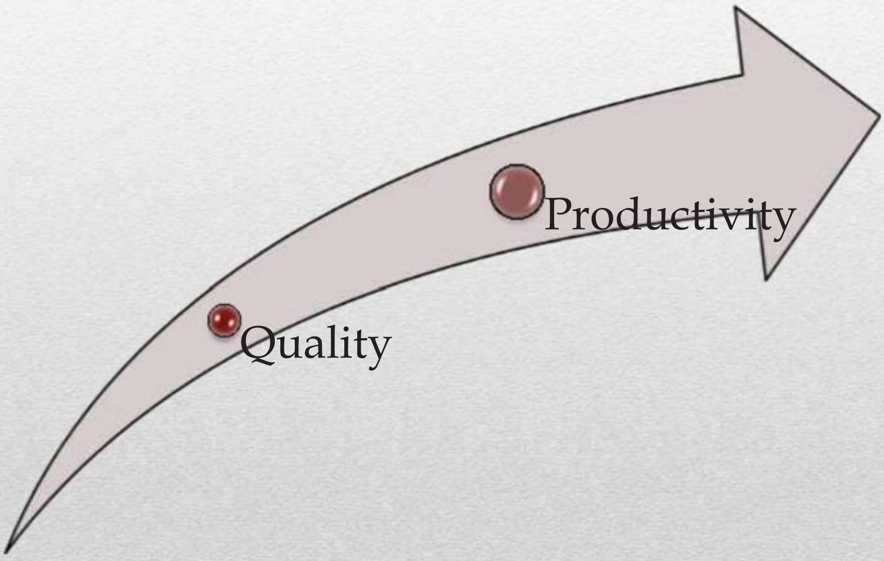
TPM Principles

- Increase overall equipment effectiveness
- Upgrade operations and maintenance skills
- Employee involvement through small group activities
- A fact-based approach to continuous improvement

TPM POLICY & OBJECTIVES

AIM of TPM

TARGET



TPM Policy & Objectives

TPM Policy & Objectives

To maximize equipment effectiveness

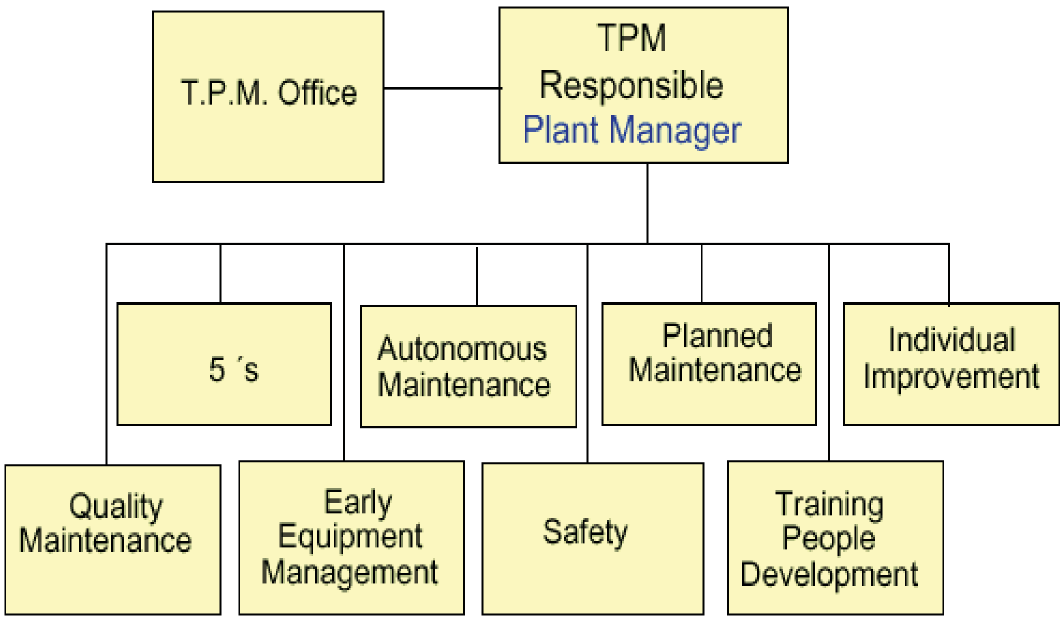
Zero breakdowns and failures

Zero accident, Zero defects

Through total employee involvement

TPM STRUCTURE

T.P.M. PLANT WIDE STRUCTURE



Eight Pillars of TPM

- Autonomous maintenance
- Focused improvement
- Education and training
- Planned maintenance
- Quality maintenance
- Early management and initial flow control
- Safety, hygiene and pollution control
- Administrative and office TPM

Steps in JISHU HOZEN

- Conduct initial cleaning/inspection
- Eliminate sources of contamination
- Establish provisional standards
- Develop general inspection training
- Conduct general inspections
- Improve workplace management and control
- Participate in advanced improvement activities

Jishu Hozen = autonomous maintenance

A Chart for Autonomous Maintenance

Autonomous Maintenance
Routine Cleaning, Inspection, & Lubrication Standard

Dept. / Line : Bldg Y	Area : Bag Printer	Mach. ID :	Date: 4/28/2004	Tag # :

Diagram	No.	Item	Criterion	Method	Tools	T (Min)	Freq S	Freq D	Freq W	Freq M	Person Resp.
		Cleaning									
	1	Water trap	Empty bowl	Open valve	Cloth	1		X			Operator

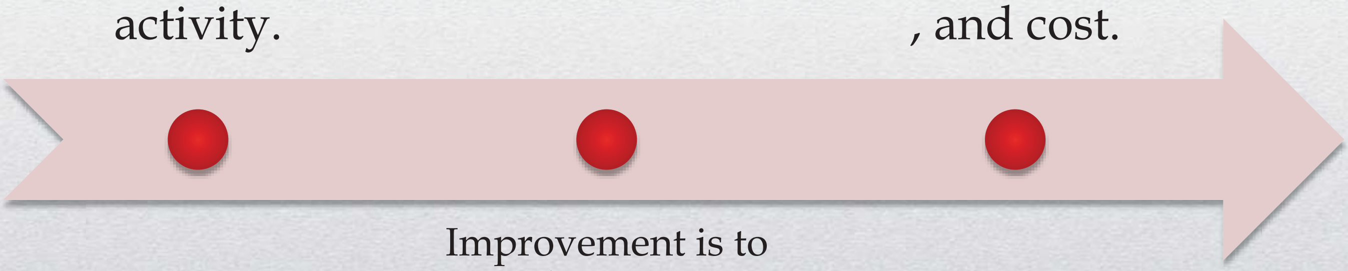
This is the maximum level for water in the bowl.

Open valve at bottom to release water, wipe up with clean cloth.

Focused Improvement

Improvement on every one's activity.

Improvement in Reliability, Maintainability , and cost.



Improvement is to eliminate Production losses and cost reduction.

Planned Maintenance

Logical analysis "Real causes for real counter measures".

- Focus on Prevention.
- It is aimed to have trouble free machines and equipments producing defect free products for total customer satisfaction.
- Example: Preventive Maintenance, Breakdown Maintenance, etc.,

Planned maintenance

Steps in Planned maintenance :

- Equipment evaluation and recoding present status.
- Restore deterioration and improve weakness.
- Building up information management system.
- Prepare time based information system, select equipment, parts and members and map out plan.
- Prepare predictive maintenance system by introducing equipment diagnostic techniques.
- Evaluation of planned maintenance.

Quality Maintenance

Developing perfect machine for perfect Quality.

Eliminating In – Process defects and custom complaints.

Policy :

- Defect free conditions and control of equipments.
- QM activities to support quality assurance.
- Focus of prevention of defects at source
- Focus on POKA-YOKE. (fool proof system)
- In-line detection and segregation of defects.
- Effective implementation of operator quality assurance.

Education & Training

- Skills development for uniformity of work practices on machines.
- Skills for Zero defects, Zero breakdowns & Zero accidents.
- Multi Skilled employees in all departments

Educating and Training Activities

Setting policies and priorities and checking present status of education and training.

↓

Establish of training system for operation and maintenance skill up gradation.

↓

Training the employees for upgrading the operation and maintenance skills.

↓

Preparation of training calendar.

↓

Evaluation of activities and study of future approach.

↓

A clear understanding of the criteria for judging normal and abnormal conditions

↓

The ability to quickly respond to any and all abnormalities

Skill levels

Four Levels of Skills

- Level 1: Lack both theoretical and practical ability (needs to be taught)
- Level 2: Knows theory but not in practice
- Level 3: Has mastered practice but not theory
- Level 4: Mastered both practice and theory

Development Management

Developing machines for "high equipment effectiveness".

- Quick process for developing new products.

Development Management

Policy

- Practice concepts of zero losses in every sphere of activity.
- relentless pursuit to achieve cost reduction targets in all resources.
- Relentless pursuit to improve over all plant equipment effectiveness.
- Extensive use of PM analysis as a tool for eliminating losses.
- Focus of easy handling of operators.

Safety, Health & Environment

Zero accidents and Zero hazards at works.	Zero Pollution at Plant and Environment.
• Safe SOP's • Hazards control	• Efficient waste control system • EPA standards

Office TPM

Office TPM must be followed to improve productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation

Office TPM

Plans & Guidelines:

- Providing awareness about office TPM to all support departments
- Helping them to identify **P, Q, C, D, S, M** in each function in relation to plant performance
- Identify the scope for improvement in each function
- Collect relevant data
- Help them to solve problems in their circles
- Make up an activity board where progress is monitored on both sides - results and actions
- Fan out to cover all employees and circles in all functions.

Office TPM

P Q C D S M in Office TPM :

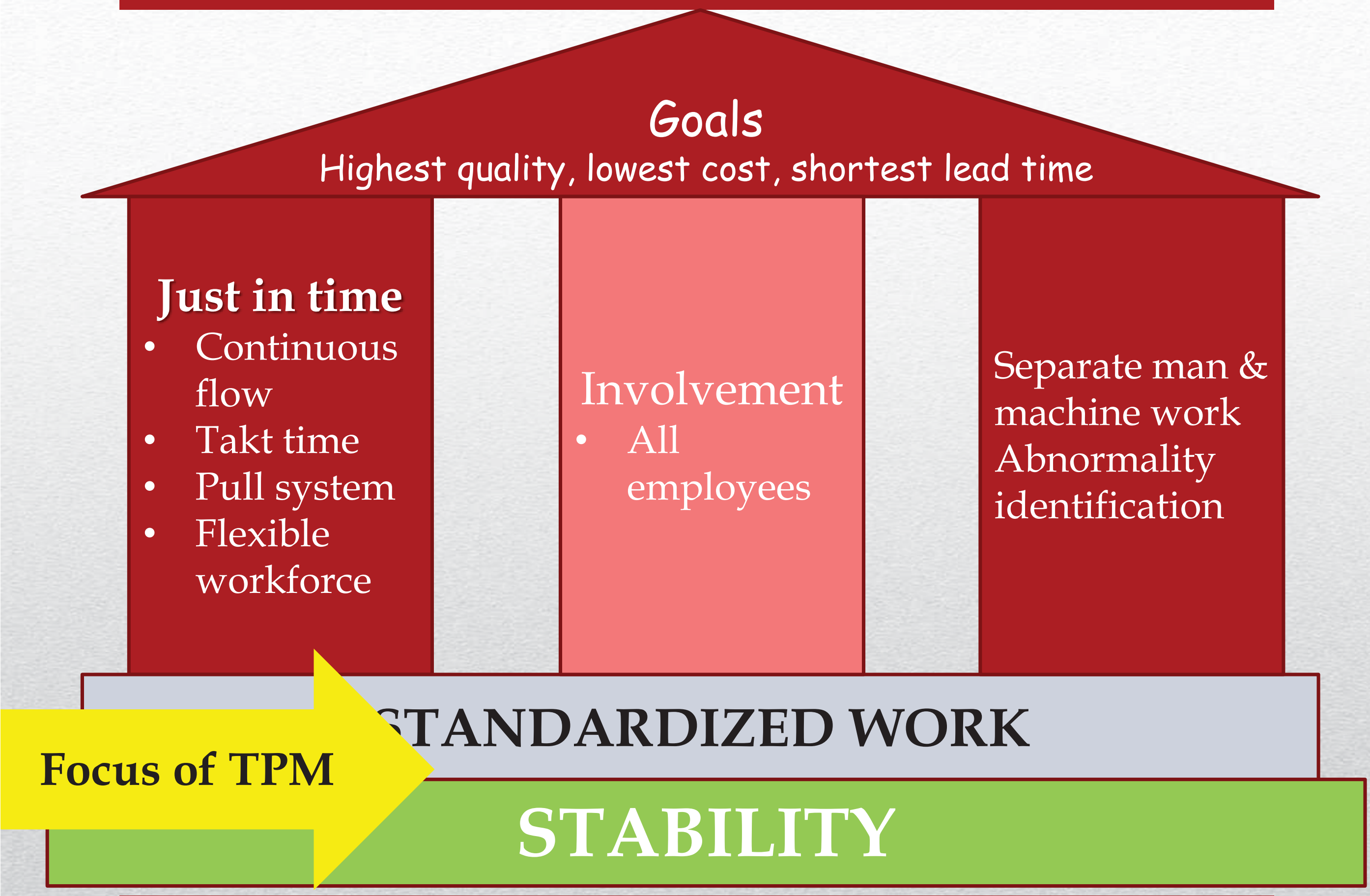
- P - Production output lost due to Material, Manpower productivity, Production output lost due to want of tools.
- Q - Mistakes in preparation of cheques, bills, invoices, payroll, Customer returns/warranty attributable to BOPs, Rejection/rework in BOP's/job work, Office area rework.
- C - Buying cost/unit produced, Cost of logistics - inbound/outbound, Cost of carrying inventory, Cost of communication, Demurrage costs.

Office TPM

P Q C D S M in Office TPM :

- D - Logistics losses (Delay in loading/unloading)
  - Delay in delivery due to any of the support functions
  - Delay in payments to suppliers
  - Delay in information
- S - Safety in material handling/stores/logistics, Safety of soft and hard data.
- M - Number of Kaizens in office areas

TPM
GOALS & STRATEGY

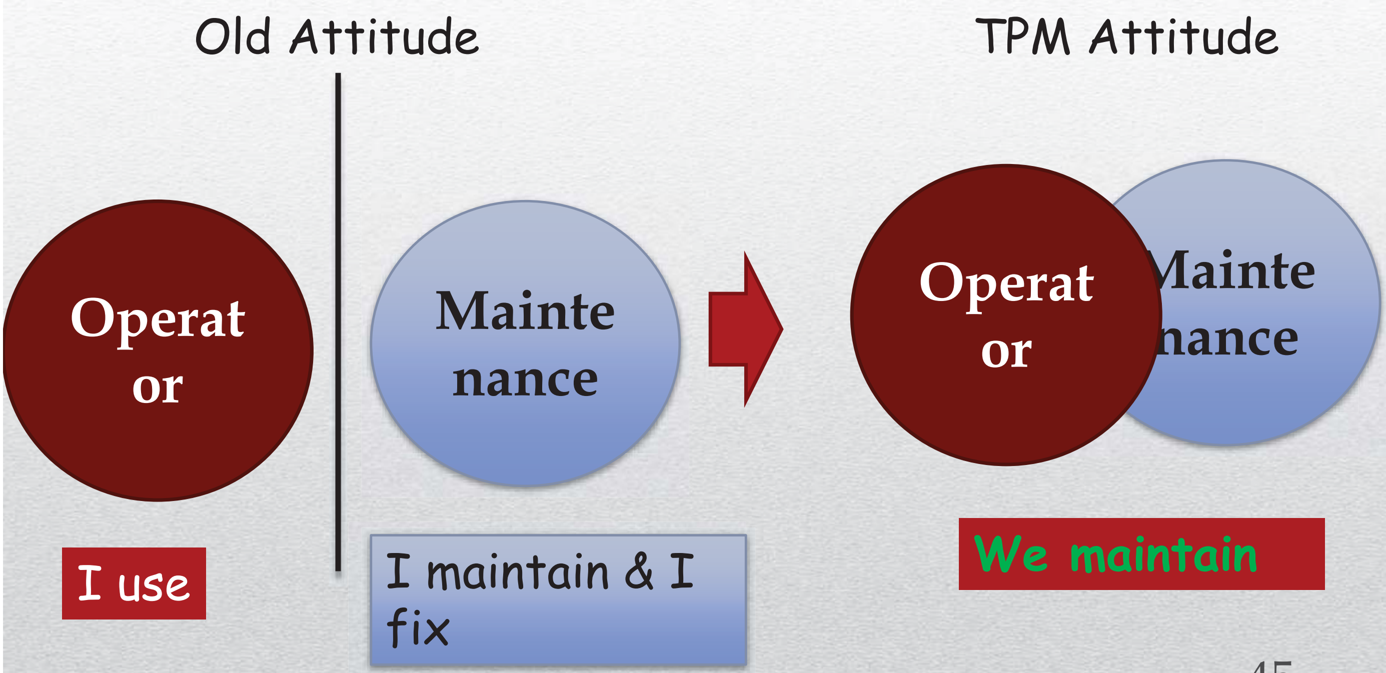


TPM Strategy

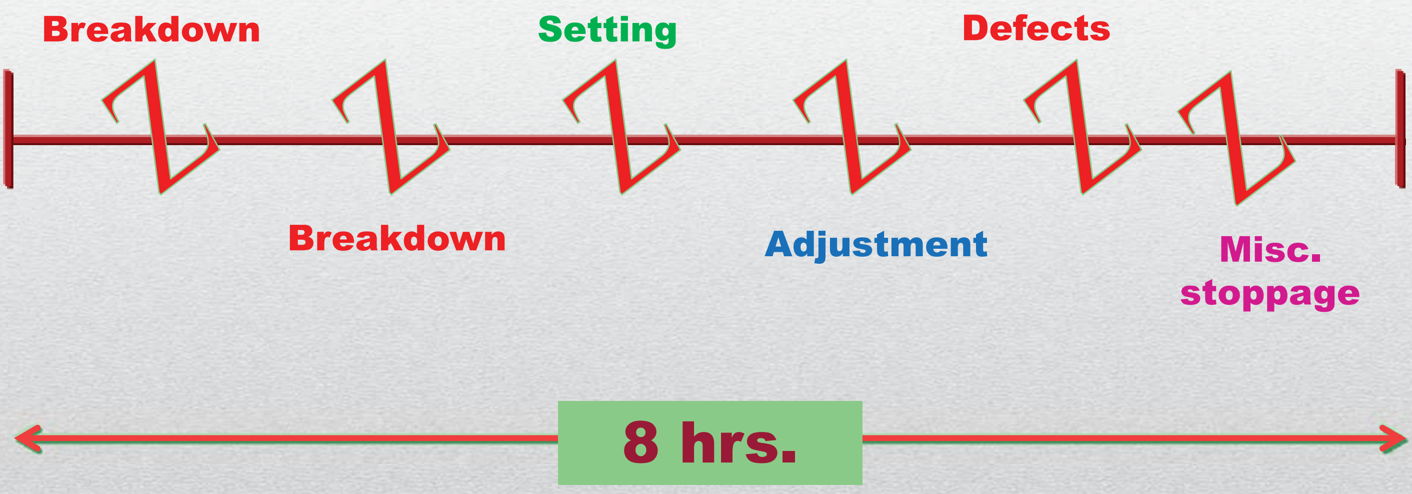
- "Strategy of TPM is to change the attitude from "I use, You maintain" to "I use, I maintain".

- Think about how to Increase production and reduced cost by reducing or eliminating loss, and this is the TPM.

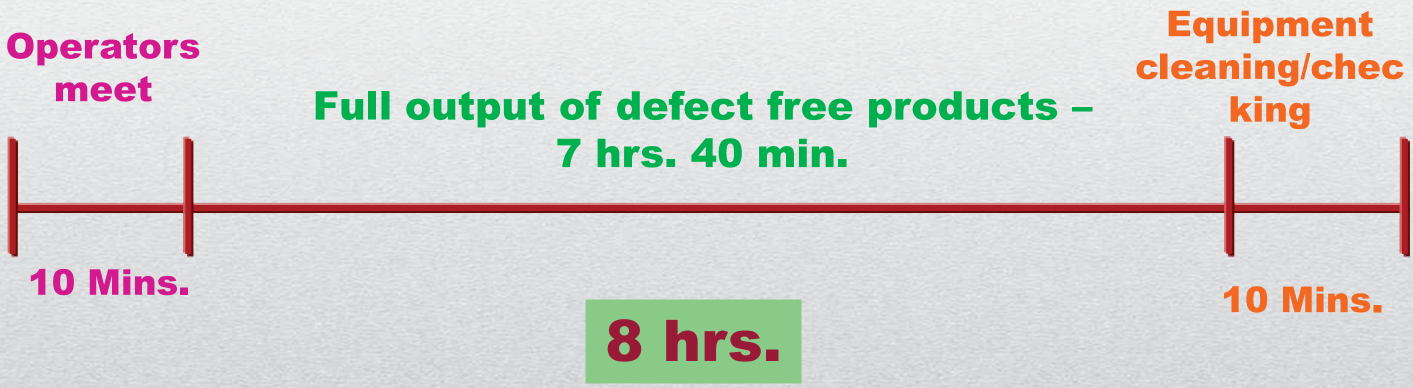
TPM ATITUDE



TRADITIONAL MANUFACTURING



MANUFACTURING WITH TPM



TPM enables:

Reactive to pro-active

- Breakdowns are analyzed
- Causes investigated
- Actions taken to prevent further breakdowns

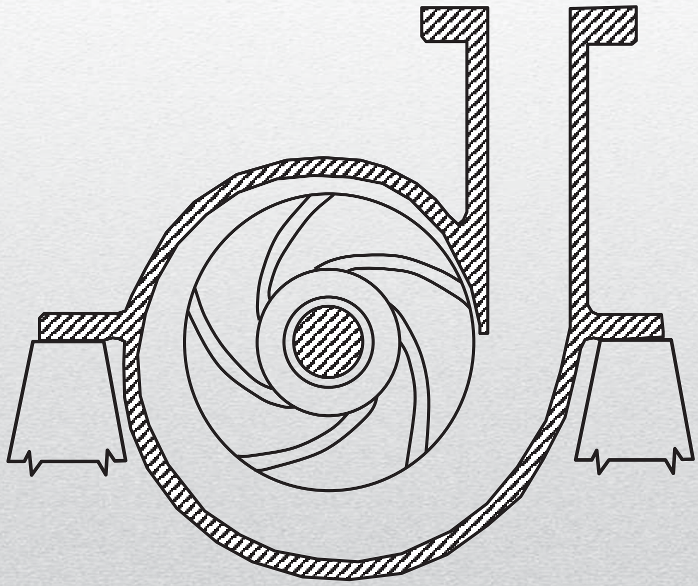
free up maintenance professionals

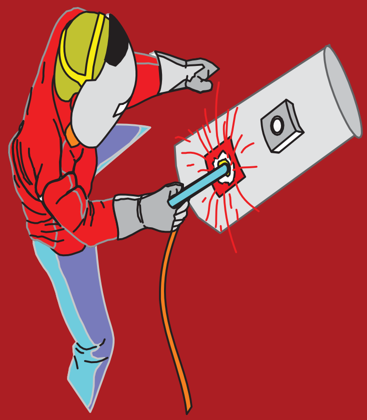
- Carry out scheduled and preventive maintenance
- Gather relevant information as important input to the maintenance system
- Keep the system up to date
- To review cost effectiveness

Workshop Activity

Cooling water pumps

- Cooling tower operator
- Maintenance personal
- Develop a TPM plan





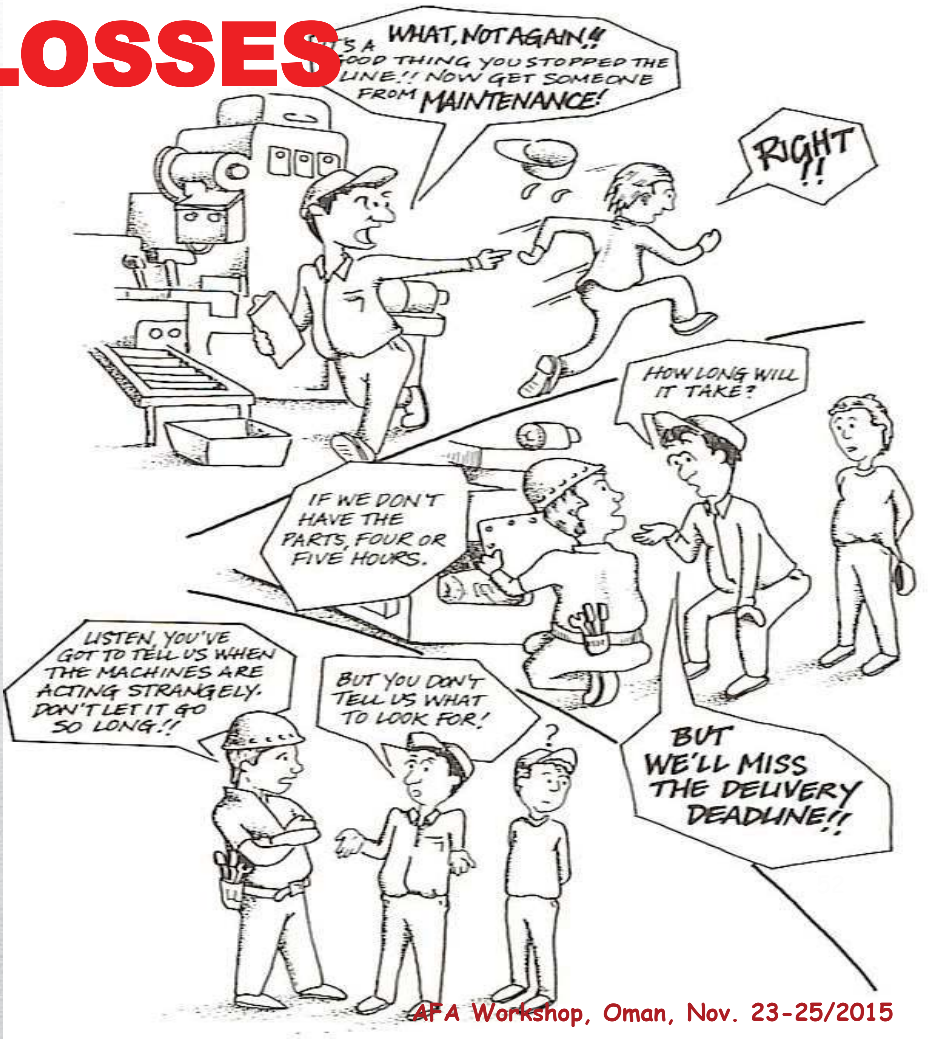
TPM FOUNDATION

5 S

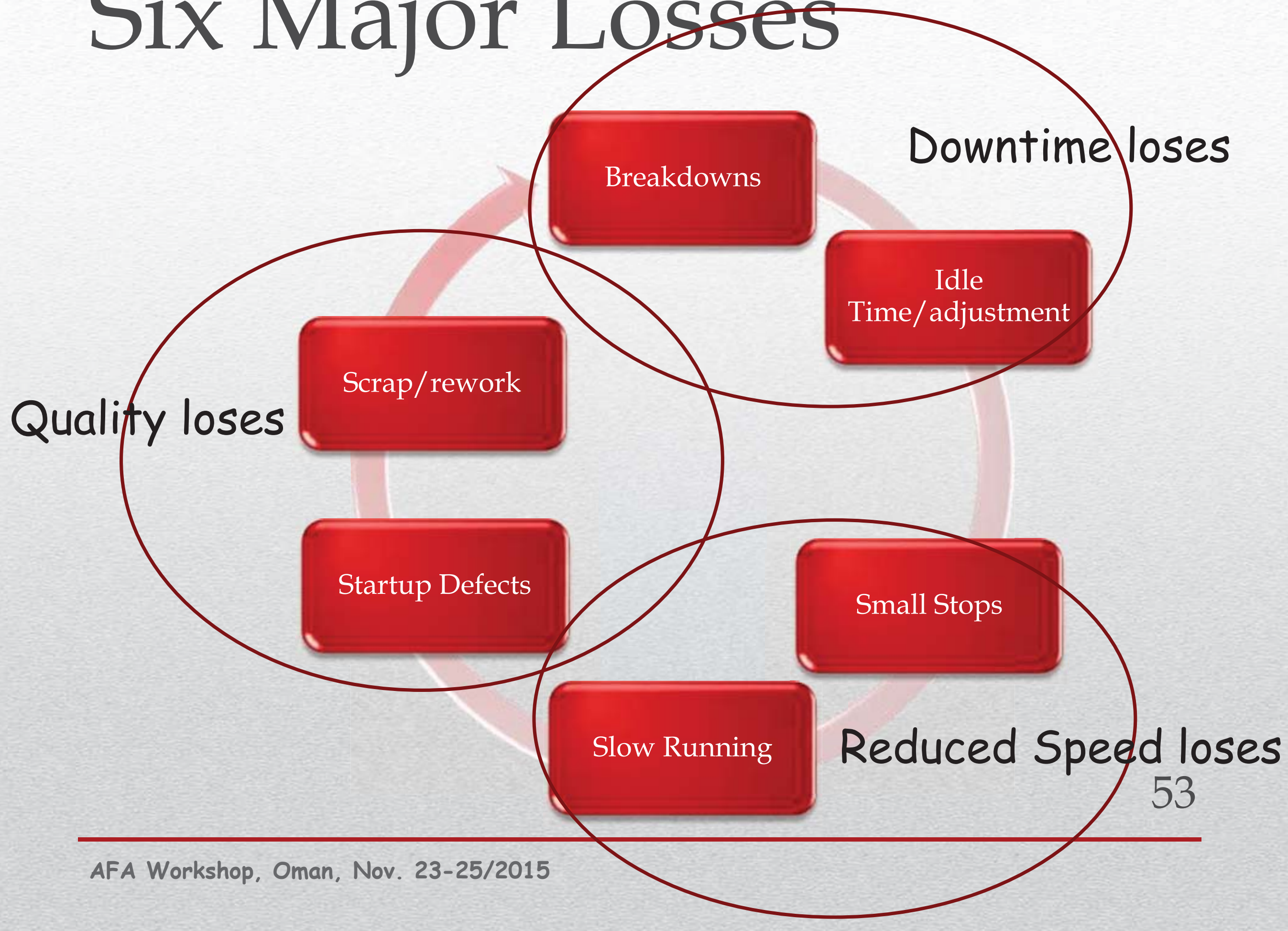
TPM STARTS WITH 5S

- **Sort/** *Seiso* **(organize)**
- **Shine/** *Seiri* **(clean)**
- **Set in order/** *Seiton* **(make orderly and neat)**
- **Standardize/** *Shitsuke* **(visual place for everything)**
- **Sustain/** *Seiketsu* **(maintain the system)**

PLANT LOSSES



Six Major Losses



Planned Downtime losses

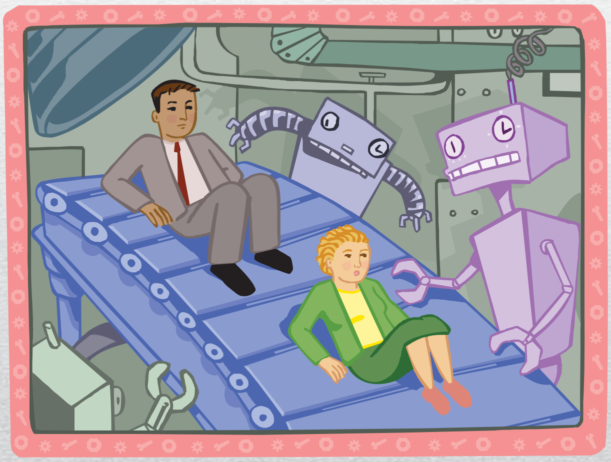
- Start-ups
- shift changes
- coffee and lunch breaks
- planned maintenance shutdowns

Unplanned Downtime Losses

- Equipment breakdown
- Changeovers
- Lack of material

Reduced Speed Losses

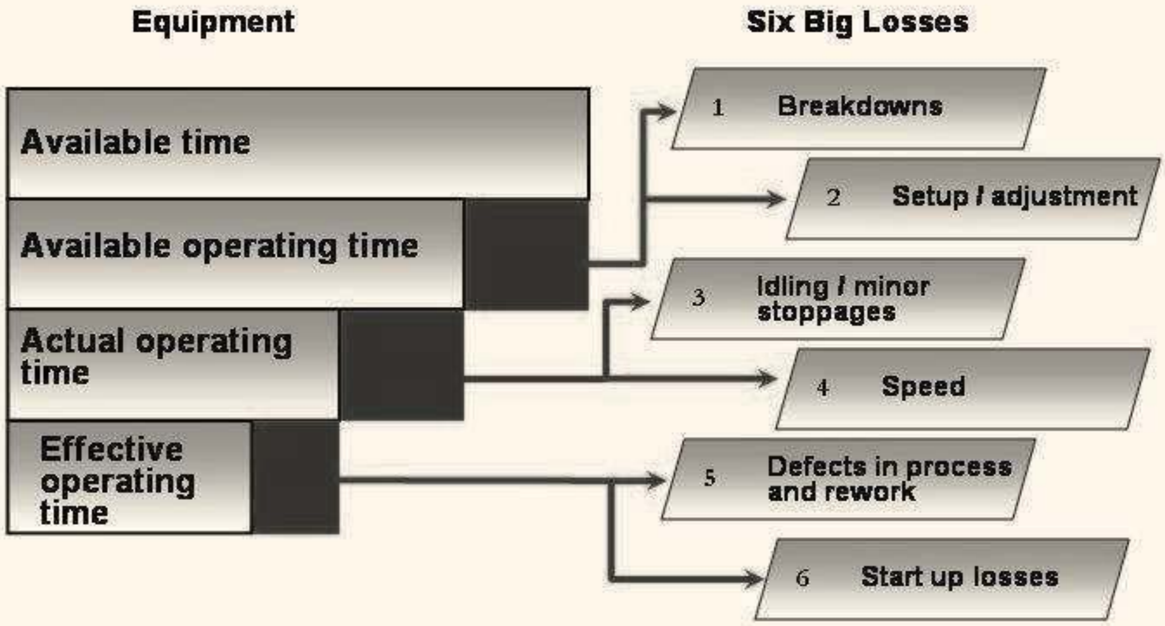
- Idling and minor stoppages
- Slow-downns



Poor Quality Losses

- Start up defects
- Scrap & rework

Loss Elimination through TPM?



TPM - Benefits

Improved equipment eliminates the root cause of defects

Defects are prevented through planned maintenance

Preventive maintenance costs are reduced as equipment operators conduct autonomous maintenance

TPM - Benefits

Improved equipment designs ensure that new equipment naturally produces fewer defects

Simplified products designs and a redesigned process produce with few defects

Engineers, technicians and managers are trained in maintenance and quality

thanks

ACKNOWLEDGMEN
Data has been taken from different sources. Credit goes to original authors only

Impact of Effective Maintenance Management on Mechanical systems

Eng. Matrouk.S.Alanazi

Mechanical Maintenance purpose

- To increase reliability of equipment and thus availability and productivity
- To achieve optimal cost levels
- To guarantee safety and quality
- To protect health and environment

Maintenance Experience and training

to understand the maintenance function , philosophy

And its tools , one should be exposed ,engaged or have gained most of the following valuable experience at a sound maintenance establishment.

- Responsible for the maintenance function at section level, including the planning, supervising, and engineering staffs
- Responsibility is to assist supervisors in overseeing that other employees carry out facility maintenance tasks and responsibilities in an effective and quality way.
- To Make sure right type of maintenance on equipment and factory machines are made safely with excellent tracking and recording methods.
- Make sure workshop and workplace is within compliance guidelines for government and international agencies that monitor safety, fire protection, quality and environment.
- Coordinates closely with counterparts in other in-house organizations, to ensure that Maintenance & company objectives are being met.
- responsibility for delegating assignments to the appropriate personnel

Maintenance Enhancement by learning and training

Examples of applied Training made at APC

- Conditions of contract for business & projects (FIDIC)
- Project Management Professional (PMP)
- Project planner primavera P3
- Reliability Centered Management (R.C.M)
- Maintenance planning & control
- Supervision systems
- Effective communications
- Tetralogy- metal and machine protection methods
- Radiographic (NDT) to ASME codes
- DOS, WINDOW, WINWORD, EXECL
- Hydraulic sys ▪Measurement sys▪ Industrial oils greases grading

Maintenance leader

Any maintenance leader should have the well and mean to delver most of the following qualities:

- Getting along very well with others
- Manpower at all level is known to him
- Always take good care of the work force and how he is perceived by others
- Always seek and work towards healthy Industrial relationship built in trust.
- The ability to understand what every job requires and how to apply prober work study
- The ability to identifies each individual competence level and to use situational leadership were and when appropriate
- The ability make sure people knows what to do, how to do it and are held accountable for doing it.

Typical Greatest strength of Maintenance

- Strong emphasis imposed on safety, health and having clean environment
- Human factor. Most technical manpower should be Well educated and had good training.
- Unique experience gained at each particular site
- Adequate resources ,workshops ,rest place and premises made available for work purposes
- Manpower located at short distance to work Ares
- Always seeking good work conditions
- Having smooth good relation with other departments

Tools for effective Maintenances

Mechanical Maintenance Management has to be based on:

- Defined objectives
- Defined philosophy
- Defined procedures
- Adequate Organizational structure and strategy

Maintenance management to integrates efforts and procedures for total maintenance performance aiming to provides simple and efficient control over plant equipment availability as well as reliability. To enhances operations, inspection and material control.

Mechanical Maintenance Major Objective

Mechanical Maintenance Philosophy

Maintain and restore what is needed, when it is needed, with a minimum amount of materials, equipment, labor and space using the prober type of maintenance

- Reactive Maintenance
- Corrective Maintenance
- Preventive Maintenance
- Predictive Maintenance
- Maintenance Prevention

objectives for a Mechanical maintenance organization strategy

- Maximum production at the lowest cost, the highest quality, and within optimum safety standards
- Identify and implement cost reductions
- Provide accurate equipment maintenance records
- Collect necessary maintenance cost information
- Optimize maintenance resources
- Optimize capital equipment life
- Minimize energy usage
- Minimize inventory on hand

Mechanical Maintenance procedures to achieve objectives

a) Promote productivity
b) Reduce cost
c) Measure performance
d) Measure work load
e) Measure manpower required by craft
f) Control every hour of manpower and mobile equipment
g) Provide information for cost control
h) Promote communication

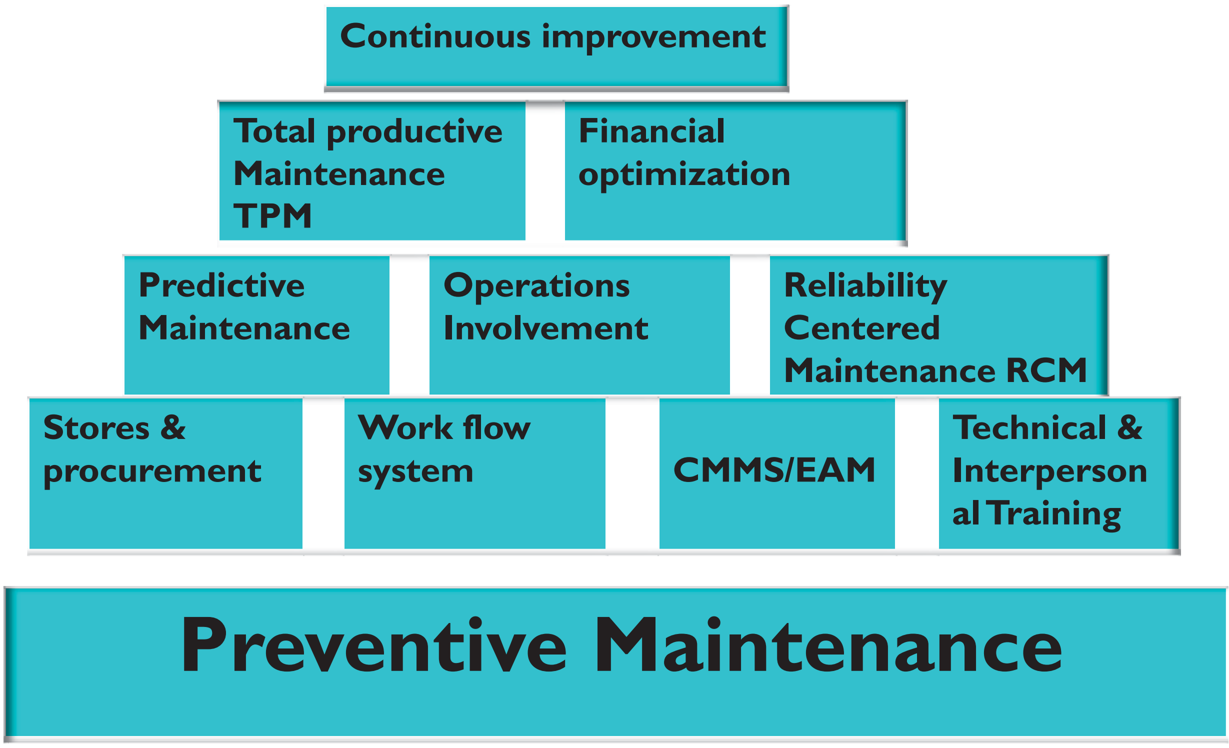
Current challenges and areas of improvements

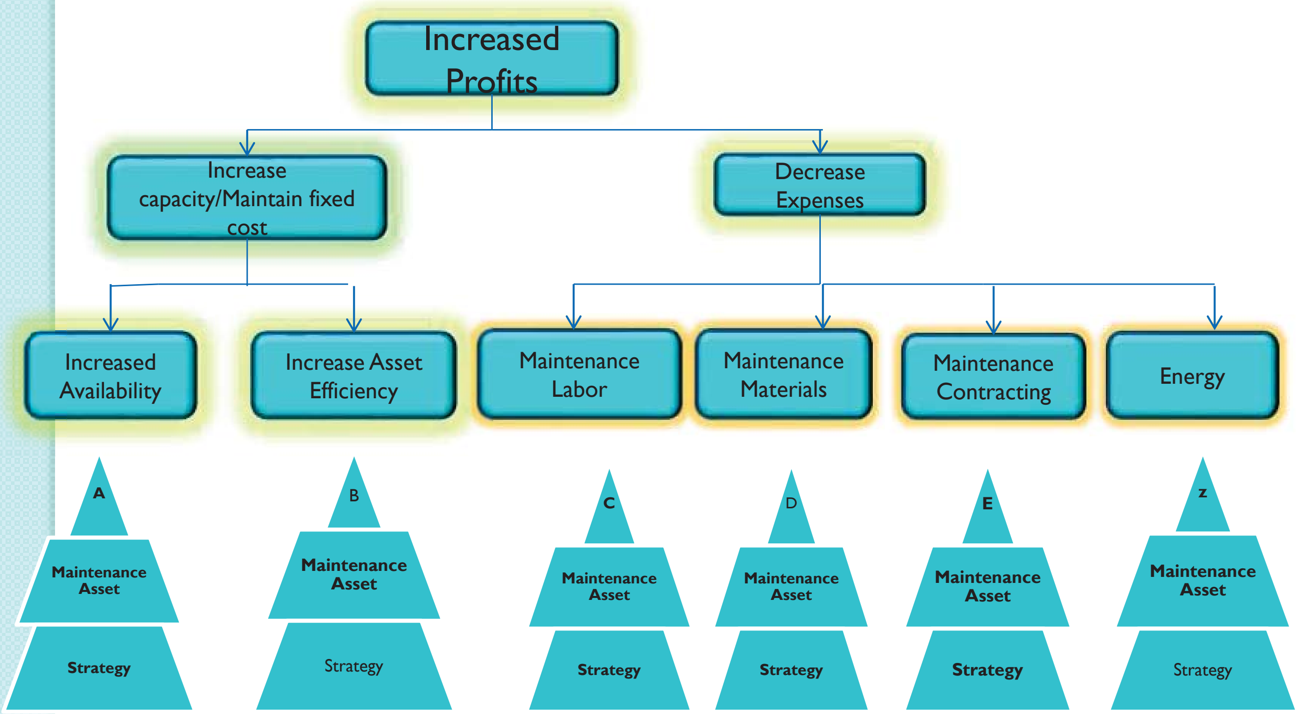
- High percentage of the maintenance team time is spent fire fighting the daily problems versus performing planned or scheduled maintenance? Is the ratio anywhere near an ideal 80% planned and 20% reactive (80/20) that well run maintenance organizations achieve ?
- What performance measurements are in place? Do you know if your team is working efficiently? How long does it take to process a work request or what is the average time to repair a broken valve etc.?
- How many maintenance strategies can we employ? Shall we rely on predictive technologies, condition based principals, preventive maintenance, RCM when do you use each one and why?
- How much of equipment maintenance is dependent on the knowledge of one or two people? Is a key player getting ready to retire?
- How much downtime do we have? Why?
- knowing what is our energy costs are per asset? And understanding the relationship between preventive maintenance and energy efficiency?
- knowing where all assets and equipment are, what condition they are in, their maintenance history etc.?

Adequate Organizational structure and strategy TO Meet maintenance challenges

The goals and objectives of the mechanical maintenance organization determine the type of maintenance organization that is established. If the goals and objectives are progressive and the maintenance organization is recognized as a contributor to the corporate bottom line, variations on some of the more conventional organizational structures can be used

Maintenance /Asset strategy





Thank you

Eng. Matrouk.S.Alanazi

PREDECTIVE MAINTENANCE & IMPACT ON RELIAILITY

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AFA Workshop on "Quality Control & Assurance in Maintenance in Fertilizer Industries" Oman 23 – 25/11/2015

Learning Outcome

- Explain the importance of maintenance in production systems
- Describe the range of maintenance activities
- Discuss predictive maintenance and the key issues associated with it
- Describe how different Condition Monitoring Systems works.
- describe how predictive maintenance effects reliability

Contents

Introduction

- To keep system operative
- Increase availability of a system
- Keep system's equipment in working order

- **Maintenance is a set of organised activities that are carried out in order to keep an item in its best operational condition with minimum cost acquired.**

SUNDER INDUSTRIAL STATE LAHORE

Nov. 04,2015

Sunder Industrial Estate Building collapse

53 Workers died

200 Injured

GOOD MAINTENANCE IS GOOD SAFETY

- New legislative requirements
- Increased stakeholder scrutiny of safety performance
- Risk Management strategies
- ZERO HARM
- Good Safety is Good Business

Why Maintenance

- To keep equipment/system operative.
- Attempt to maximize performance of production equipment efficiently and regularly
- Prevent breakdown or failures
- Minimize production loss from failures
- Increase reliability of the operating systems
- To keep operation safe
- To prevent leakages/losses

Maintenance Objectives

PLANT

MAINTENANCE

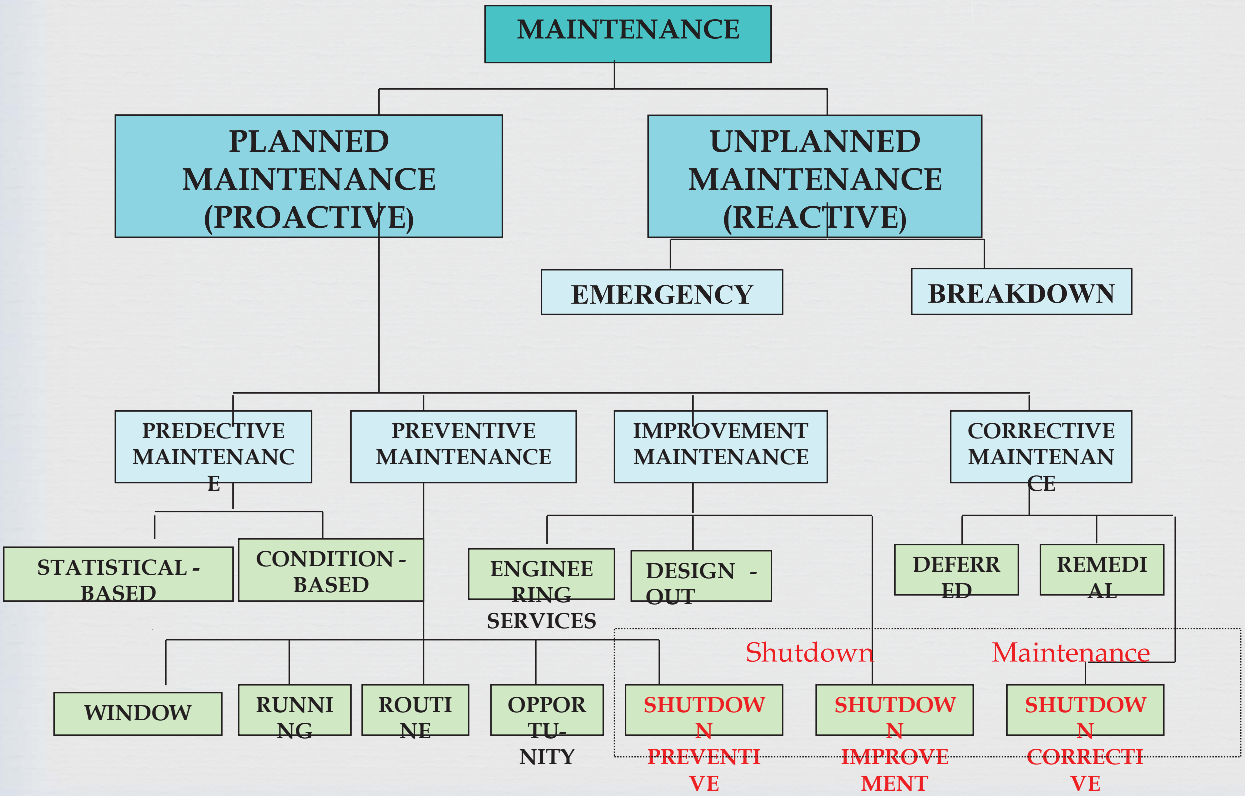
- Maximising Production
- Minimising Energy Usage
- Optimising Useful Life of Equipment
- Providing Budgetary Control
- Optimising Resources Utilisation

- Reduce Breakdowns
- Reduce Downtime
- Improving Equipment Efficiency
- Improving Inventory Control
- Implementing Cost Reduction

Types of maintenance management systems

- Preventive maintenance (PM)
- Corrective or Breakdown maintenance
- Scheduled maintenance
- Predictive (Condition-based) maintenance (PdM)

Types of Maintenance (Cont.)



Predictive Maintenance

What do we mean by Predictive Maintenance?

"To declare or indicate in advance"

Predictive Maintenance

- An inspection activity (condition based) on PM task list if predictive
- Forecasting replacement before failure
- Historical Data
- Real-time Technology
- Accurate on time Maintenance

Predictive maintenance

- Observe and response
- In predictive maintenance, machinery conditions are periodically monitored and this enables the maintenance crews to take timely actions, such as machine adjustment, repair or overhaul
- It makes use of human sense and other sensitive instruments, such as audio gauge, vibration analyzer, amplitude meter, pressure, temperature and resistance strain gauges etc.

PdM Cont…

Involves condition monitoring of equipment, and a methodology for the performance of maintenance only when there is objective evidence of need

Part of an overall maintenance effort

- to prevent unscheduled downtime from failure
- predict the opportune time for maintenance.

Need of a PdM system

- Increased Automation
- Business loss due to production delays
- Production of a higher quality product
- Just-in-time manufacturing
- Need for a more organized, planned environment

Growing expectation of maintenance

Phase I

Fix it when it broke

Phase II

- Higher plant availability
- Longer equipment life
- Lower Cost

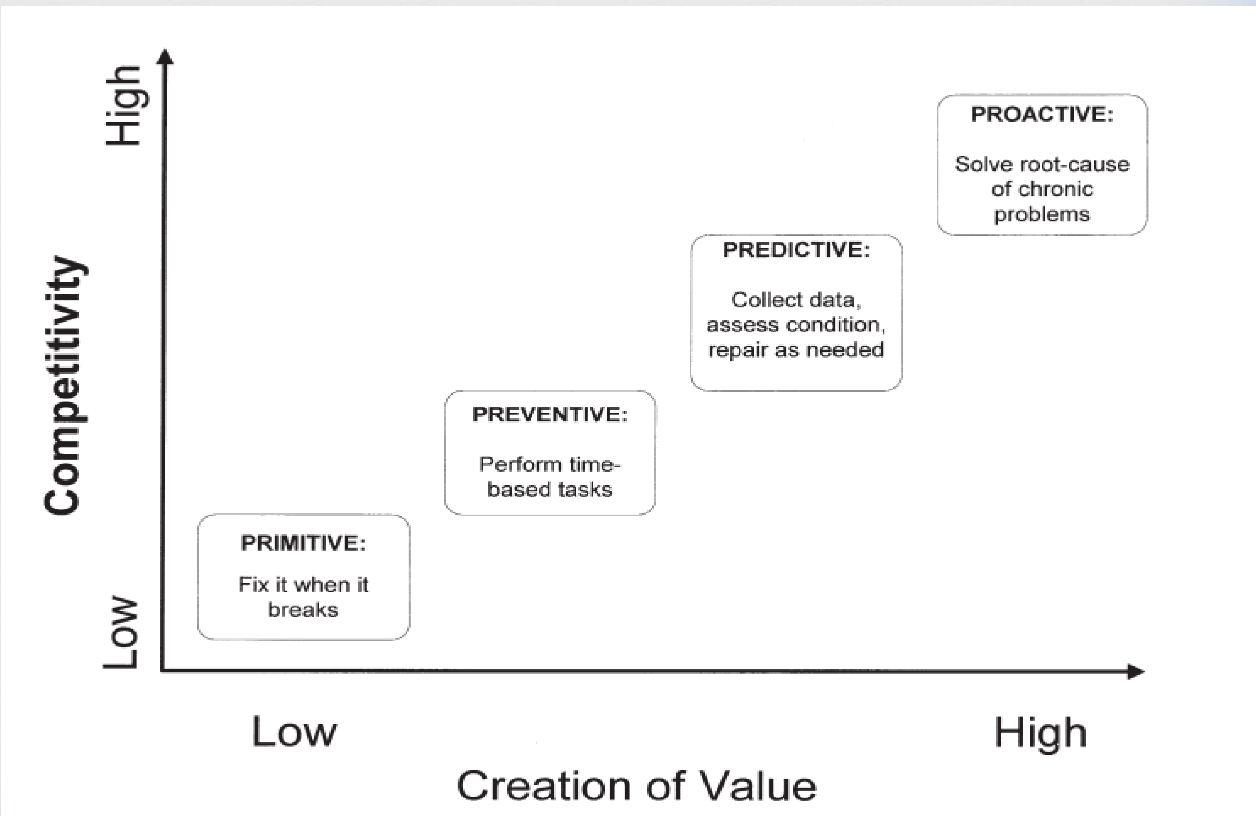
Phase III

- Higher plant availability
- Reliability
- Greater safety
- Improved product quality
- Environment friendly
- Longer equipment life
- Improved cost effectiveness

1940 1950 1960 1970 1980 1990 2000

wwII

Evaluation of maintenance



Strategic Importance of Maintenance and Reliability

The objective of maintenance and reliability is to maintain the capability of the system

Strategic Importance of Maintenance and Reliability

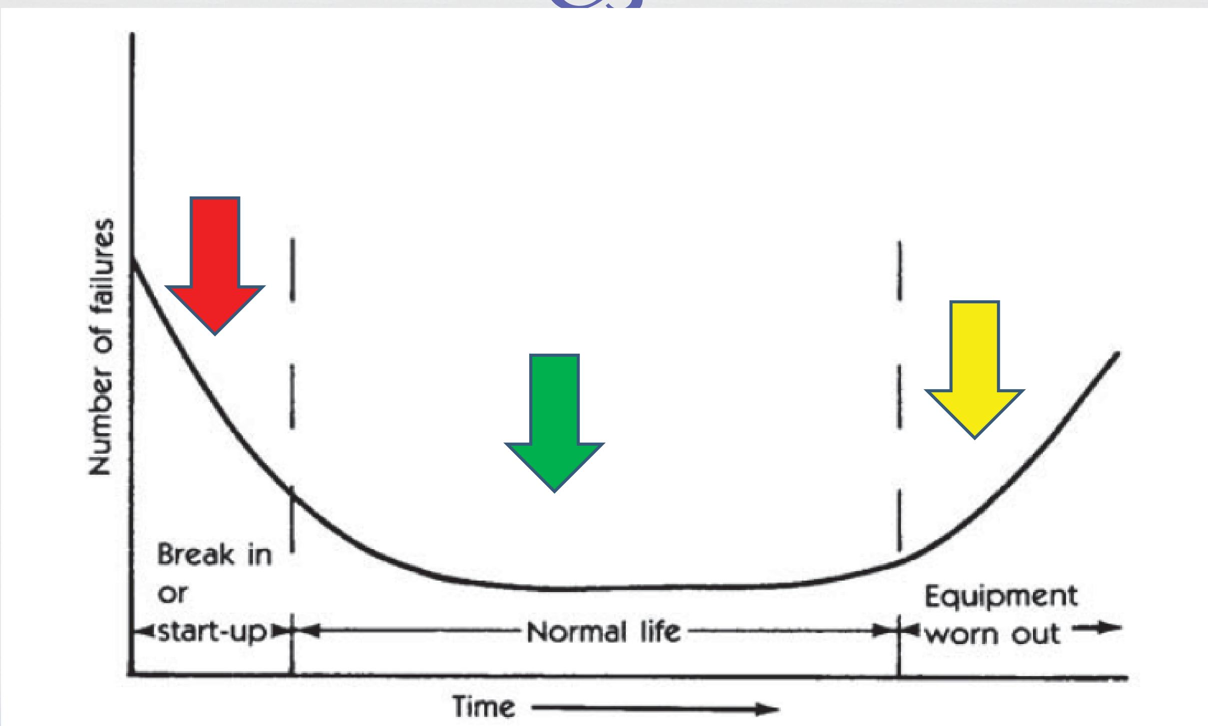
- **Failure has far reaching effects on a firm's**
  - Operation
  - Reputation
  - Profitability
  - Dissatisfied customers
  - Idle employees
  - Profits becoming losses
  - Reduced value of investment in plant and equipment
  - Employ's life threat

Maintenance and Reliability

Maintenance is all activities involved in keeping a system's equipment in working order

Reliability is the probability that a machine will function properly for a specified time

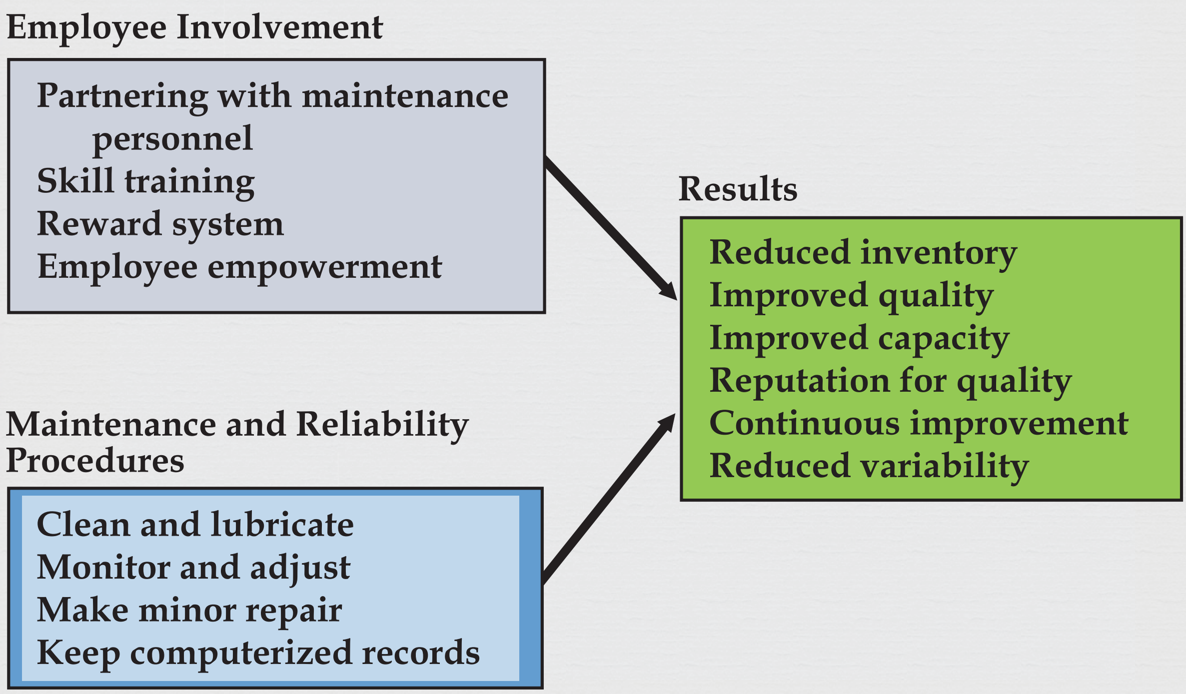
Equipment Life & Reliability
Bath Tub Chart



Important Tactics

- **Reliability**
  - **Improving individual components**
  - **Providing redundancy**
- **Maintenance**
  - **Implementing or improving preventive maintenance**
  - **Increasing repair capability or speed**

Maintenance Management



Reliability

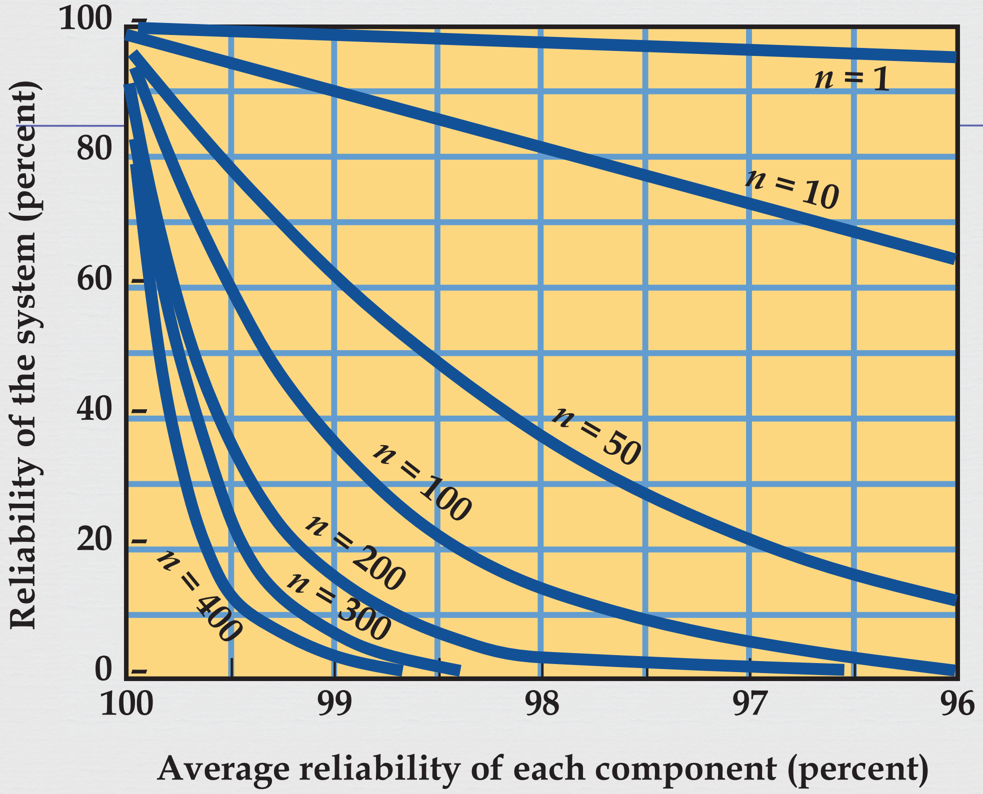
Improving individual components

$$R_s = R_1 \times R_2 \times R_3 \times \ldots \times R_n$$

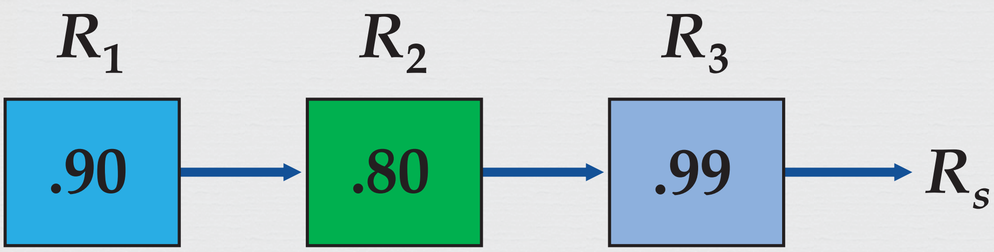
where R_1 = reliability of component 1
R_2 = reliability of component 2

and so on

Overall System Reliability



Reliability Example



Reliability of the process is

$$R_s = R_1 \times R_2 \times R_3 = .90 \times .80 \times .99 = .713 \text{ or } 71.3\%$$

Case study 1

Abnormal temperature at blower bearing observed

BRAIN STORMING

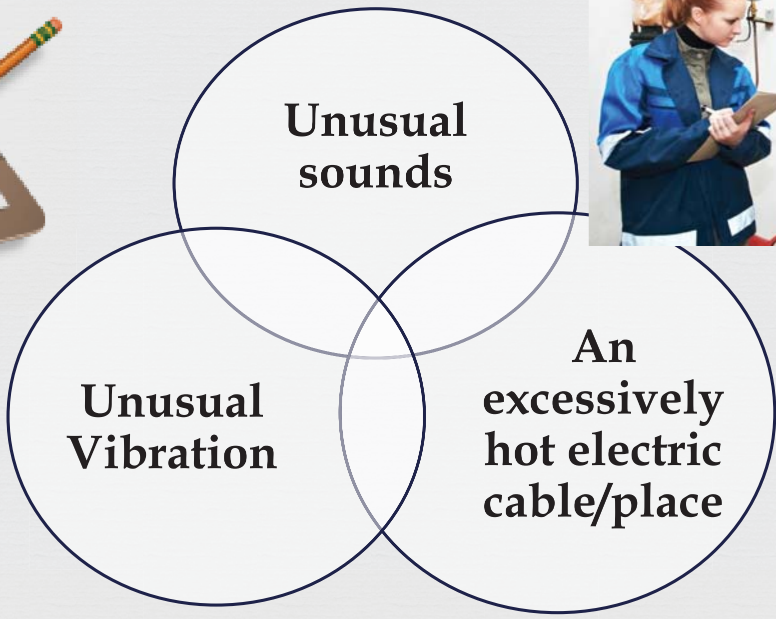
While visiting plant area your observed that there is abnormal sound in boiler feed water pump

What you will do being a maintenance engineer

Pd Maintenance Procedure

- Identify the work required
  - CMMS system (SAP Notifications)
  - Can be raised by “anybody”
- Review the Notifications
  - Done by somebody who understands business “risk”
  - Determine the business risk
    - Consequence & Probability
    - People, Assets, Environment, & Reputation
  - Convert Business Risk to Priority
  - Determine required **End Date** for work & drive Maintenance Execution to achieve this end date
- Assign to personnel to Scope & Plan work

Condition Monitoring System

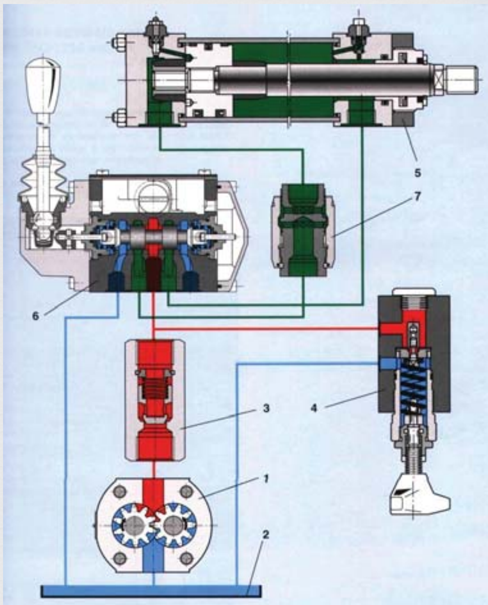


Predictive Maintenance Tools

- Oil Analysis
- Vibration analysis
- Infrared Thermography
- Oil and Water Analysis
- Other Tools:
  - Ultrasonic testing
  - Liquid Penetrant Dye testing
  - Shock Pulse Measurement (SPM)

Oil Analysis

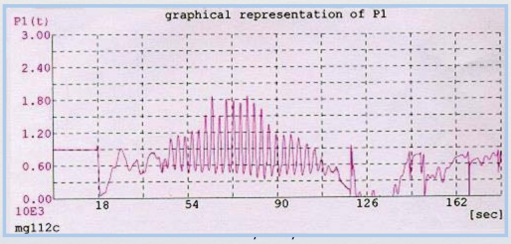
- Affects on Machine Devices
  1. Pumps
  2. Oil tank
  3. Flow control value
  4. Pressure relief valve
  5. Cylinders (counter balance)
  6. Directional control valves
  7. Throttle valve
  8. Heat exchangers



Oil Analysis (cont.)
What we measure

- Fluid Properties
  - Viscosity analysis
  - FTIR – Fourier transform infrared spectroscopy
  - Element analysis
- Contamination
  - Particle count
  - Moisture analysis
  - Patch Test
- Wear Debris
  - Wear debris density
  - Analytical ferrography
  - Elemental analysis

Vibration



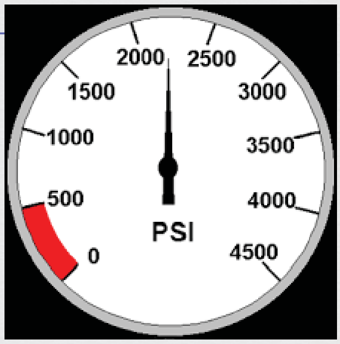
Vibration Analysis

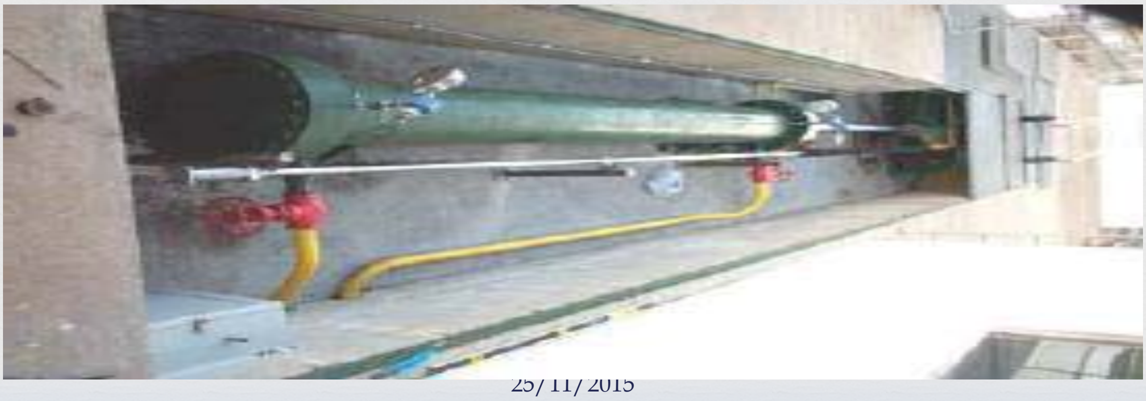
- Periodically collect and analyze vibration data on machine tools and components
- Install remote collection boxes and permanent mount accelerometers
- Field balancing on fans and blowers
- In Shop balancing (Balance Stand) on fans, blowers and rotating components

Vibration Analysis (cont.)

- Laser shaft alignment on rotating equipment (except process pumps)
- Laser sheave to sheave alignment
- Acceptance Testing on new equipment and components
- Assist shop personnel in troubleshooting suspect bearing and alignment problems
- Ultrasonic testing

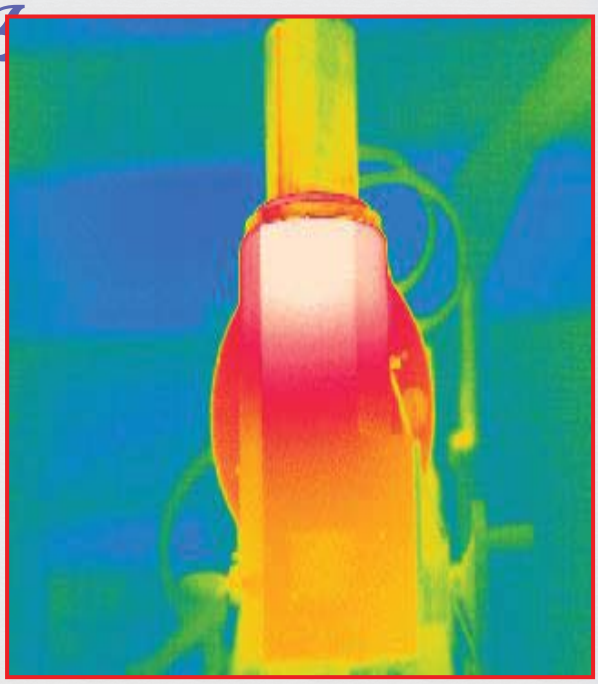
Temp & Pressure





Thermography

- Periodically inspect electrical components and control cabinets for heat related issues
- Assist shop personnel in troubleshooting suspect electrical problems
- New equipment acceptance testing



Thermography (cont.)

- Aids in identifying bearing and coupling problems in rotating equipment
- Identify heat exchanger problems
- Identify problems in heating and cooling coils
- Identify insulation problems with ovens and furnaces
- Identify problems with oven and furnace door seals

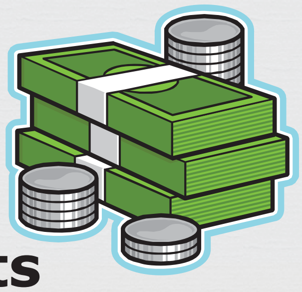
Complete Inspection

Predictive Maintenance
Other Tools and Techniques

- Ultrasonic and dye testing – used to find stress cracks in tubes, turbine blades and load bearing structures
  - Ultrasonic waves sent through metal
  - Surface coated with red dye, then cleaned off, dye shows cracks
- Shock-pulse testing – a specialized form of vibration analysis used to detect flaws in ball or roller bearings at high frequency (32kHz)

BENEFITS

Performance high level



Lowers repair costs

Lengthens lifespan

BENEFITS

Increases safety

Reduces interruption of services

Greater customer satisfaction

Positives

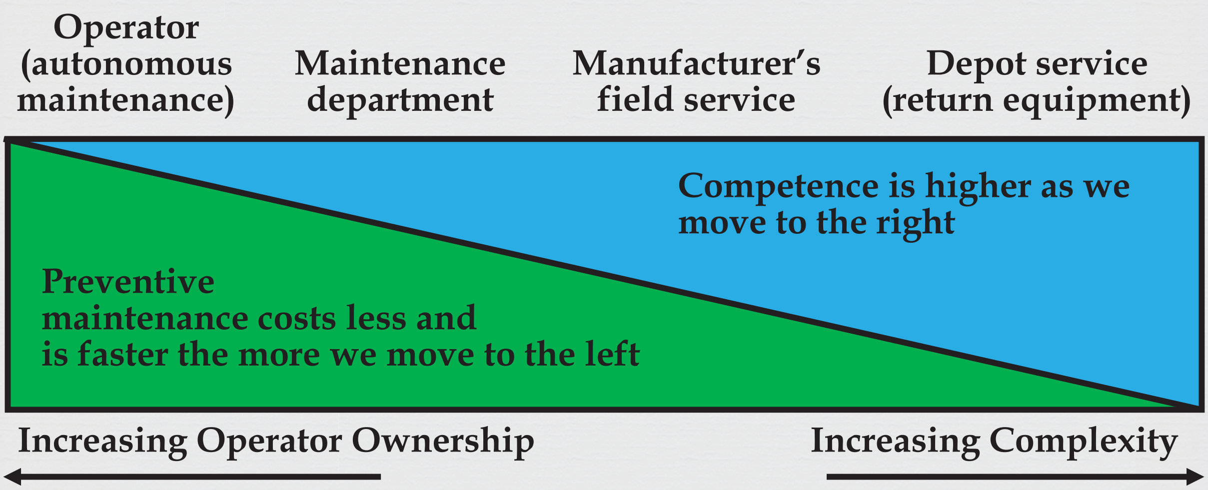
- Constant Monitoring of operation of equipment
- Monitoring can be done off site
- Improves accuracy of diagnostics
- Close to Real time information
- Predict repairs before failures
- Improves maintenance data

Negatives

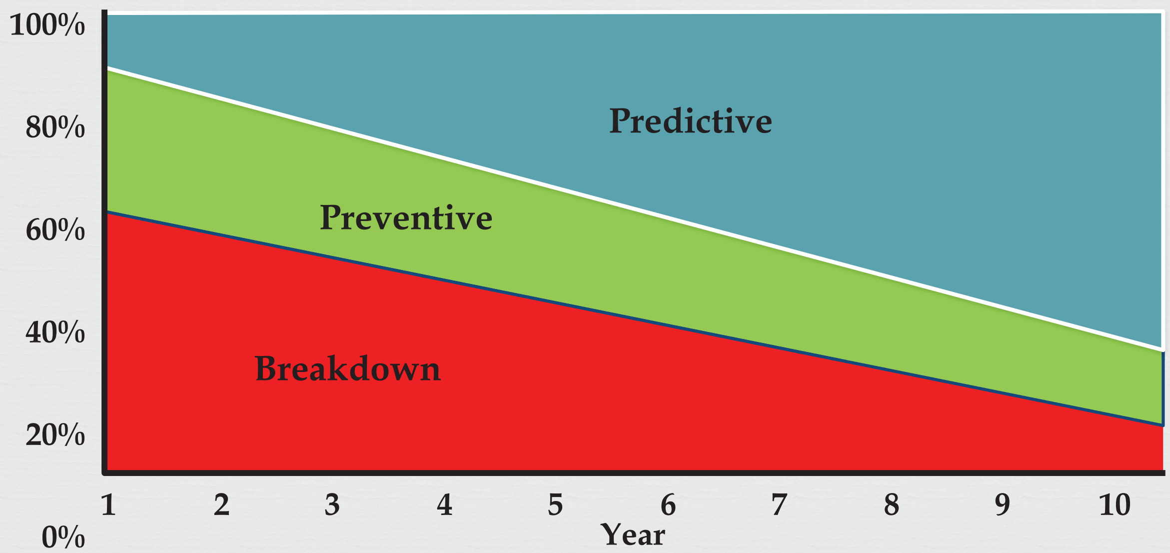
Requires more administrative manpower

Still evolving creating another set of issues

How Maintenance is Performed



Maintenance Strategy Implementation



Is Predictive Maintenance Cost Effective?

- In most industries the average rate of return is 7:1 to 35:1 for each predictive maintenance dollar spent
- Vibration analysis, IR thermography and oil/water analysis are all economically proven technologies
- The real savings is the avoidance of manufacturing downtime – especially crucial in JIT

Predictive/condition Monitoring schedule

Criticality	Frequency of Vibration capturing	Frequency of Signature analysis	No of equipment's
Super critical	7 Days	weekly	18
Critical	7 Days	only for those equipments which run above threshold limit	551
Semi critical	15 Days	only for those equipments which run above threshold limit	832
Essential	30 Days	only for those equipments which run above threshold limit	564

Best Practices

Replace Components Before Failure

Replace Units Before Major Failures

TCO Total Cost of Ownership

THANKS

Disclaimer

Data in these slides have been taken from different sources. Credit goes to original authors only

IJC PREDICTIVE MAINTENANCE PRACTICES AND ITS IMPACT ON RELIABILITY

Indo Jordan Chemical Co

IJC PREDICTIVE MAINTENANCE PRACTICES AND ITS IMPACT ON RELIABILITY

ABOUT THE COMPLEX

- The Phosphoric Acid Complex consists of
  - 700 MT P_2O_5 / day Phosphoric Acid plant, based on Hydro Agri's (Norway) Single Stage Hemi Hydrate process.
  - 2,000 MT H_2SO_4 /day Sulphuric Acid plant, based on Monsanto's (USA) Double Conversion Double Absorption process.
  - Associated Utilities.
- In addition, Phosphoric acid storage facility at Aqaba consists of
  - 4 X 5,000 m^3 capacity storage tanks.

Contents:

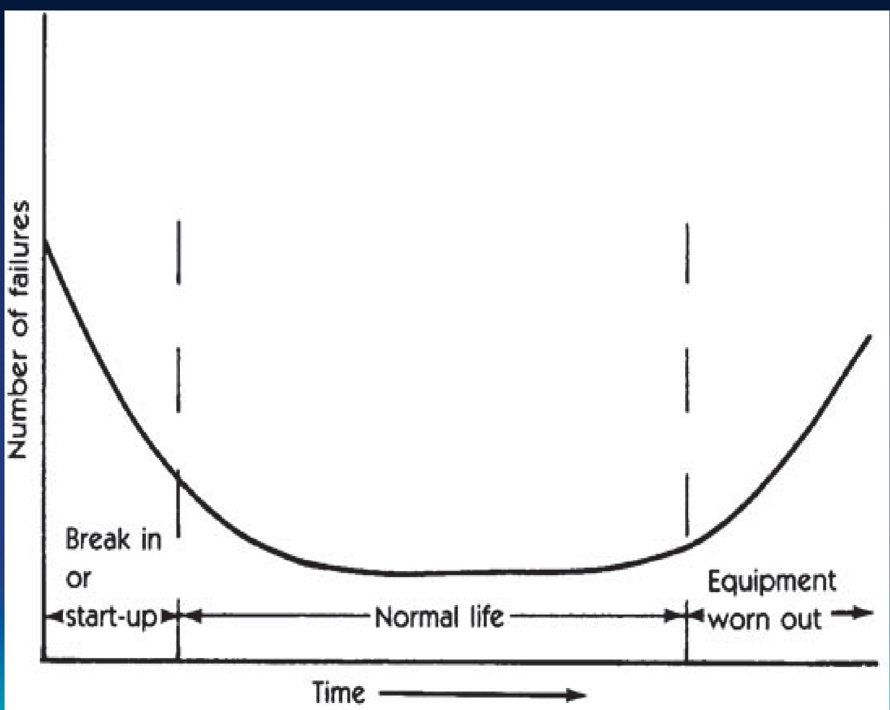
1. Difference between preventive maintenance and predictive maintenance.
2. IJC Implemented predictive maintenance in parallel with preventive maintenance.
3. Steps were followed to implement predictive maintenance.
4. Predictive Maintenance techniques.
5. Achievement and Impact on reliability.
6. Conclusion

1. Difference between preventive maintenance and predictive maintenance.

<u>Preventive maintenance:</u>

- Preventive maintenance is maintenance that is regularly performed on a piece of equipment to reduce the chance of failure .
- Preventative maintenance is performed while the equipment is still working, so that it does not break down unexpectedly.
- All preventive maintenance programs are **time-driven**, that is mean that maintenance based on history .

- Preventive Maintenance depend on MTBF



Predictive maintenance:

- The aim of predictive maintenance is to predict when equipment failure might occur.
- To prevent occurrence of the failure by performing maintenance.
- It is philosophy, or attitude, simply stated, uses the actual operating operation condition of plant equipments and system to optimize total plant operation.
- Predictive maintenance is a **condition- driven** preventive maintenance

2. IJC Implemented predictive maintenance in addition to preventive maintenance.

Preventive Maintenance	Predictive Maintenance
Routine of scheduling.	Data about the equipment is collected and analyzed .
Performing repair tasks before it becomes necessary.	Performing repair to predict a machine breakdown or failure.
Unneeded repairs can happen.	Repairs are made as needed.
More cost.	Less cost.
Reliability is less.	Reliability is high.

3.Steps Were Followed To Implement Predictive Maintenance.

Objective

- Minimize unscheduled equipment failures.
- Minimize maintenance cost.
- Minimize lost production.

Procedure

- Determine the equipments should be monitored.
- Determine the parameters that describe the operating condition.
- Finalized the required technique need to be followed for each equipment.

Documents

- Create standards. It is important to create standards for the implementation of the technology, analytical standards and reporting standards.
- Prepare the required documents need to be filled by the team.

3. Steps Were Followed To Implement Predictive Maintenance.

procurement
- Identify what type of instrument to be used.
- Procurement for required instruments. (vibration monitoring, thermometer

Training
- Dedicated and accountable personnel
- Train the required team for the task.
- Train the team to use the tools. Tools manufacture can help to train them.

Feed Back
- Check the accuracy of the data.
- Share the result with your team.

Predictive maintenance technique

1- Vibration Monitoring

- Portable Vibrometer is used.
- Identify the location for measurin and reference reading.

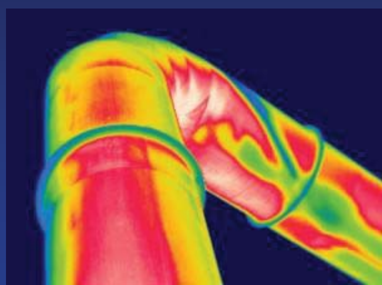
- Vibration readings were plotted.
- RCA for high vibration.
- Future plan: introduce the vibration analyzer.

2- Tribology

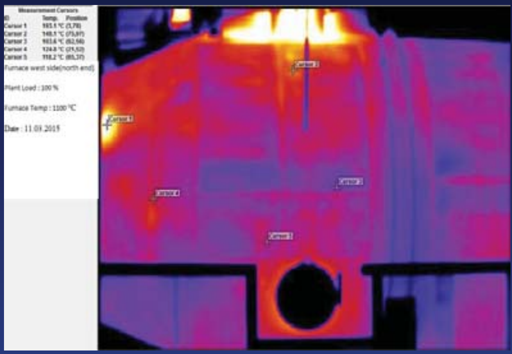
- Lubricating oil analysis.
- Conserve and extend the useful lubricants.
- Wear particle analysis provides direct information about the wearing condition of the machine.

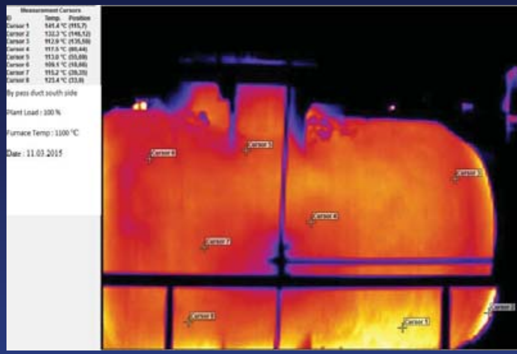
3- Thermography

- Identify the high temperature in equipments, that is indication for high friction.
- 
- High Temp in lines, vessels.



- 
- High Temp in electrical items.





4- Visual inspection

a) Ultrasound

- Use to monitor the noise level.

- The turbulent flow of liquids and gases through a restricted orifice (i.e., leak).

- Ultrasonic has been, and continues to be, a primary test methodology for materials testing

2) Visual inspection

- This can vary from one to others plants.
- Checking for any up normal condition.
- Checking for any external effect on the equipments.

Boiler Details

Boiler Reg. No.	: FM-038 / 52
Make	: M/s. Thermax Babcock & Wilcox Limited.
Year of Commissioning	: 1997
Boiler Capacity	: 30.6 TPH
Steam Pressure	: 12 Bar
Steam Temperature	: 192 °C (Saturated)
Duration of Study	: October 14th to October 17th 2014

Test scope and procedure

SR. No.	COMPONENT	AREA / LOCATION	TESTS TO BE CARRIED OUT
1	Steam Drum	• Drum internals • 100% ligaments	• Visual Inspection. • Florescent Magnetic Particle Inspection (FMPI)
2	Mud Drum	• Drum Inside. • 100% ligaments	• Visual Inspection. • Florescent Magnetic Particle Inspection (FMPI)
3	Water wall tubes	• Overall • On every alternate tube on RHS and LHS and rear wall. • Tube Sampling (3 Nos.)	• Visual Inspection • Ultrasonic Thickness Gauging. • Furnace wall tube sample for Laboratory testing.
4	Boiler bank tubes	• Overall • On accessible locations (Front and rearmost rows) at 2 elevations • On randomly selected tubes through drums	• Visual Inspection • Dimensional Measurement • Ultrasonic Thickness Gauging • Fiber optic Inspection
5	Boiler Operation & Maintenance	• Failure History study. • Boiler Operation Study. • Preservation methods study, if any. • Boiler maintenance study. Log sheet data study.	• Since commissioning

5. Achievement and Impact on Reliability.

- Ability to minimize the sudden break down for all rotary equipments.
- Increase the belt life in our horizontal vacuum belt filter to 4 years compare with before 3 years life. By close monitoring for the hardness and visual inspection.
- Replacement the waste heat boiler just on time before catastrophic failure.
- Replacement the turbine rotor just on time to improve the efficiency and prevent high vibration in turbine.

- Re gasket for plate heat exchanger before efficiency get reduced.
- Minimize the over-time cost.
- Minimize the inventory.

Conclusion

If we don't apply the Pdm

- Maintenance always need to be standby.
- Maintenance Over-Time will be increased.
- Damage will extend further.

If we apply the Pdm.

- Simply Maintenance team and Management will be happy

  - No surprise break downs
  - Reduced need for “back up” equipment
  - Minimize maintenance resource

THANKS

الإتحاد العربي للأسمدة
Arab Int'l Organization منظمة عربية دولية
Arab Fertilizer Association
Since 1975

الشركة العمانية الهندية للسماد
OMIFCO

Quality Control and Assurance in Maintenance in Fertilizer Industry Workshop

Day 2

Tuesday: Nov. 24, 2015

Muscat - Sultanate Oman

23-25 November 2015

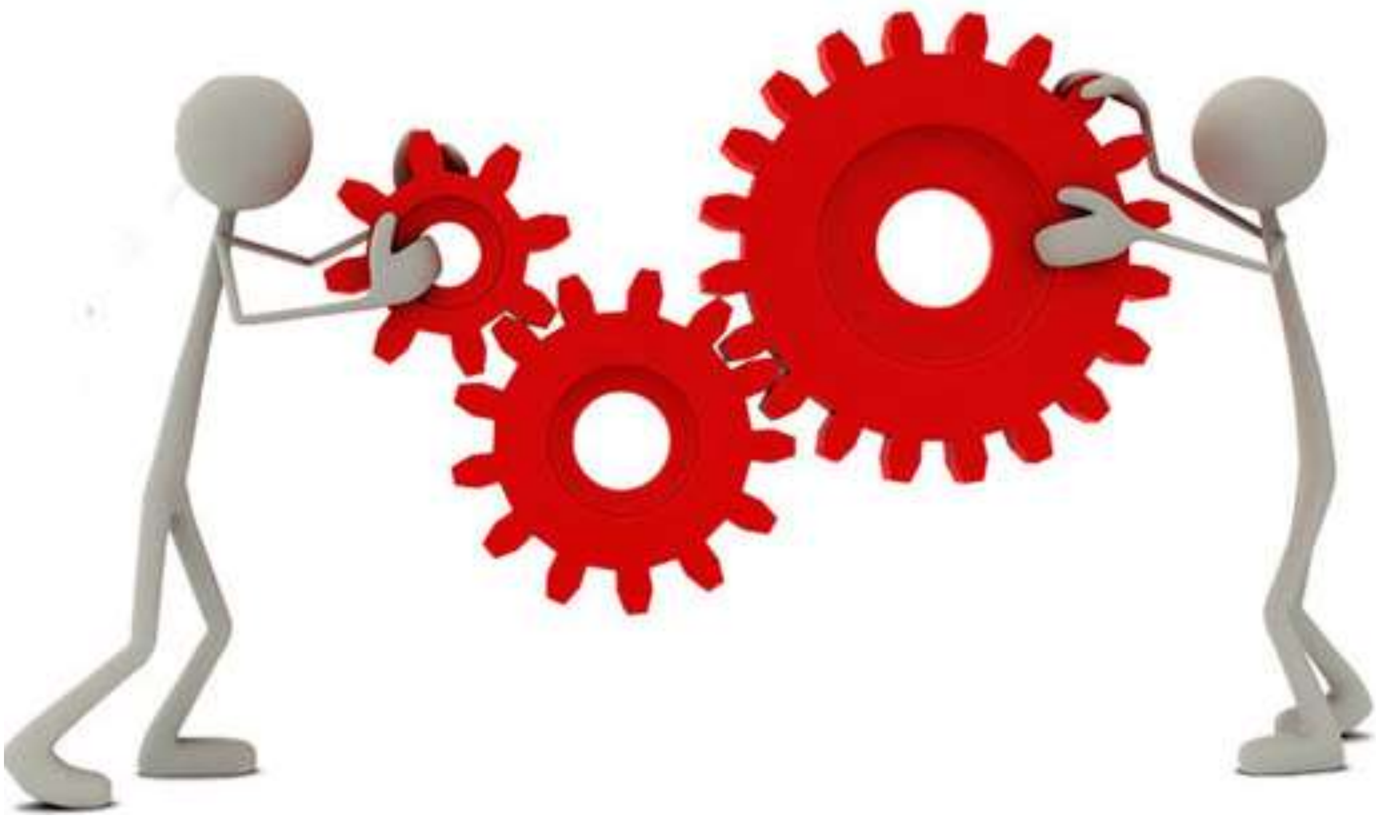
TURNAROUND MANAGEMENT AND IMPACT OF EFFECTIVE PREVENTIVE MAINTENANCE PROGRAMS.

Engr. Muhammad Sajid
Lecturer
University of Gujrat, Pakistan

AFA Workshop on "Quality Control & Assurance in Maintenance in Fertilizer Industries"
Muscat, Oman 23 – 25/11/2015

TOPICS

- Preventive Maintenance
- Turnaround Management



Objective

- Describe preventive maintenance
- Discuss why PM is required
- History of maintenance
- Effectiveness of PM system

Preventive Maintenance

- Scheduled
- Planned maintenance actions
- Prevention of breakdowns and failures.
- The primary goal of preventive maintenance is to prevent the failure of equipment before it actually occurs.

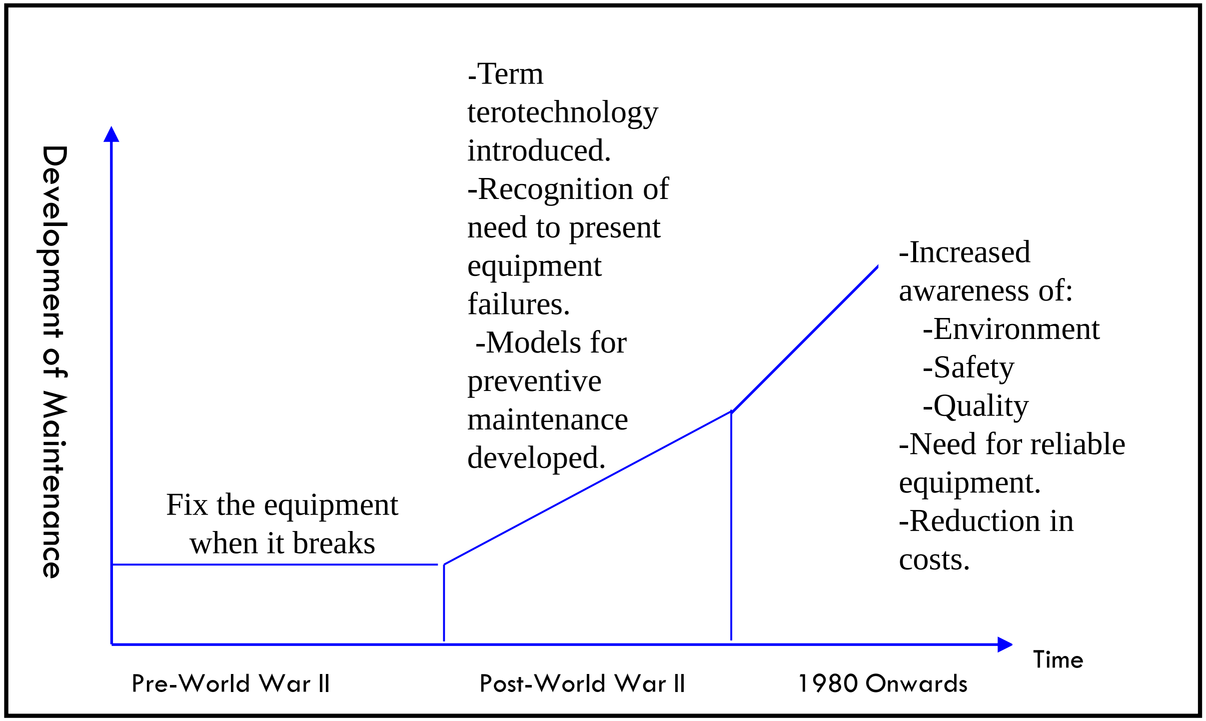
Preventive Maintenance

It is designed to preserve and enhance equipment reliability by replacing worn components before they actually fail.

Why PM system…

- Increased Automation
- Business loss due to production delays
- Production of a higher quality product
- Just-in-time manufacturing
- Need for a more organized, planned environment

HISTORY



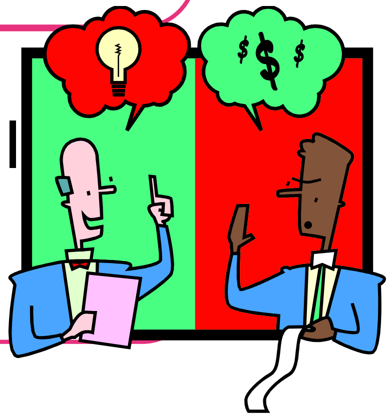
Maintenance History
(Adapted From Shenoy, Bhadury 1998)

Advantages of a PM system

Reduced production downtime, resulting in fewer machine breakdowns.

Better conservation of assets and increased life expectancy of assets, thereby eliminating premature replacement of machinery and equipment.

Timely, routine repairs circumvent fewer large-scal repairs.



Continued -

Reduced cost of repairs by reducing secondary failures. When parts fail in service, they usually damage other parts.

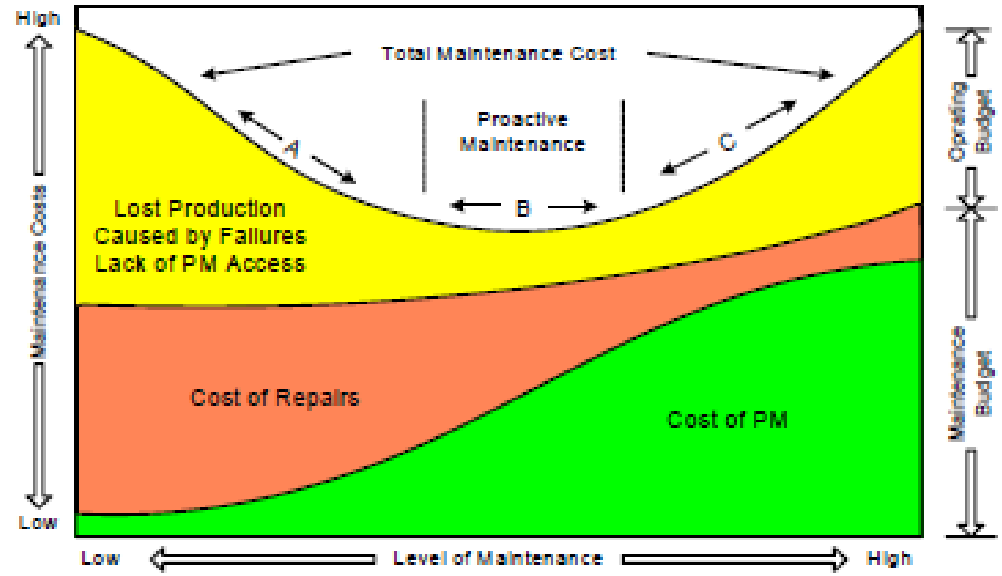
Better quality products

Identification of equipment with excessive maintenance costs

Improved safety and quality conditions.

PM---- A Controlled Experiment

Do not attempt to immediately PM everything apply A-B-C Analysis to equipment criticality build upon early successes.



Reactive Maintenance
Excessive Repairs & Failures

Excessive PM
No Failures & No Repairs

Total Maintenance Related Cost = Cost of PM
+
Cost of Repairs
+
Cost of Production Losses caused by Failures & PM Time

* Excessive Tinkering

Manage Maintenance – Do not allow it to control Operations!
PM does not achieve reliability, it preserves reliability!

Indicators of Ineffective PM

Low equipment utilization due to unscheduled stoppages

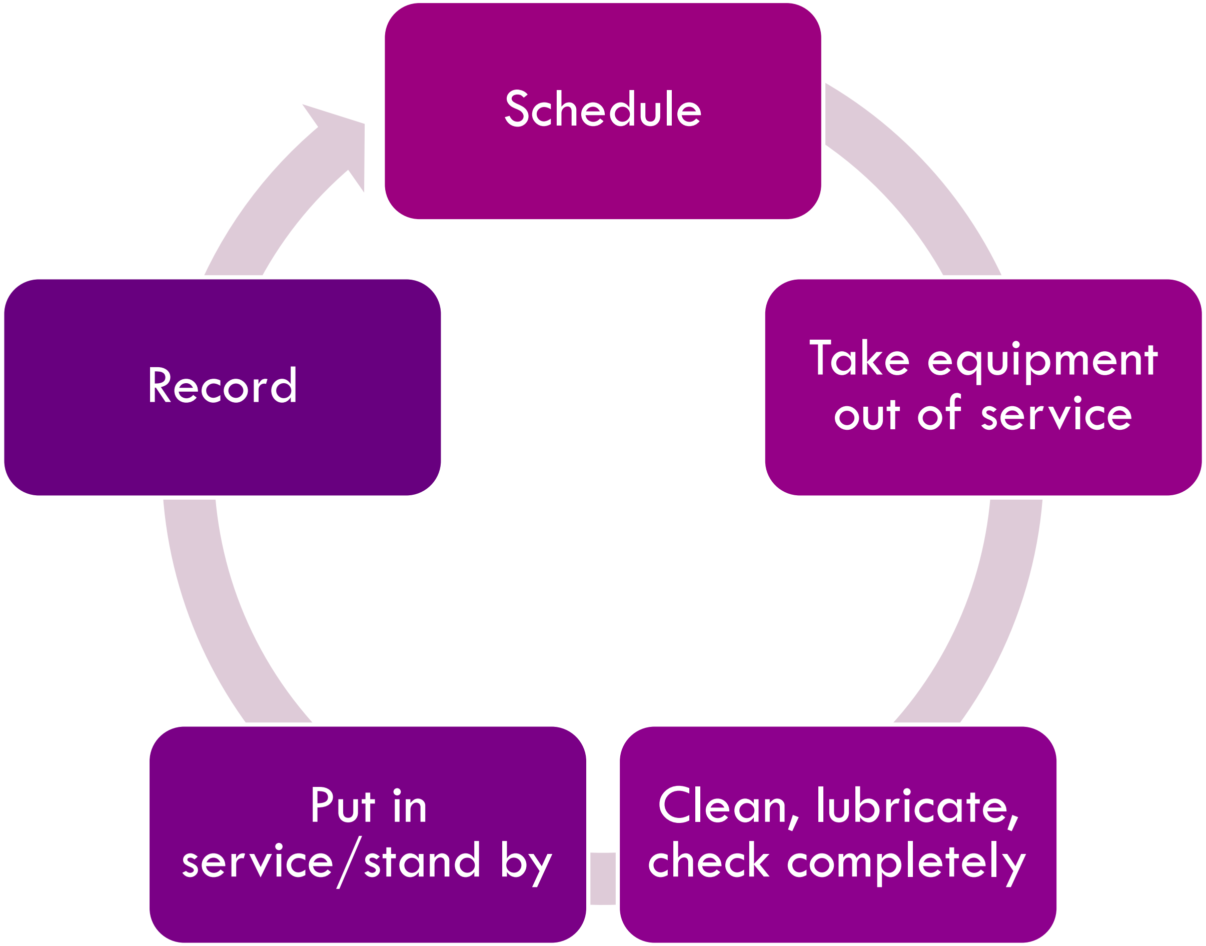
High wait or idle time for machine operators during outages

High scrap and rejects indicative of quality problems

Higher than normal repair costs due to neglect of proper lubrication, inspections or service.

Decrease in the expected life of capital investments due to inadequate maintenance

Preventive Maintenance Process



DETAIL OF CATEGORIES

CATEGORY-A (MONTHLY)

- Add oil if required.
- Clean oil bulbs and level windows.
- Check gland/seal leakage.
- Check ΔP of Lube oil filters.
- Cleaning, greasing of bearings and megger test of the motor.
- Flush cooling water lines.
- Inspection/Clean suction strainer.

CATEGORY-B (03 MONTHS)

- Check Coupling elements and tighten bolts, if required.
- Inspection and cleaning of suction strainer
- Check air breathers.
- Flush cooling water lines.
- Check/replace lube oil filters.
- Replace oil/grease.
- All jobs of category A

DETAIL OF CATEGORIES

CATEGORY-C (06 MONTHS)

- Check alignment.
- Check bearing condition.
- Check and clean Coupling shim pack.
- Replace plungers and valves.
- Inspection of gear box and clutch box.
- Inspection of suction/discharge valves and NRV's
- All jobs of category B

CATEGORY-D (YEARLY)

- General checking/overhauling of all the equipment.
- Check foundation bolts.
- Check Mechanical/Carbon packing.
- Clean Lube oil coolers.
- All jobs of category C

PREVENTIVE MAINTENANCE SCHEDULE OF AMMONIA PLANT

Sr.No.	Equipment Name	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	BOILER FEED WATER PUMP A104-J	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)
2	BOILER FEED WATER PUMP A104-JA	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)
3	BOILER FEED WATER PUMP A104JB	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)
4	AMMONIA INJECTION PUMP A108-LJ	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)
5	AMMONIA INJECTION PUMP A108-LJA	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)
6	PHOSPHATE DOSING PUMP A107-LJ	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)
7	PHOSPHATE DOSING PUMP A107-LJA	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)
8	HYDRAZINE DOSING PUMP A103 LJ	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)
9	HYDRAZINE DOSING PUMP A103 LJA	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)
10	QUENCH WATER PUMP A-109-J	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C,D (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C (2nd WEEK)
11	QUENCH WATER PUMP A109-JA	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C,D (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C (2nd WEEK)
12	SEMI LEAN SOLUTION PUMP A107-J,JHT	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C,D (2nd WEEK)
13	SEMI LEAN SOLUTION PUMP	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C,D (2nd WEEK)

What really should PM focus on?

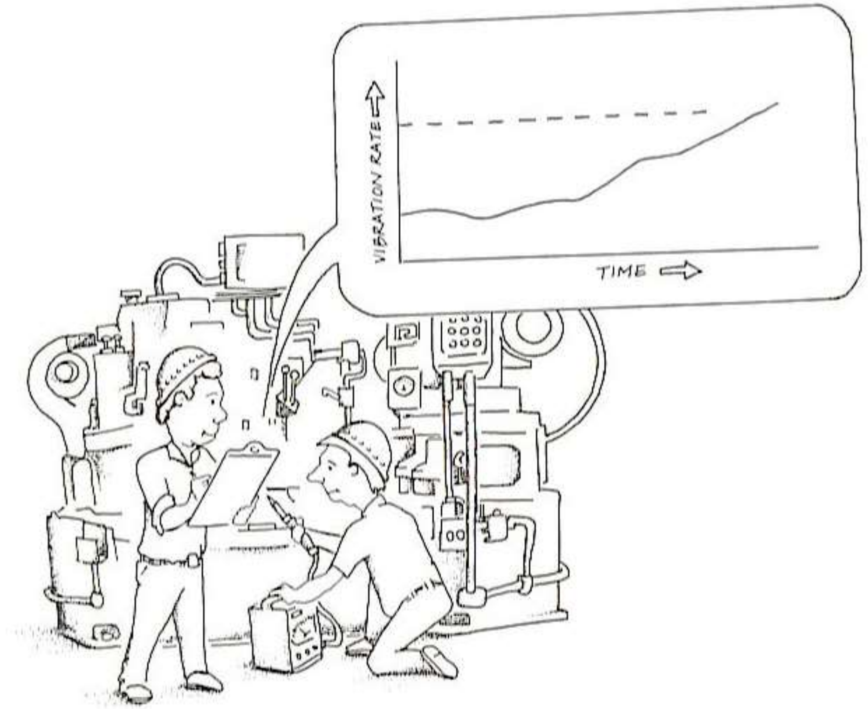
- Cleaning
- Lubrication
- Correcting deficiencies

} Found through testing and inspection

Predetermined parts replacement should be minimal and done only where statistical evidence clearly indicates wear-out characteristics

Three Principles of Prevention

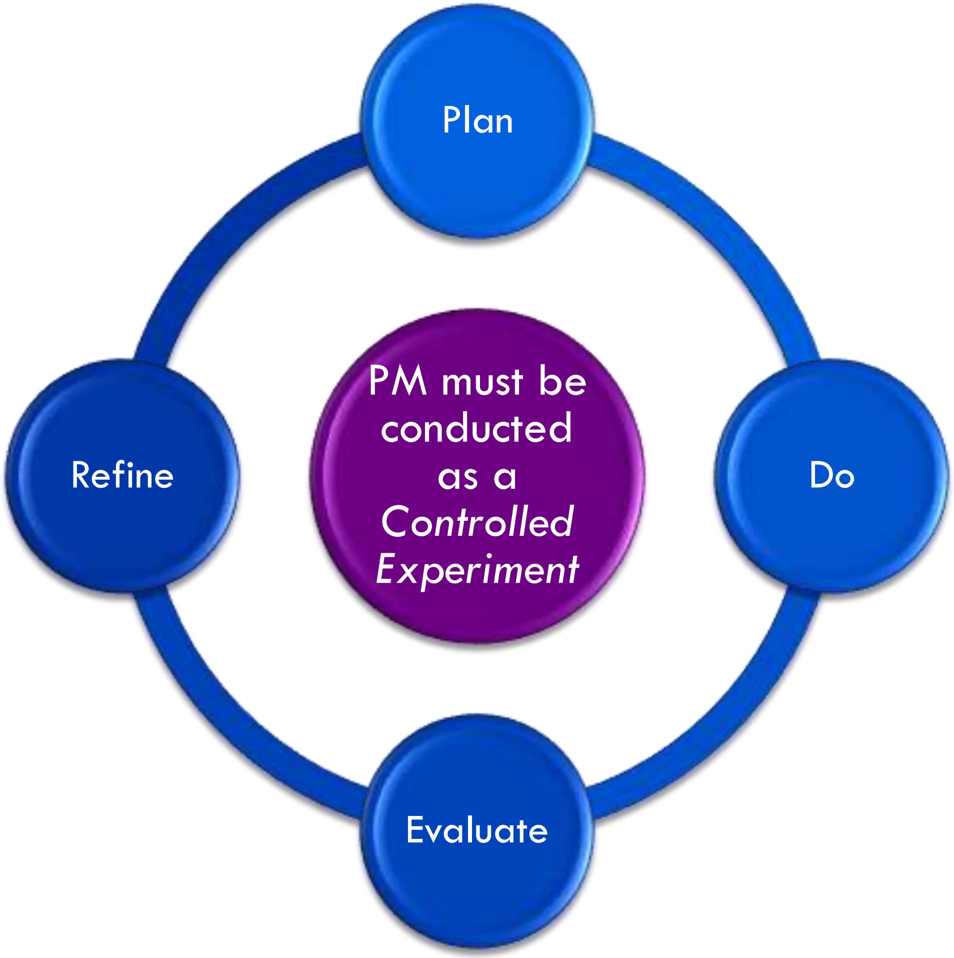
- Maintenance of normal conditions
- Early discovery of abnormalities
- Prompt response



Effective PM Requires:

- Top management understanding of the *true cost of poor maintenance*, which is several times initial estimate
- Sustained management leadership and absolute commitment
- Knowledge of equipment/process conditions required to yield quality, output, safety, and compliance standards
- PM and other programmed maintenance must be a normal part of schedule and capacity determination. Management must insure that PPM is never delayed.
- Weekly adherence to a balanced PM schedule

PM


Plan
Refine
PM must be conducted as a *Controlled Experiment*
Do
Evaluate

TURNAROUND

Objective

- What is turnaround
- Describe motivation is turnaround
- Effective turnaround process
- Key performance indicators
- Effect of PM system on turnaround

TURNAROUND

- Annual/biannual
- Planned
- Wanted
- To keep system operative for rest of the time

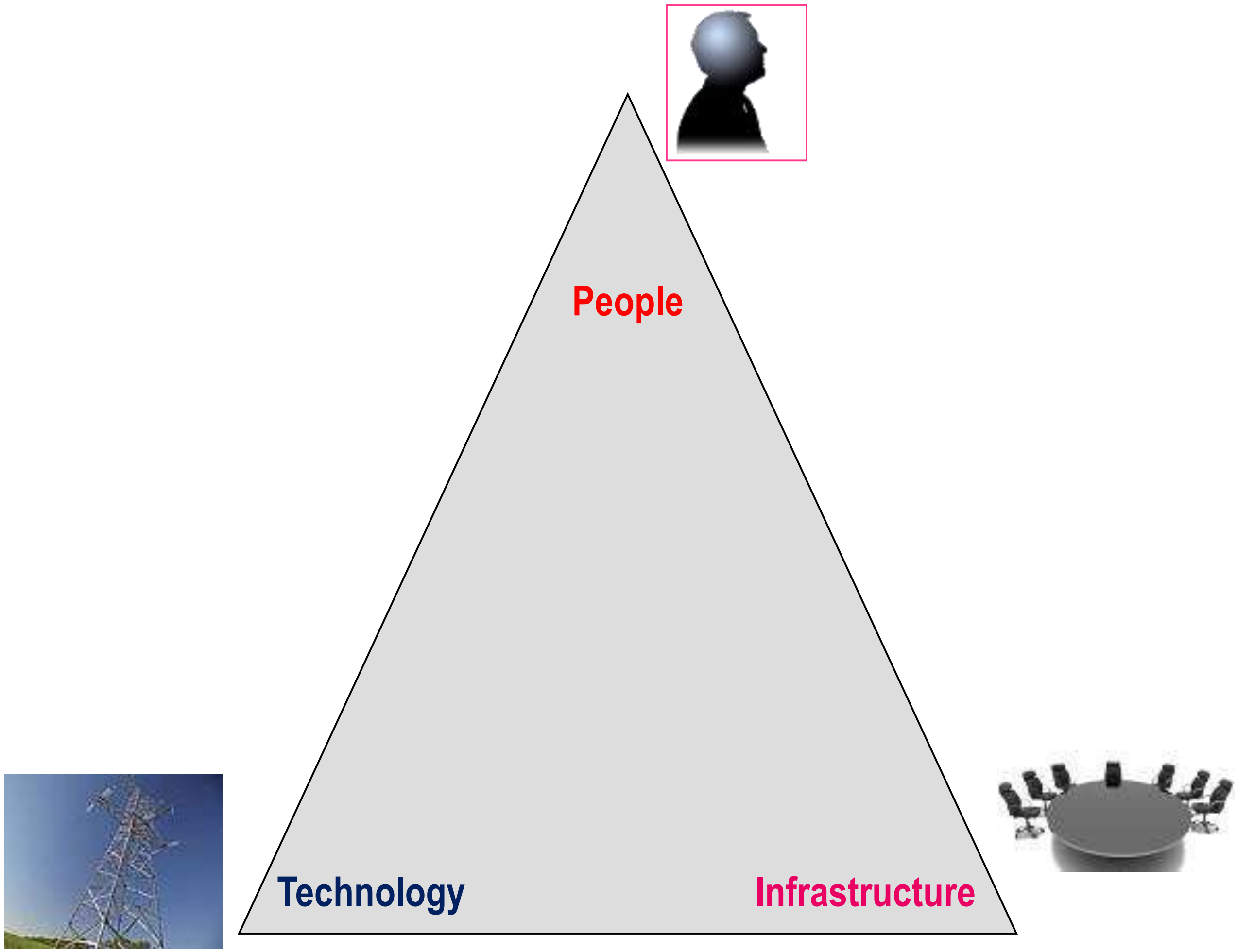
Motivation

- Firms are expected to adopt turnaround (financial and corporate) strategies when they experience performance shocks.
- Turnaround actions include
  - Financial strategies
  - Corporate restructuring strategies

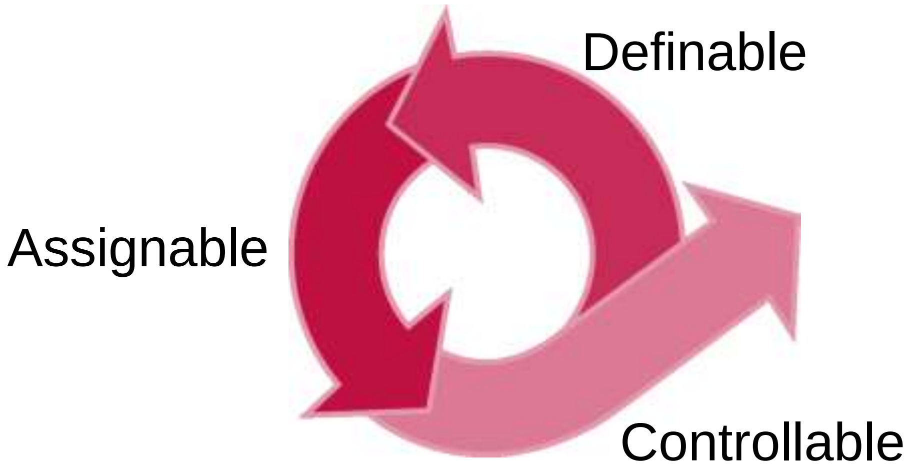
Motivation

- Do firms adopt turnaround strategies to deal with performance shocks?
- Do turnaround strategies result in performance improvement? (contemporaneous and/or lagged)
- Is there any interaction effect of turnaround actions on firm performance?

TURNAROUND REQUIREMENTS



TURNAROUND



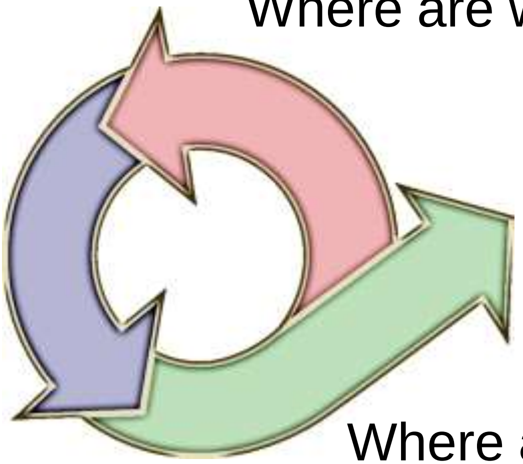
ELEMENTS OF TURNAROUND

- Detailed planning and organization of the work involved
- Removal of assets from production
- Inspection and work execution, product changes, repairs, improvement activities or a combination of these
- Restart of the asset/unit/plant and restoration to “should” performance levels

Overview

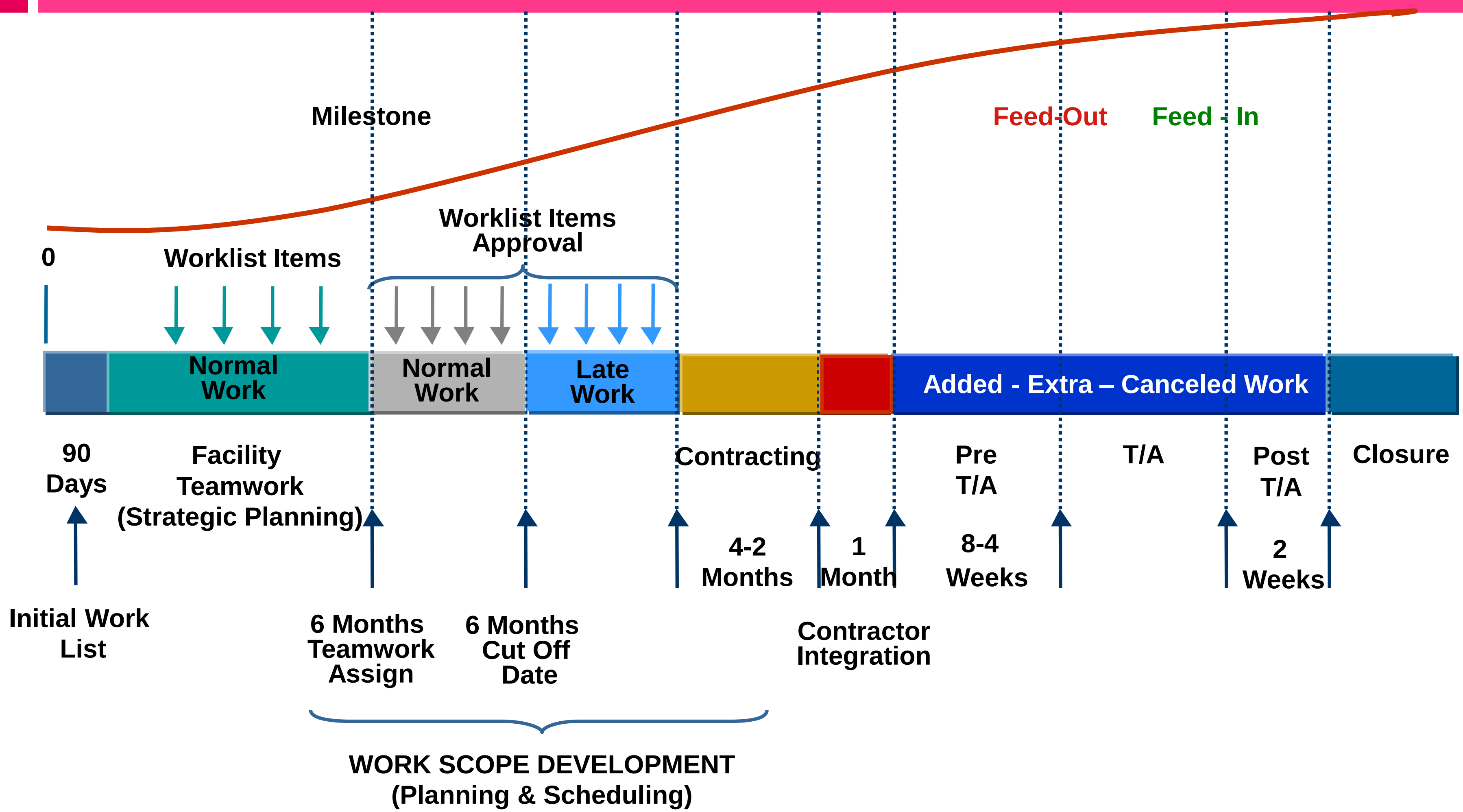
Where are we?

Where should we



Where are we going?

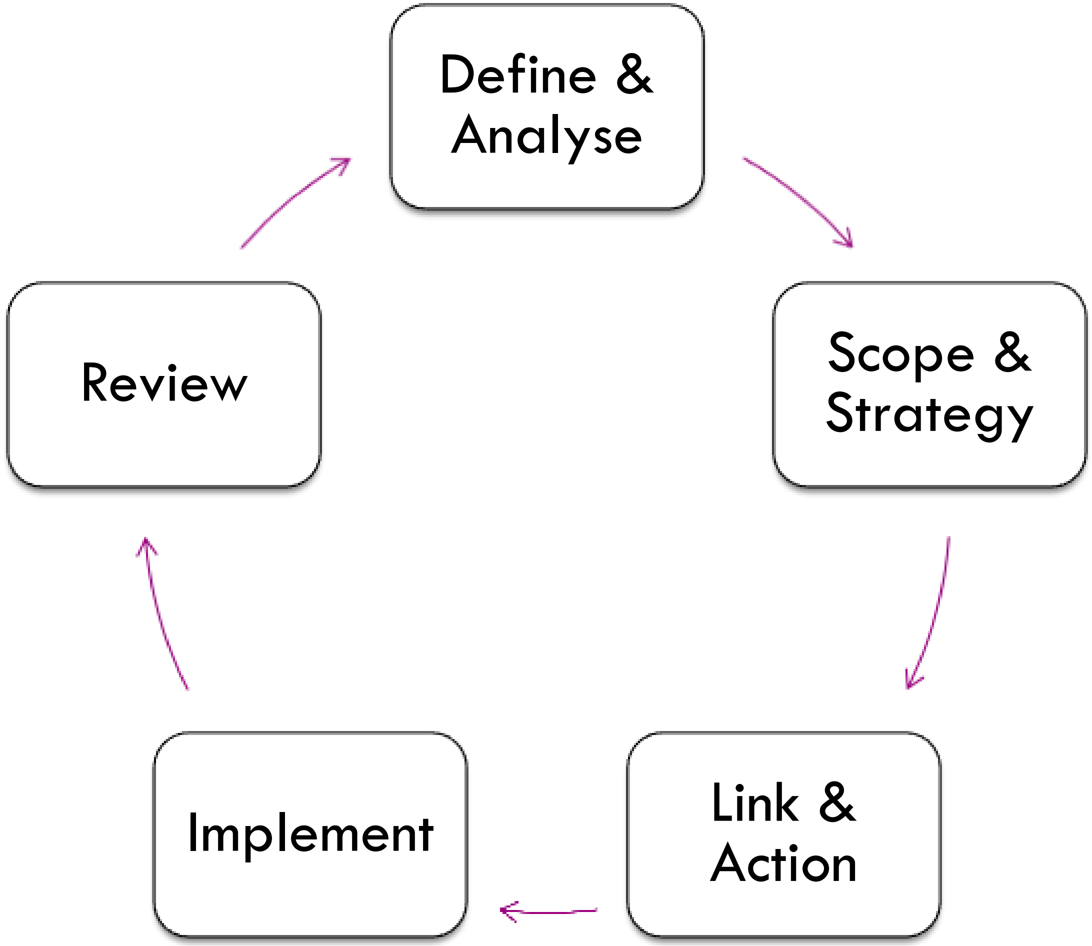
Turnaround Management Process – Project Management



Support, Resources and Associated Responsibilities

- Position Titles
- Roles and Responsibilities (Workflow Activities)
- Qualification, Certification and Training Requirements
- Contract versus In-house
- Responsibility Matrix
- Activity / Task Identification (Milestone Schedule)
- Best-practice Guidelines and Procedures
- Accountability – Weekly Project Management Meeting
- Project Management Software
- Resource performance assessments, daily, weekly, based on activity completion – quantity and quality

Turnaround Management Process



Pre-turnaround

- Manage upwards as well as downwards
- Managing a large Program requires input from various stakeholders
- Shutdown Steering Group to set strategic direction
- Cross-section of senior management
- Must have a Charter (avoid micro-managing)

Milestone - Plant Turnaround Management Process

Milestone	Phase	Origin	Area of Responsibility	Time to Plant Shutdown Date
Selection of T/A manager	1	Process	Owner	
Turnover meeting	1	Process	Outgoing T/A Manager	
Initial cost estimate	1	Process	T/A Team	
Work breakdown structure	1	Process	T/A Manager	
Cost Control Structure	1	Process	Administration	
Organizational Breakdown Structure	1	Process	T/A Team	
Work list cut-off date	2	Process	T/A Team	
Support plans complete	2	Process	Support plan rep	
Work Package complete	2	Process	Planning	
Master Execution Sched complete	3	Process	Scheduling	
Detailed cost estimate	3	Process	T/A Manager	
Procurement of materials	3	Process	Procurement	
Procurement of machinery	3	Process	Procurement	
T/A Readiness Review Audit	3	Process	T/A Team	
Plant feed-out	4	Process	Operations	0 months
Plant feed-in	4	Process	Operations	
Reports & documents complete	5	Process	T/A Team	
Evaluate plant turnaround	5	Process	T/A Team	
Postmortem meeting	5	Process	T/A Manager	
T/A Summary report	5	Process	T/A Manager	

Turnaround Planning

- How are you going to do the work?
- Basic requirements:
  - Job Tasks, Steps, Duration, & Sequence
  - Resources
    - People
    - Materials
    - Tools
    - Equipment
  - Cost Estimate
  - Risk Assessment
  - Safety Requirements

PLANNING

- Must Justify why a job is being done in Shutdown

CRIT	Shutdown criteria
DUR	Duration
DIS	Can only be done while equipment is disassembled for other shutdown work
SYN	Synergies with doing work in conjunction with other shutdown work
UTIL	Utility equipment that is only available during shutdown period
HAZ	Work of a hazardous nature that must be done while plant is isolated
OTH	Other (please advise)

GANTT CHART DEVELOPMENT

- A Gantt Chart is required
- Develop a Critical path
- Duration to be prime-to-prime
- Have ONE schedule
- Duration of each step to be such as to be easily tracked
  - Less than reporting period (target for <12 hours)
  - Larger jobs to have milestones or other metric to track progress
- Create a Baseline & track progress against the baseline

RISK ANALYSIS

- Use a Risk Management Process
- Potential Problem Analysis
- PPA Criteria
  - Quality Critical Work
  - Reliability Critical Work
  - Safety
  - Critical Path
  - Tasks with prior problems
  - New &/or Unusual Tasks
  - Work Group Involvements
  - Review job again if criteria changes

SCHEDULING

- When you are going to do the work?
- Scheduling involves several key plant stakeholders
  - Supervisors (own the labour & equipment resources)
  - Operations (own the plant)
  - Scheduler (**builds** the schedule)
  - Warehouse (owns the materials)
- Someone must "own" the Schedule (senior role)
- Cyclic process (usually weekly)
- Separate roles for Planning & Scheduling

EXECUTION

- Do the work
  - Do the work you say you are going to do
  - Do it when you say you are going to do it
  - Like taking your car in for a service
- Measure performance by KPIs
  - Schedule Attainment
  - PM Compliance
  - Orders completed by required end date
- Ownership of KPIs is at the appropriate stakeholder
  - **NOT** the Planner (or Scheduler)
  - Schedule Attainment → Supervisor
  - PM Compliance → Maintenance Engineer
  - Orders by End Date → Maintenance Engineer

Execution Phases

Pre-Execution

Execution

Post-Execution

Execution Phases

Pre-Execution:

- Physically preparing work-site and equipment.
- Planning work activities.
- Defining the schedule.
- Procuring Parts, Labor & Equipment

Execution Phases

Execution:

- – Physically executing the work.
- – Reporting progress and actuals.
- – Creating/planning follow up work.
- – Managing Schedule and Cost.

MEETING STRUCTURE

Consistent meeting times

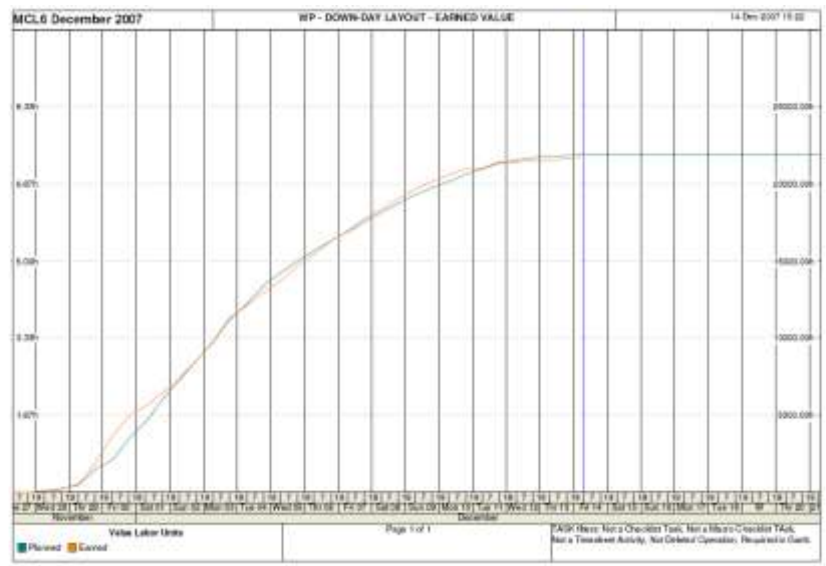
- 09:30 AM Morning Area Meeting
- 4:00 PM Managers Meeting

Schedule Updates

- 7:45 AM Update for Morning Meeting
- 3:15 PM Update for Night Shift

FEED BACK

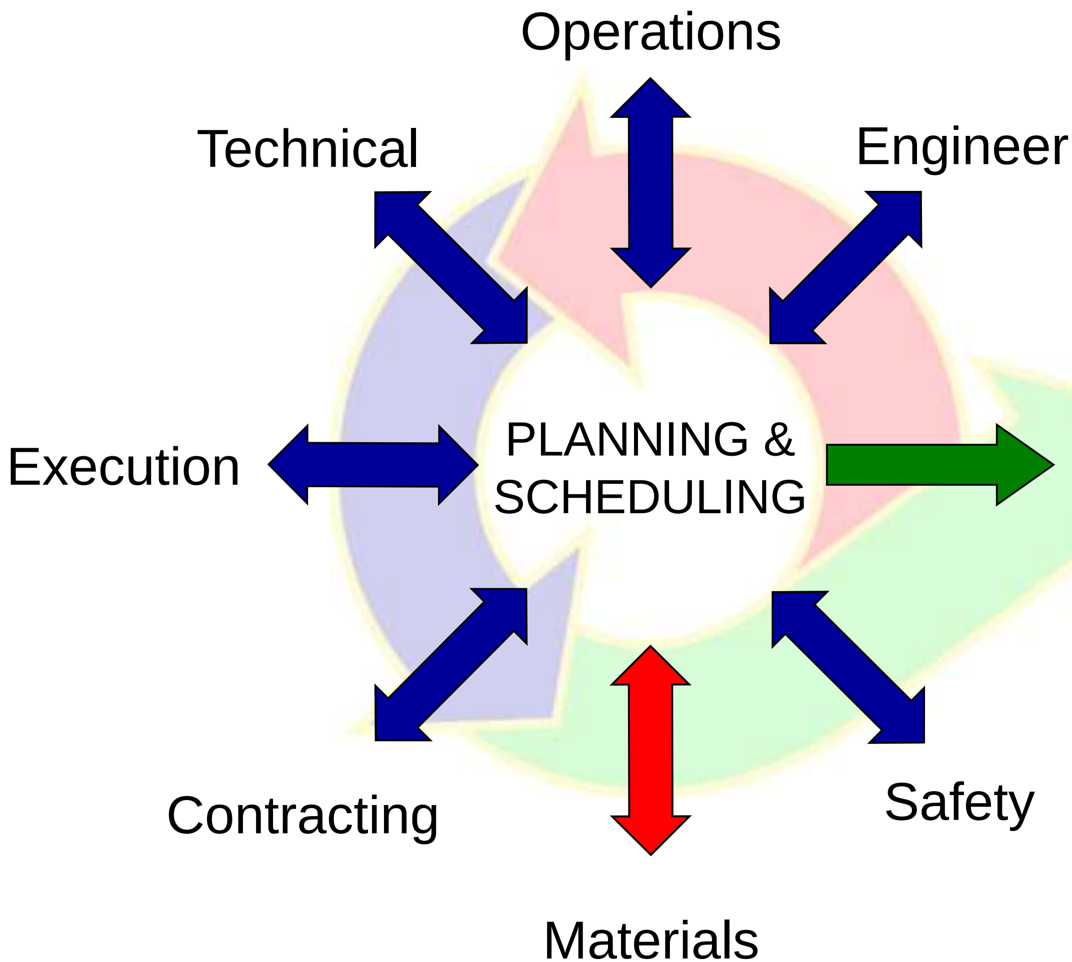
- Tool for tracking progress against schedule
- Quickly shows if you are falling behind schedule
- Forecast costs to complete work



SHUTDOWN COMMUNICATIONS

- Email is a problem
  - Reply All
  - Mass Distribution lists
  - Not everyone has email access
- Noticeboards not very effective
- Tool-Box talks are very effective
- Meetings work well
- Large mass meetings do not work well
- Signs work well for operators
- Flashing signs work extremely well
- Your audience is not homogenous
- People will generally not spread rumours that they believe are not true

COMMUNICATION STRATEGY



FACILITY MANAGEMENT

- ✓ Turnaround Project Status
- ✓ Key Performance Reports

Execution Phases

Post-Execution:

- Physically disassembling work-site and activating equipment.
- Actuals data reconciliation.
- Invoice payments.
- Material reconciliation

CLOSE-OUT

- Often forgotten part of process
- Record completion of each step
- Collect hours worked
- Collect history (damage, cause, activities)
- Determine costs
- Continuous learning

WORKFLOW

Putting it all together

POST SHUTDOWN REVIEW

- Carry out SWOT Analysis
  - Consolidate issues
  - Feed-Back into Management Plan for future shutdowns
- Some issues that came out of manufacturing site shutdown
  - Need two night shift managers
  - Need to update schedule twice per day
  - **Supply Department was very happy**
  - No IT issues
  - **Site Security not up to scratch**
  - **Steering Group worked well**
  - **Site Wide Coordination worked well (forum of regular Meeting)**
  - Communication needs a lot of work
  - **Fix the phones**

Effective Turnaround

- Effective Turnaround Management is dependent on performance from all Functional Areas and Stakeholder Departments

- Technical
- Engineering
- Logistivs
- Project cost control
- scheduling

- Contracting
- Planning
- Execution
- Safety
- Materials

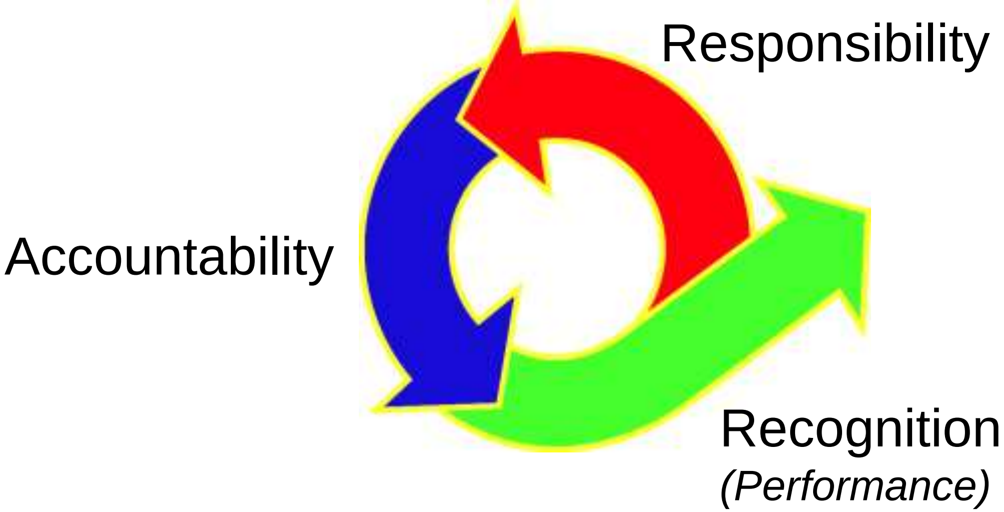
- Administration / Resources
- Process Operations
- Workscope Optimization
- Capital Work
- Routine Maintenance

Effective Turnaround (Cont…)

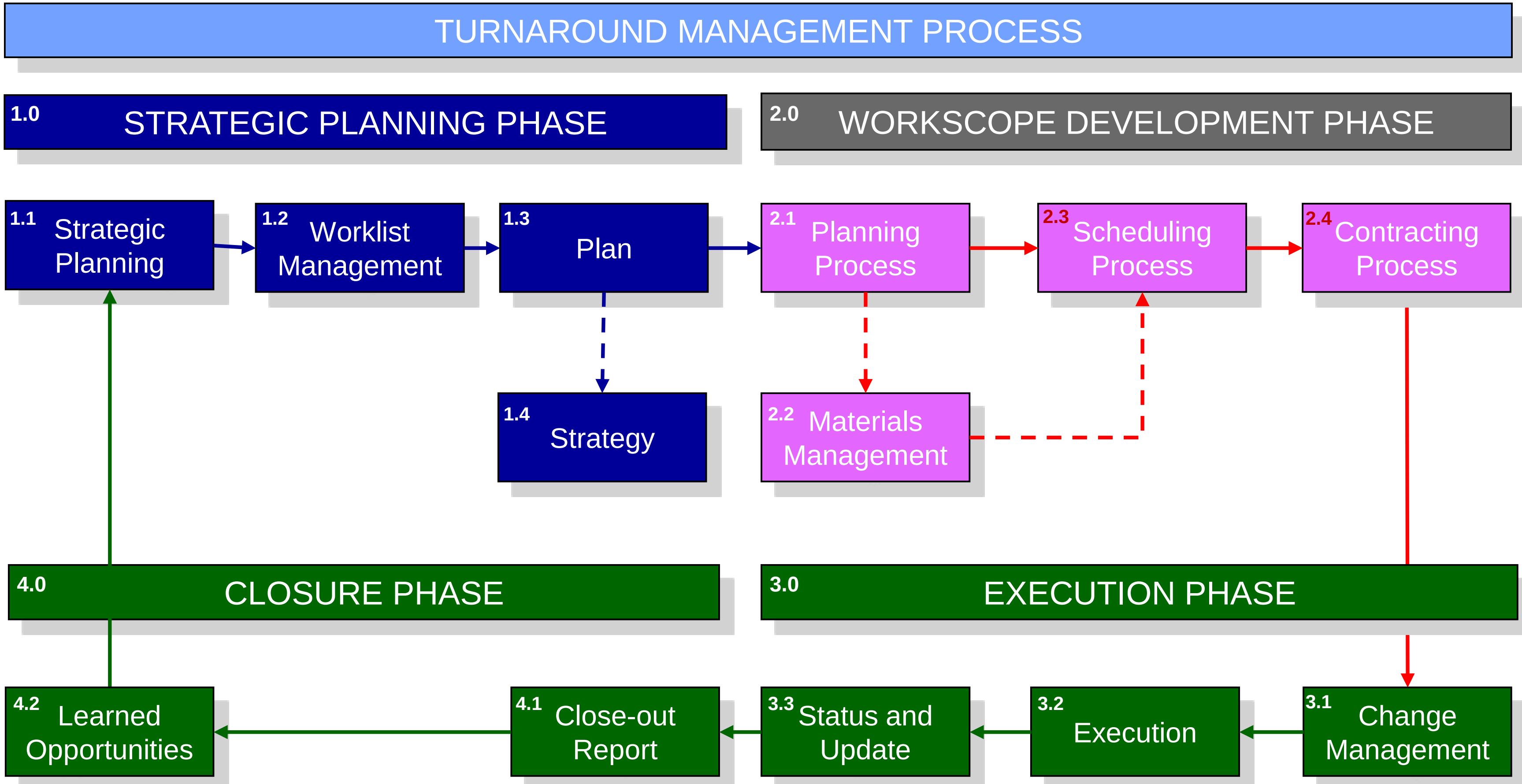
- Your collective-knowledge, materials and management tools need a home
- Your Turnaround Manager is a Driver, not a Chauffeur, He needs a roadmap, *even though he's not afraid to ask for directions*
- Accurate project status in real-time - good, bad, under or over, you need to know *where you are*, *where you should be*, and *where you are going*!

Turnaround Management Focus

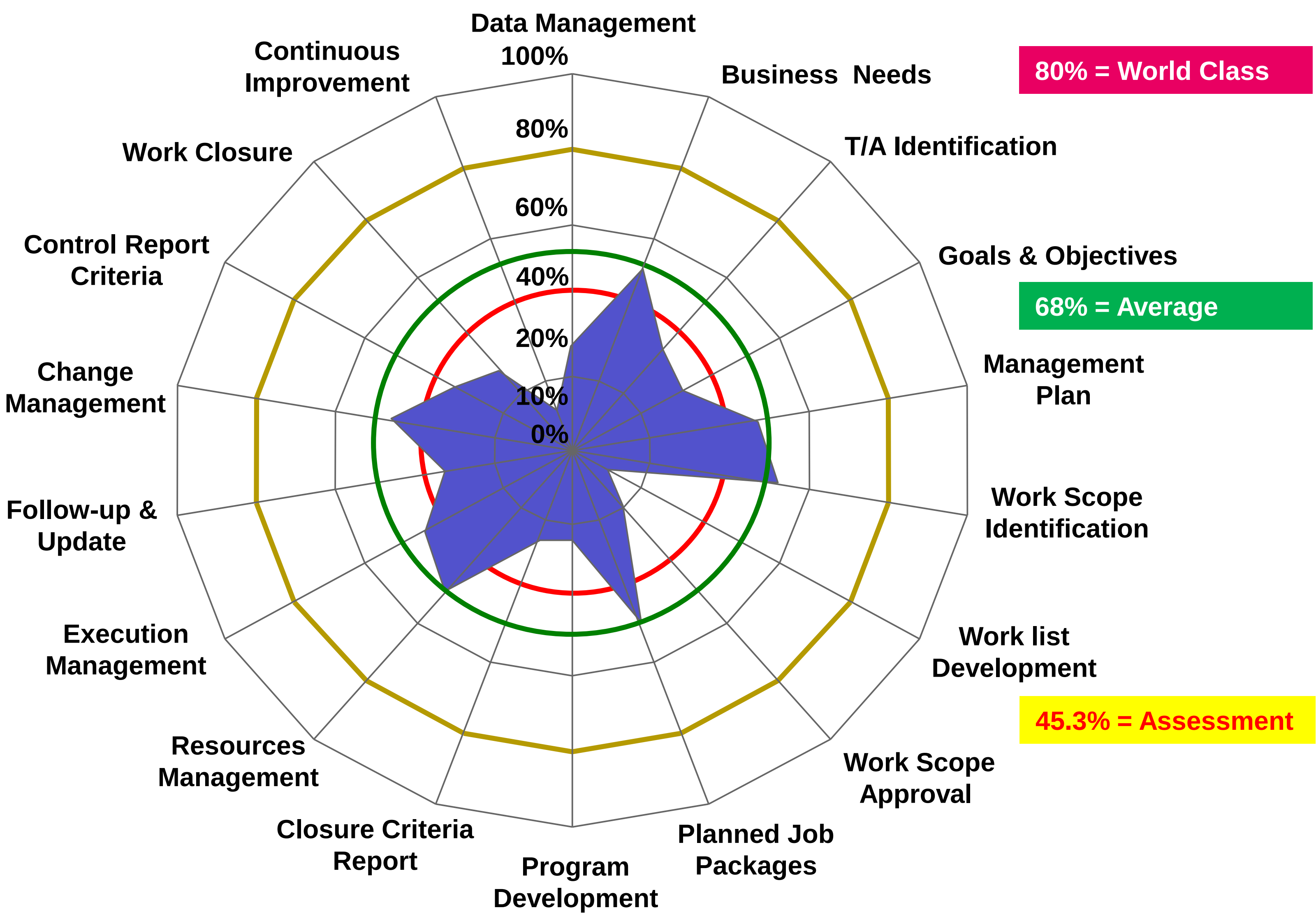
Turnaround Performance



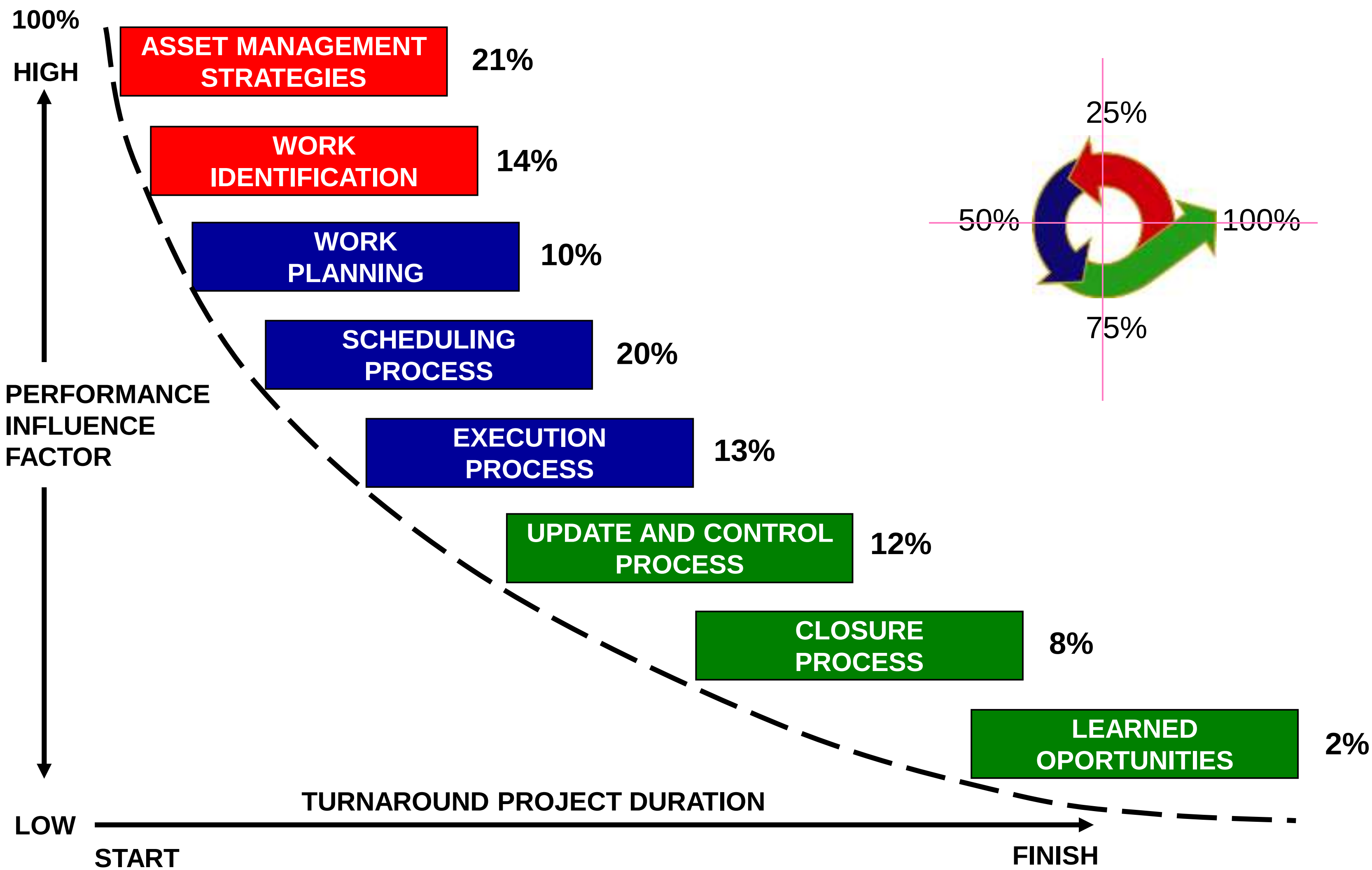
THE TURNAROUND MANAGEMENT PROCESS ON FLOW



Turnaround Management Process assessment results



ABILITY TO INFLUENCE PERFORMANCE



Turnaround Management Process Phases

Strategy Planning

- ✓ Business Needs
- ✓ Risk/Cost/Benefit
- ✓ Scope Approval
- ✓ Goals & Objectives
- ✓ Responsibilities Matrix
- ✓ Turnaround Organization
- ✓ Work Breakdown Structure
- ✓ Milestone Event Schedule

Management Plan

- ✓ Communications Plan
- ✓ Cost Collection Plan
- ✓ Planning & Scheduling Plan
- ✓ Inspection / QA / QC Plan
- ✓ Administration Plan
- ✓ SHE Plan
- ✓ Materials Plan
- ✓ Logistics Plan
- ✓ Continuous Improvement Plan
- ✓ Change Management Plan

Execution Plan

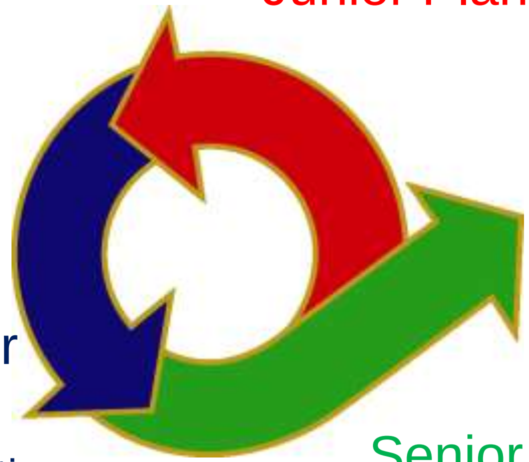
- ✓ Planning Resources
- ✓ Planned Job Package
- ✓ Execution Strategies
- ✓ Operation Strategies
- ✓ Work Execution Program
- ✓ Report Structure
- ✓ Update & Follow Up Strategy

Execution

- ✓ Mobilization
- ✓ Pre-Turnaround Scope
- ✓ Feed Out
- ✓ Turnaround Scope
- ✓ Start Up
- ✓ Post Turnaround Scope
- ✓ Demobilization
- ✓ Closure
- ✓ Next Turnaround

Planner Profiles

Junior Planner / Clerical



- ✓ Document Control
- ✓ Data Entry
- ✓ Report Generation
- ✓ Planned Job Package Development
- ✓ Construct Coffee

Intermediate/Field Planner

- ✓ Field Planning
- ✓ Materials Requisitions
- ✓ Execution Strategy
- ✓ Report Creation
- ✓ Execution Updates
- ✓ Execution Resource for Operations / Technical and Execution Supervision

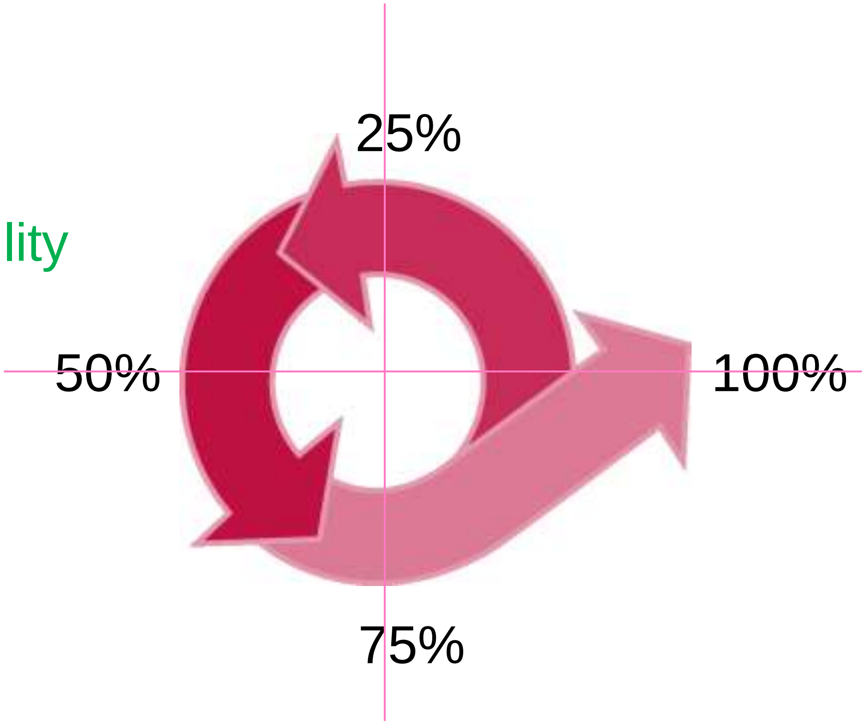
Senior Planner / Scheduler

- ✓ Master Plan & Schedule
- ✓ Cost / Schedule Optimization
- ✓ Meeting Facilitator
- ✓ Execution Re-scheduling
- ✓ Resource Management and Control
- ✓ Schedule Analysis
- ✓ Management Resource for Project Controls

Turnaround Performance

Key Performance Indicators

- Process Availability = % Throughput
- Asset Reliability = Cost
- Maintainability =
  - ✓ Safety
  - ✓ Quality
  - ✓ Man-hours
  - ✓ Indirects
  - ✓ Materials
  - ✓ Schedule



Turnaround Success

- Discipline
- A common process
- Visibility of daily progress
- Managed risk
- Timely decisions by daily monitoring of cost vs. plan

Key Performance Indicators / Targets

- ✓Safety
- ✓Quality
- ✓Duration / Schedule
- ✓Cost
- ✓Process Availability

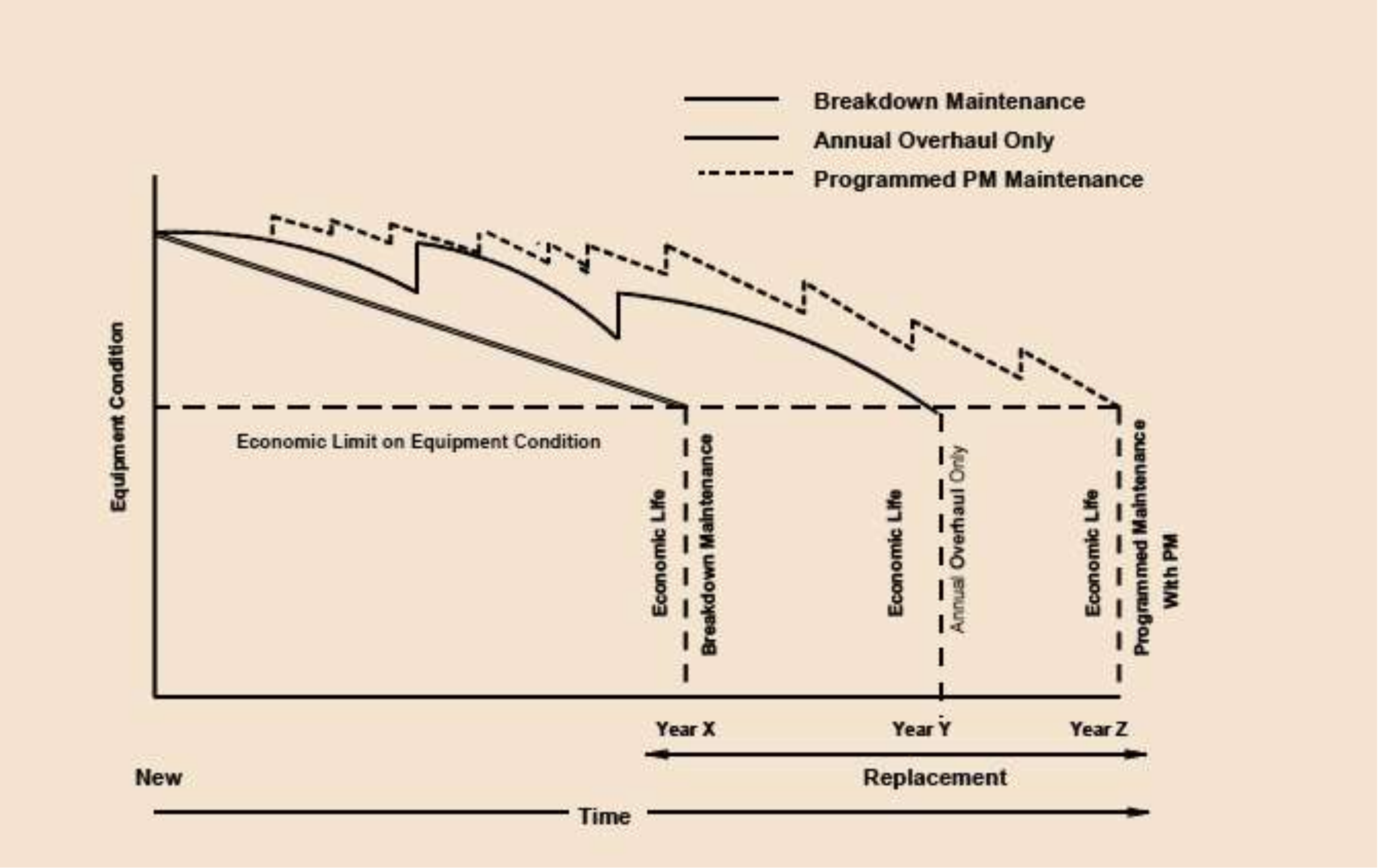
Best Practices for Shutdowns, Turnarounds and Outages

- Long-term planning
- Core team development
- Plan development

Successful ATA Completion

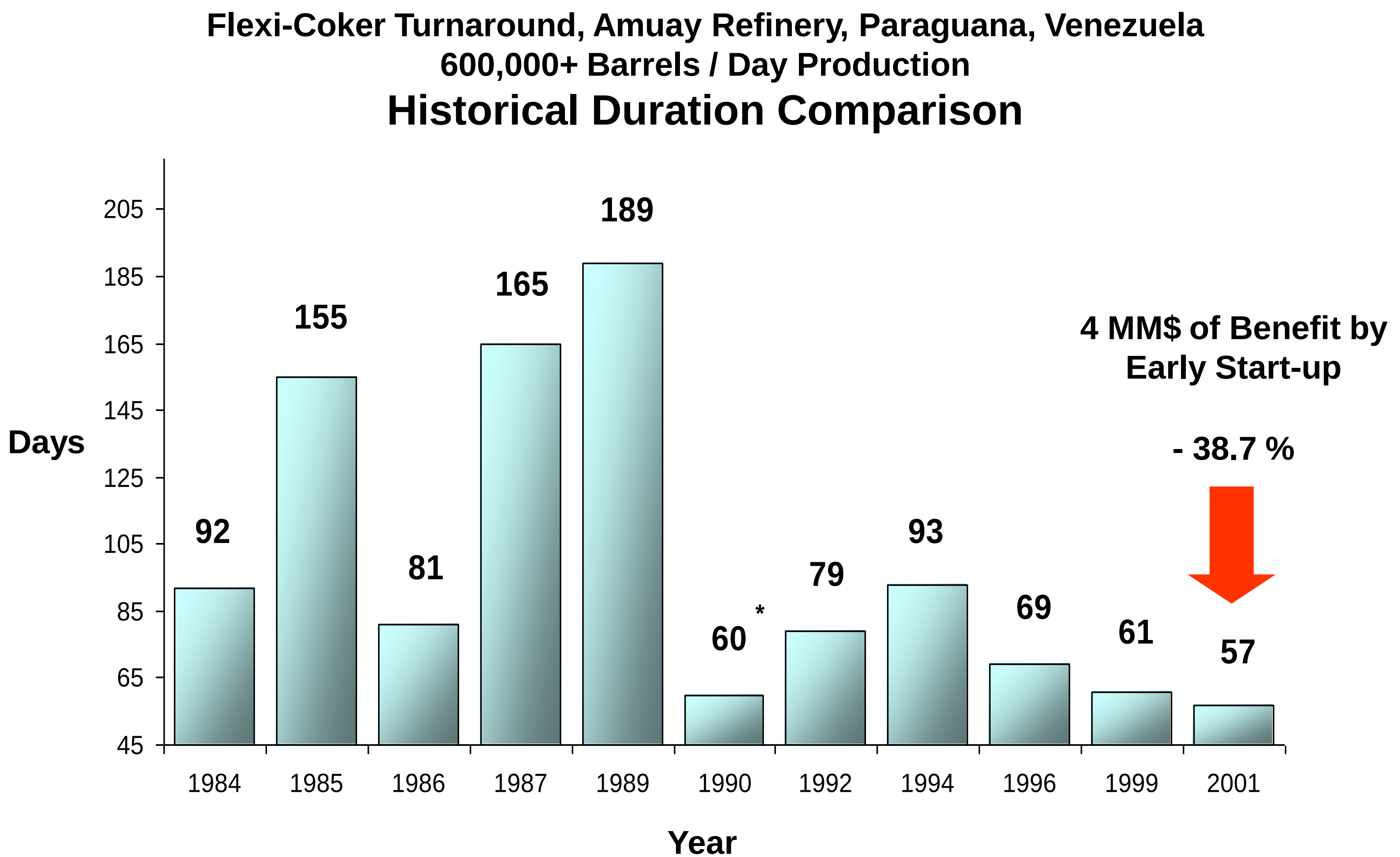
- Defined Turnaround Management Process
- Orientation / Training / Coaching
- Best-practice Guidelines
- Best-practice Procedures
- World-class Planning & Scheduling Softwares
- Incentive Based Contracting Strategies

Preventive Maintenance Impact



Proven results – a case-study of enhanced turnaround performance

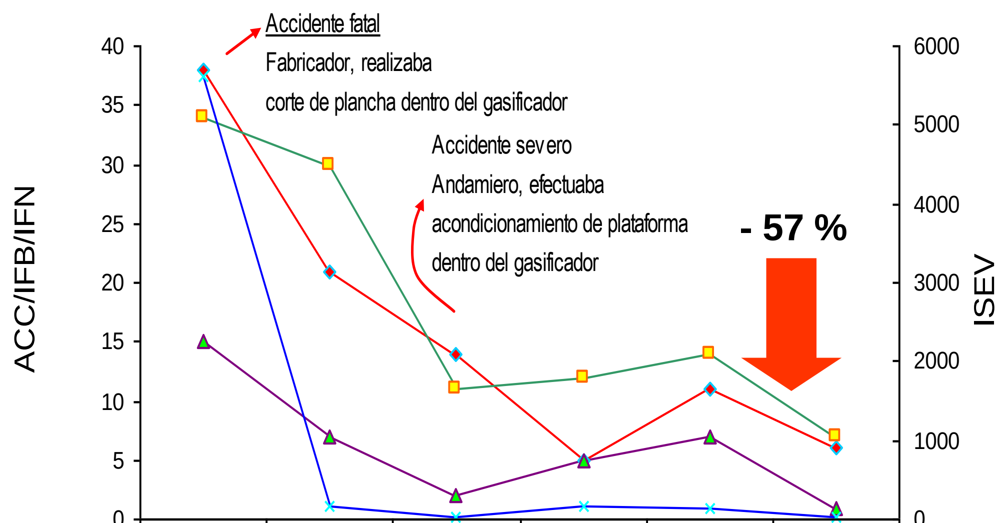
Proven results – a case-study of enhanced turnaround performance



Proven results – a case-study of enhanced turnaround performance

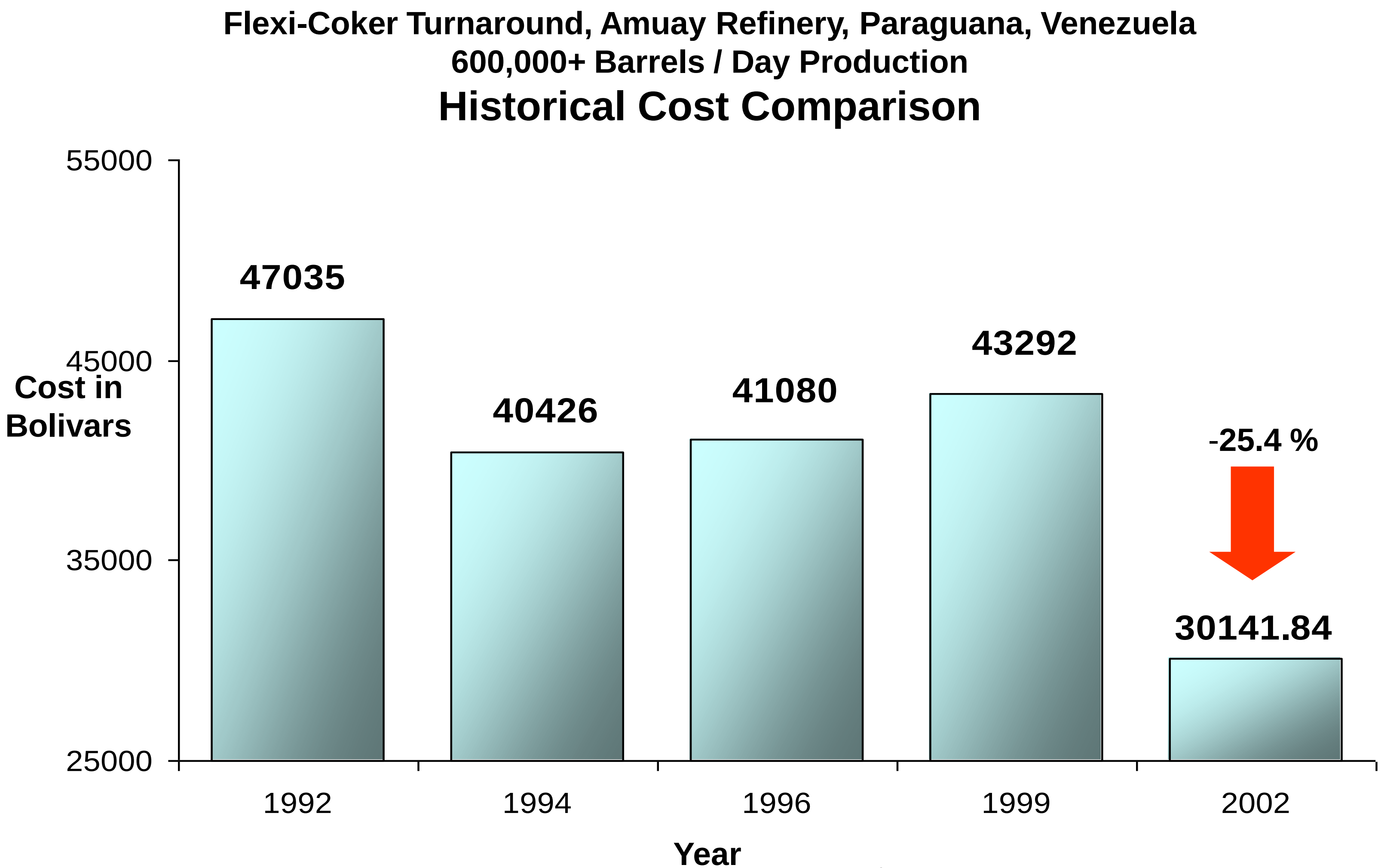
Flexi-Coker Turnaround, Amuay Refinery, Paraguana, Venezuela
600,000+ Barrels / Day Production

Historical Safety Comparison



	FKAY 89	FKAY 92	FKAY 94	FKAY 96	FKAY 99	FKAY 01
No. Accidentes	38	21	14	5	11	6
IFB	34	30	11	12	14	7
IFN	15	7	2	5	7	1
ISEV	5622	155	41	169	137	16

Proven results – a case-study of enhanced turnaround performance



Motivating Maintenance Worker

- Training programs – most effective
- Establish inspection and preventive maintenance as a recognized, important part of the overall maintenance program.
- Assign competent, responsible people to the preventive maintenance program.

Continued -

- Follow-up to assure quality performance and to show everyone that management does care.

- Provide training in precision maintenance practices and training in the right techniques and procedures for preventive maintenance on specific equipment.

- Set high standards.

- Publicize reduced costs with improved up-time and revenues, which are the result of effective preventive maintenance

DISCUSSION

THANKS

COMPUTER IN MAINTENANCE

Engr. Muhammad Sajid
Lecturer
University of Gujrat, Pakistan

AFA Workshop on "Quality Control & Assurance in Maintenance in Fertilizer Industries" Oman 23 - 25/11/2015

الإتحاد العربي للأسمدة
Arab Fertilizers Association

OBJECTIVES

- Discus how a computer is applicable in maintenance
- What are benefits of computerized maintenance system
- Advantages and limitations of computerized maintenance system
- Ultimate business effects

OUTLINE

- Computerized maintenance
- Maintenance management process
- Case study
- Workshop exercise
- Advantages of CMMS
- Limitations of CMMS

MAINTENANCE OF EQUIPMENTS

Maintenance

Modifications

Facilities (Buildings, Control rooms, Floors, Lifts)

Equipments (Mechanical, Electrical etc)

- Rotary
- Stationary

MAINTENANCE DECISION MAKING

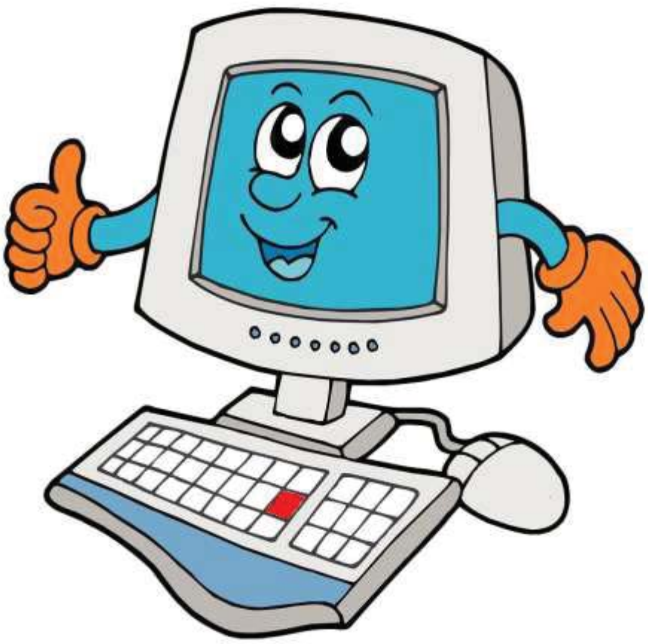
- Equipment conditions
- History of failure
- Direct cost of maintenance
- Inventory values and material movements
- Man-hours spent on maintenance
- Overtime paid and use of other facilities
- Performance of the maintenance workforce
- Reliability and maintainability of equipment

COMPUTERIZED MAINTENANCE

- Maintenance : A significant portion of cost of doing business leading to optimum usage of maintenance.
- Planning & scheduling is one of the ways for optimization.
- Amount of clerical work or paper shuffling associated with such planning & scheduling is a great problem.
- Computerization can solve such problem.
- A good computerized system can provide information about availability of materials, costs of job, facility or type of work so on.

COMPUTERIZED MAINTENANCE

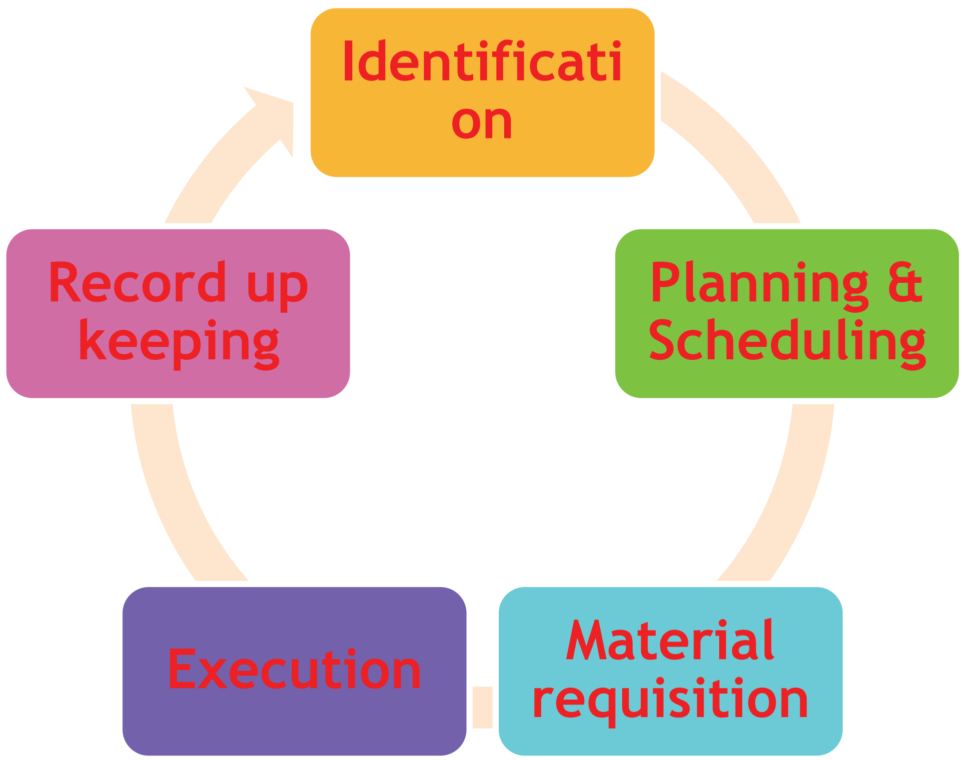
- Assignments of cost
- Equipment identification
- Employee lists
- Priorities
- Store catalog
- Equipment Bill of materials
- Cause codes
- Action codes



COMPUTERIZED MAINTENANCE PLANNING

- Communication gap
- Computer vendors role
- Master plan
- Management information system (MIS)
- Managerial participation
- Information needs
- Human acceptance

MAINTENANCE MANAGEMENT



COMPUTERIZED MAINTENANCE PLAN

- Major Question…
  - Were the communications clear and adequate for the people associated with the work?
  - Was the job plan simple enough to understand?
- Effective planning…..
  - Better access to the information
  - Better planning of available resources
  - Better control
  - Overall cost reduction

IDENTIFICATION

- Abnormality
  - Control system
  - Condition monitoring
- Frequency of occurrence
- Exact Location
  - Temperature changes
  - Pressure disturbances
  - Concentration changes
  - Flow rates

PLANNING & SCHEDULING
CODES

CRIT	Shutdown criteria
DUR	Duration
DIS	Can only be done while equipment is disassembled for other shutdown work
SYN	Synergies with doing work in conjunction with other shutdown work
UTIL	Utility equipment that is only available during shutdown period
HAZ	Work of a hazardous nature that must be done while plant is isolated
OTH	Other (please advise)

PLANNING & SCHEDULING

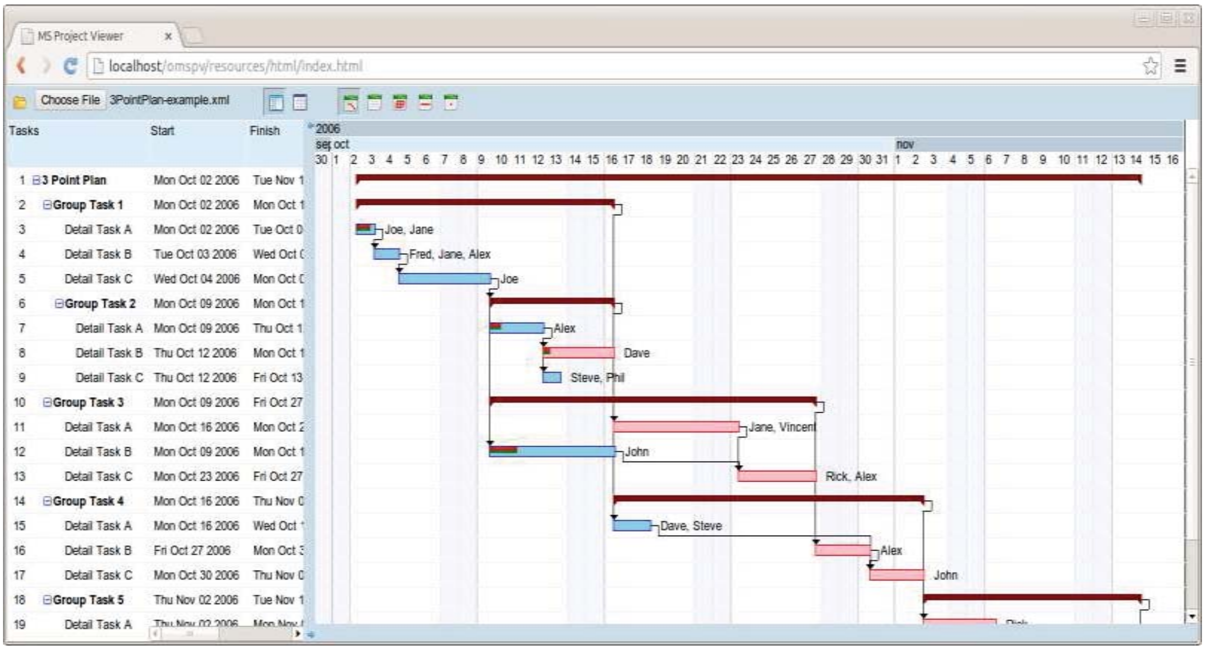
Excel Work Sheet

PREVENTIVE MAINTENANCE SCHEDULE OF AMMONIA PLANT

Sr.No.	Equipment Name	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	BOILER FEED WATER PUMP A104-J	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)
2	BOILER FEED WATER PUMP A104-JA	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)
3	BOILER FEED WATER PUMP A104JB	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)
4	AMMONIA INJECTION PUMP A108-LJ	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)
5	AMMONIA INJECTION PUMP A108-LJA	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)

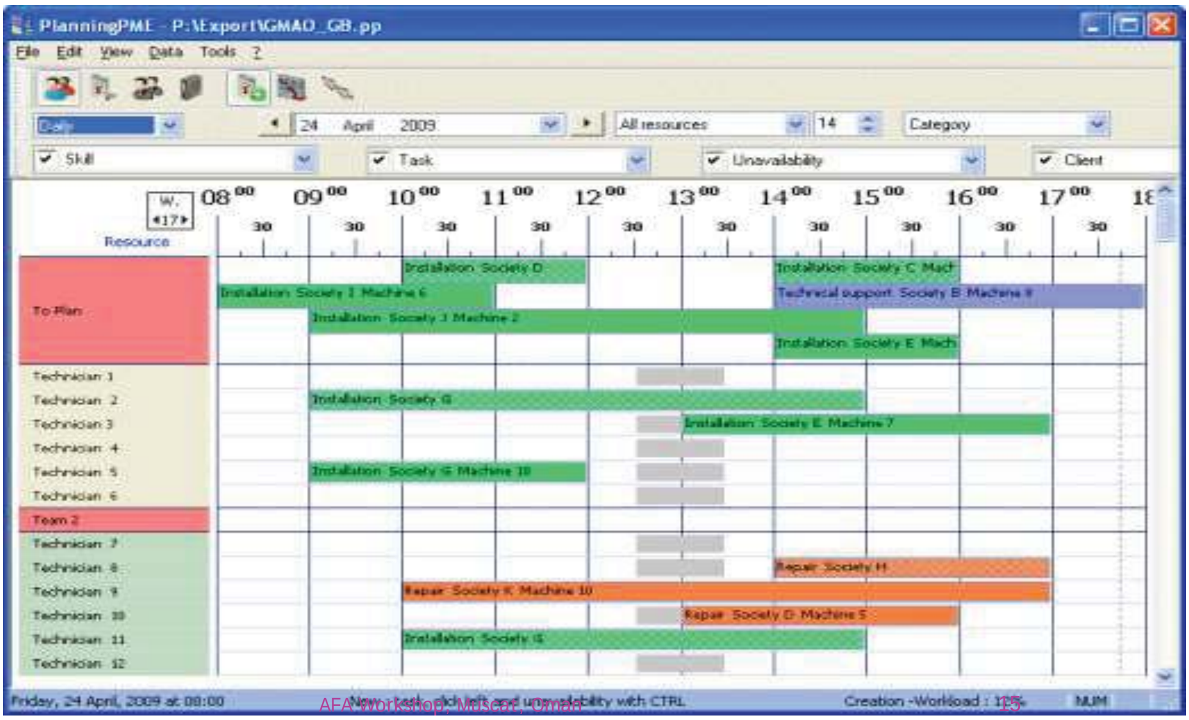
PLANNING & SCHEDULING

MS Project



PLANNING & SCHEDULING

PlanningPME



MATERIAL REQUIREMENTS

- Requests & requisitions
- Time bound
- Online access to top management
- Response recordings
- Delay elimination

EXECUTION

- Time management
- Monitoring and evolution
- Quick action on delay
- Spares and stores management
- Quick access to location

DATA RECORDING

Record of all maintenances	Equipment history	Easy to use

COMPUTERIZED MAINTENANCE MODEL

Breakdown distribution

- Indication of time between failure

Breakdown period:

- Time for which equipment remains out of service

Length of time for the actual repair time of the equipment

OPERATING CHARACTERISTICS OF A GOOD SYSTEM

1. Online inquiry	• Work orders • Materials • Equipment
2. Custom Report generation	• Work order • Materials • Equipment
3. Performance Reports	•Hours analysis •Backlog summary •Closed job summary •Schedule compliance by hours

MODERN COMPUTING TECHNOLOGIES

- **Intelligent maintenance systems (IMS)** predict and forecast equipment performance so "**near-zero breakdown**" status is achievable.
- There are two reasons for failure: equipment performance and operator/human error.
- Near-zero downtime focuses on predictive techniques to minimize failures. It focuses on features of machine performance

MODERN COMPUTING TECHNOLOGIES

- Data comes from two sources: sensors and the entire enterprise system
- By correlating data from these sources (current and historical), you can predict future performance.
- The goal is to predict product/machine health in the same way that the weather is forecast

IMPLEMENTATION OF CMMP

Program definition

- Information required. What??

Organizing responsibilities of

- Maintenance planning and scheduling
- Uploading information like employees list, parts list, equipment's list etc.
- Maintaining the files based on durations defined
- Forms preparation for data entry
- Security for system regarding usage and modifications.

IMPLEMENTATION OF CMMP

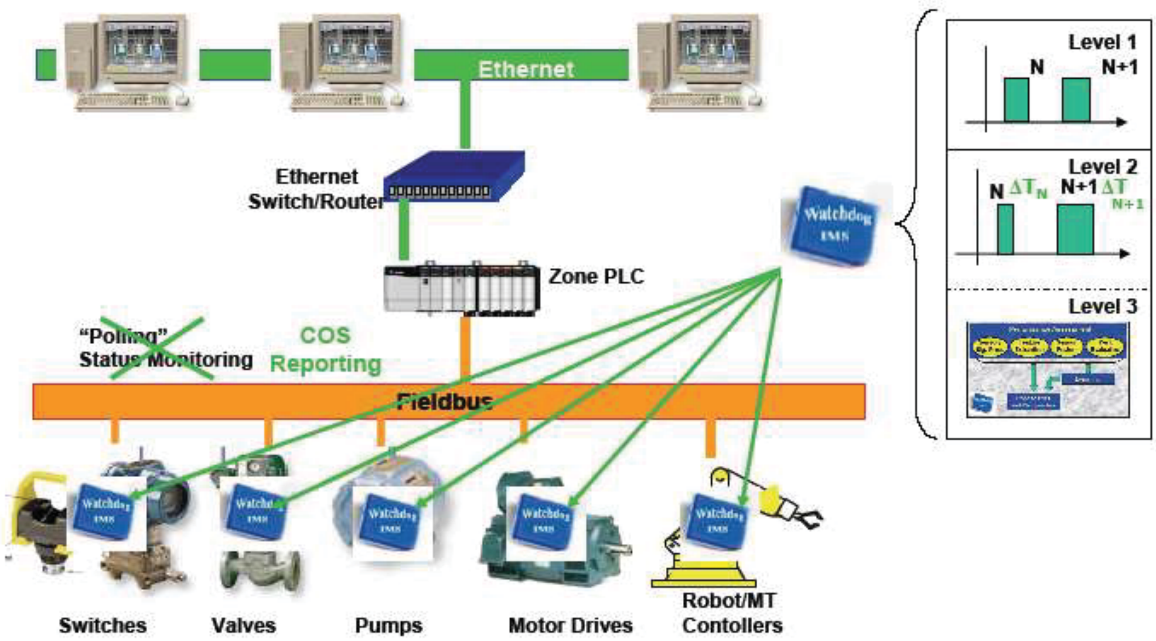
Orientation

- Orientation of CMMS from the highest level to the lowest level workforce.

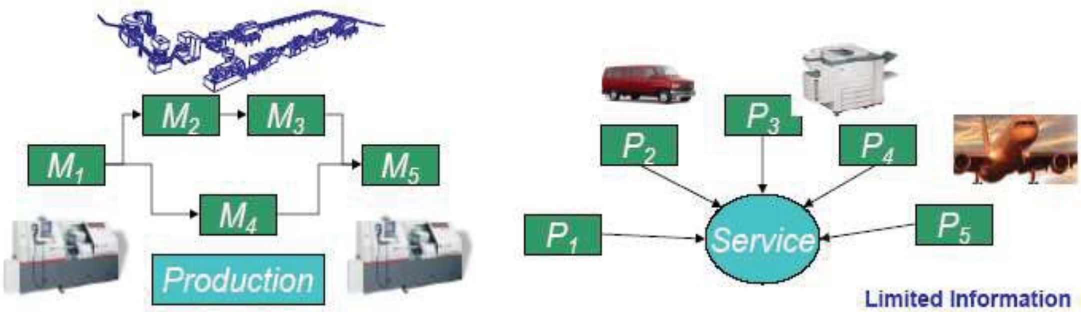
Training

- All users to write a work request
- All users how to exercise the priority system
- All data entry people for the procedures to enter the correct data.
- Maintenance management and concerned people how to read and interpret reports and other available information.

COMPUTERIZED SYSTEM



SYSTEM DECISION SUPPORT TOOL



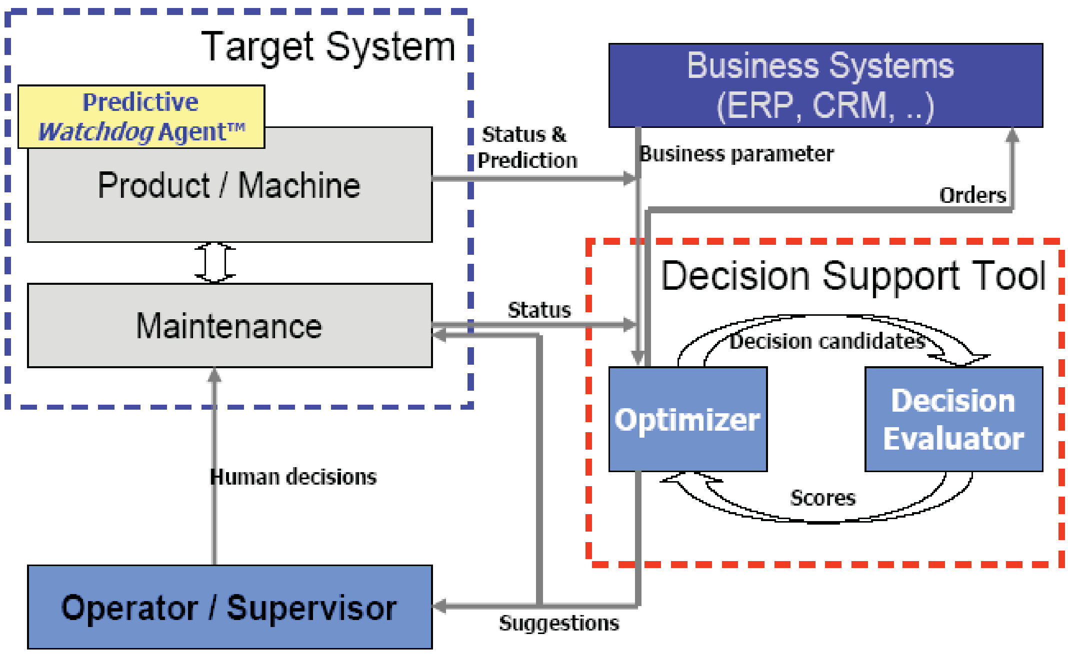
Limited Information

- What is the chance of failure for each machine?
- What is the current most likely failure to happen?
- What are the impacts of the failures?
- What is the best schedule to repair or to maintain?

Limited Crew   Limited resource

Maintenance Manager

FLOW OF INFORMATION



CASE STUDY

Fertilizer plant in Pakistan

BEFORE ERP IMPLEMENTATION

	Purchase department	Ware house	Maintenance management	TOP Management	Production	total
STAFF	6	5	3	1	1	16
Response time (days)	15	2	1	2	1	21

AFTER ERP IMPLEMENTATION

	Purchase department	Ware house	Maintenance management	TOP Management	Production	total
STAFF	3	2	1	1	1	7
Response time	10 days	8 hrs	8hrs	16 hrs	8 hrs	11.16

WORKSHOP EXERCISE

Develop a maintenance schedule for THREE cooling water circulation pumps to ammonia section

WORKSHOP EXERCISE

Job Coding

DETAIL OF CATEGORIES

CATEGORY-A (MONTHLY)

1	Add oil if required.
2	Clean oil bulbs and level windows.
3	Check gland/seal leakage.
4	Check ΔP of Lube oil filters.
5	Cleaning, greasing of bearings and megger test of the motor.

CATEGORY-B (03 MONTHS)

1	Check Coupling elements and tighten bolts, if required.
2	Inspection and cleaning of suction strainer
3	Check air breathers.
4	Flush cooling water lines.
5	Check/replace lube oil filters.
6	Replace oil/grease.

CATEGORY-C (06 MONTHS)

1	Check alignment.
2	Check bearing condition.
3	Check and clean Coupling shim pack.
4	Replace plungers and valves.
5	Inspection of gear box and clutch box.
6	Inspection of suction/discharge valves and NRV's

CATEGORY-D (YEARLY)

1	General checking/overhauling of all the equipment.
2	Check foundation bolts.
3	Check Mechanical/Carbon packing.
4	Clean Lube oil coolers.

WORKSHOP EXERCISE SCHEDULE

Sr.No.	Equipment Name	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
9	CW CIRCULATION PUMP C-GA3301A	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B (1st WEEK)	A (1st WEEK)	A (1st WEEK)	A,B,C,D (1st WEEK)	A (1st WEEK)
10	CW CIRCULATION PUMP C-GA3301B	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)	A,B,C,D (2nd WEEK)	A (2nd WEEK)	A (2nd WEEK)
11	CW CIRCULATION PUMP C-GA3301C	A (4th WEEK)	A (4th WEEK)	A,B (4th WEEK)	A (4th WEEK)	A (4th WEEK)	A,B,C (4th WEEK)	A (4th WEEK)	A (4th WEEK)	A,B (4th WEEK)	A (4HD WEEK)	A (4HD WEEK)	A,B,C,D (4th WEEK)

ADVANTAGES OF COMPUTERIZED MAINTENANCE

- Large quantity of data can be stored
- Less response time
- Better accuracy of information
- Cost optimization
- Less paper work
- Easy feedback of information
- Number of alternative solutions are possible
- Accurate forecast and better planning

LIMITATIONS OF COMPUTERIZED MAINTENANCE

- A computerized maintenance management is a fine and powerful tool for assisting but has limitation of
  - Authenticity of work request
  - Sketching of work
  - Decision about materials
  - Other constraints effecting maintenance

OVERALL EFFECT

Performance high level

Business

Thanks

ACKNOWLEDGMEN
Data has been taken from different sources. Credit goes to original authors only

SELECTION OF SCREENING EQUIPMENT FOR FINAL PRODUCT QUALITY - OMIFCO'S EXPERIENCE IN UREA GRANULATORS

Rashid AL-FARSI, Sr. Mech. Engr

OUTLINE

- INTRODUCTION ABOUT OMIFCO
- HOW UREA GRANULATION IS WORKING (PFD)
- SCREENING OF UREA GRANULES
- PROBLEMS WITH THE EXISTING SCREENS DESIGN
- STUDY FOR SOLUTIONS
- BEST OPTION CRITERIA
- INSTALLATION NEW SCREEN (ROTEX)
- COMPARISON
- CONCLUSION

OMIFCO :
(Joint Initiative of Govt. of Oman & India)

Equity Holders

OOC : Oman Oil Company S.A.O.C, Oman, (50 % shareholder)

IFFCO : Indian Farmers Fertiliser Cooperative Ltd., India (25 % shareholder)

KRIBHCO : Krishak Bharati Cooperative Ltd., India, (25 % shareholder)

Plant Capacity & Technology

Plant	Capacity	Licensor
Ammonia*	2 x 1750 MTPD	Haldor Topsoe
Urea**	2 x 2530 MTPD	Snamprogetti

* CO2 removal system, M/s Giammarco Vetrocoke

** Urea granulation, M/s Hydro Fertiliser ,Technology

Annual Installed capacity, MT

Ammonia	:	11,90,000
Urea	:	16,52,000

Project Site

- **Located at Sur Industrial State on coast near Sur (approx. 200 KM away from MCT on new Quarayat Road).**
- **Total plant area is 170 hectare which includes provision for future expansion.**
- **Deep water 1,000 M offshore for jetty facilities& seawater cooling**
- **Gas supply pipeline available since 1995.**

Project Milestones

- Project awarded on a Lump Sum Turnkey basis to Snamprogetti ,Italy &Technip-Coflexip France with a completion schedule of 35 months
- Completion of project achieved without any cost overrun and well within scheduled period.
- Operation, monitor & control of whole complex is done from Central control room (CCR).

OMIFCO – Some Milestones

Project Commencement date	15.08.2002
Natural gas charged in the complex	Jul 04
Power production started	Aug.04
Sea water intake system started	Sep.04
Steam production started	Sep 04
Desalinated water production started	Oct 04
Nitrogen production started	Oct 04
Ammonia storage commissioned	Nov 04
CO_2 production at Ammonia-I	13.03.2005

OMIFCO – Some Milestones

➢ Ammonia production -train 1	28 Mar. 05
➢ Urea production - train 1	12 April 05
➢ Ammonia production -train 2	14 May 05
➢ Urea production - train 2	28 May 05
➢ First ammonia export	20 April 05
➢ First urea export	07 June 05
➢ Preliminary acceptance	14 July 05

UFT FLUID BED GRANULATION PROCESS DESCRIPTION

- The feed solution, typically a 97% urea solution, is dispensed to the injection heads and finely atomized upwards into the bed of moving particles. This spraying is assisted by air.

- Fluidization air delivered by a fan under the perforated plate, flows through the product layer and is exhausted at the granulator top.

- Granular urea flows out of the granulator at a controlled rate to a fluid bed cooler. After cooling, the granules are lifted by means of a bucket elevator to the screening section.

- The fines fraction is recycled directly to the granulator whereas the coarse material is first crushed and thereafter sent to the granulator as seeding particles.

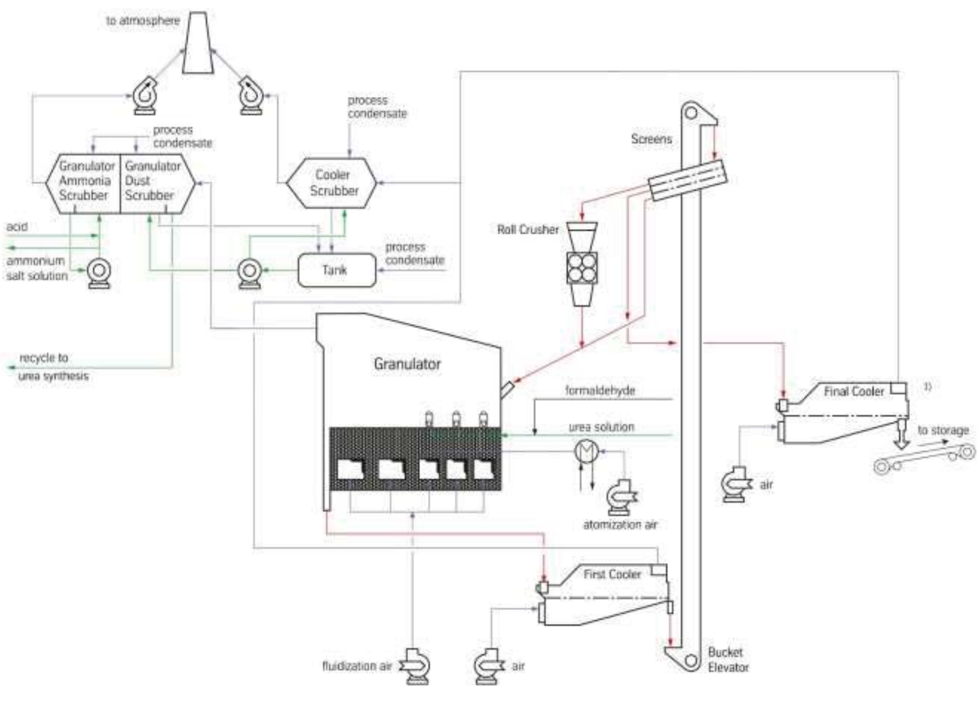
UFT FLUID BED GRANULATION PROCESS DESCRIPTION

- The on-size product is sent to the warehouse after final cooling at the required storage temperature. The cooling of urea to a constant and sufficiently low storage temperature is one of the most significant parameters to avoid caking.

- The air from the granulator and coolers contains some urea dust which is easy to catch in standard scrubbing equipment. With industrially proven scrubbers, efficiencies of more than 99.5% are easily obtained. Therefore dust outlet concentrations of less than 0.1 kg per ton of urea produced can be achieved.

- Operation of the fluid bed granulation plant is simple and very reliable, guaranteeing a high on-stream factor. The granulator itself contains no moving parts, and its design is optimized to limit down time for cleaning to a strict minimum.

GRANULATION (PFD)



1) Depending on site condition, Bulk Flow Cooler can be applied as alternative.

PRODUCT CHARACTERISTICS

- Urea granules produced in the UFT fluid bed granulation have a well-rounded shape and are very hard. They resist particularly well to crushing and abrasion and hence are dust free, non-caking and completely free flowing, even after long storage and numerous handling and shipment operations.

PRODUCT SPECIFICATION (TYPICAL)

	Standard Size	Large Size
Total Nitrogen	46.3 % wt	46.3 % wt
Biuret	0.7 – 0.8 % wt	0.7 – 0.8 % wt
Moisture	0.2 % wt	0.3 % wt
Crushing Strength	4.1 kg (Ø: 3 mm)	10.0 kg (Ø: 7 mm)
Average Diameter	3.2 mm	6.3 mm
Size Distribution	95 % wt (2 - 4 mm)	95 % wt (4 - 8 mm)
Formaldehyde	0.4 % wt	0.4 % wt

PROCESS PARAMETERS (NORMAL OPERATIONS)

• Urea Solution:	temperature	: 132 – 135 Deg.C.
	Pressure	: 2 bar (g) (at granulator header)
	Concentration	: 96%±0.5%(at granulator header)
• Atomization Air:	temperature	: 135 Deg.C.
	Pressure	: 0.45 bar (g) (at granulator header)
	Flow rate	: 66240 kg/h dry air
• Fluidization air:	temperature	: around 52 Deg.C.at granulator inlet
	Pressure	: around 700 mmWC (after dampers)
	Flow rate	: 389124 kg/h dry air
• Fluid bed:	temperature	: 104°-108°C in granulator chambers
	height	: around 1.0 m respectively 500-600 WC g

PROCESS PARAMETERS (NORMAL OPERATIONS)

• Recycle solution:	concentration	: approx..45% urea
	Temperature	: around 40°-50°C
• Solids temperature	:granulator outlet	: 95°C
	First fluid bed cooler outlet	: 70°C
	Final fluid bed cooler outlet	: 45°C

VIBRATING SCREENS INSTALLED IN OMIFCO PROJECT FOR SEPARATION OF FRACTIONS OF UREA GRANULES

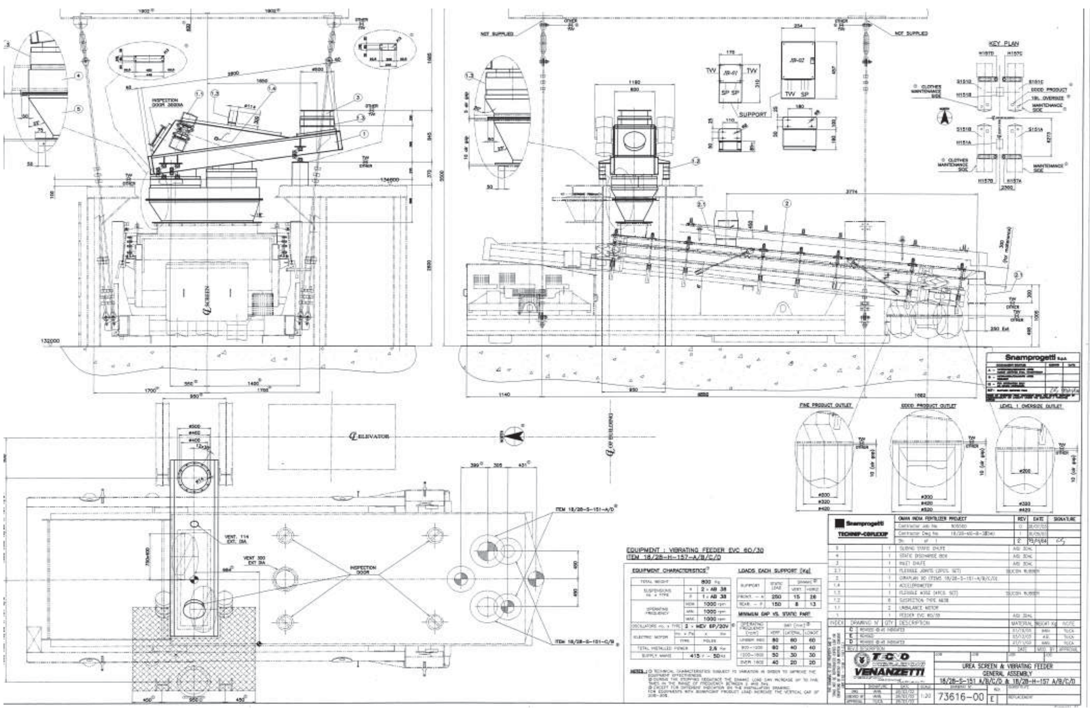
Product Screening Machine

- Model :90 HVSM2
- Make: :CHAUVIN
- Dimensions per deck : :2000X4000
- No. of Decks : 2
- Screening area per deck : 32 m2
- Total weight when empty : 8800 kg
- Weight of vibrating body : 4400 kg
- Slope : 6°
- No. of screening machines installed per granulator : 4
- Capacity of each screening machine : 40 t/h
- Spare screening machine available : No
-

MOTION CHARACTERISTICS

- Acceleration :2 g
- Speed :200 rpm

CAHUVIN SCREEN



CHAUVIN SCREEN IN OMIFCO

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

- The major moving elements which are prone to fail frequently in CHAUVIN screens are:

  - Long ropes
  - Suspension cables
  - Stabilizing rods
  - LHS & RHS cradle beams
  - Gear box bearings (each gear box consisting of 7 bearings)
  - Top bearing
  - Repair/replacement of screen mesh is tough
  - Wiremesh life is hardly one year
  - Declogging balls life is around one year

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

Long Ropes

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

Long Ropes

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

Suspension cables

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

Suspension cables

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

Stabilizing rods

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

LHS & RHS cradle beams

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

Gear box bearings

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

Gear box bearings

PROBLEMS FACING WITH THE CHAUVIN MAKE SCREENS IN OMIFCO

- Repair/replacement of screen mesh is tough
- Wiremesh life is hardly one year
- Declogging balls life is around one year

HOW CHAUVIN SCREENS RUNNING

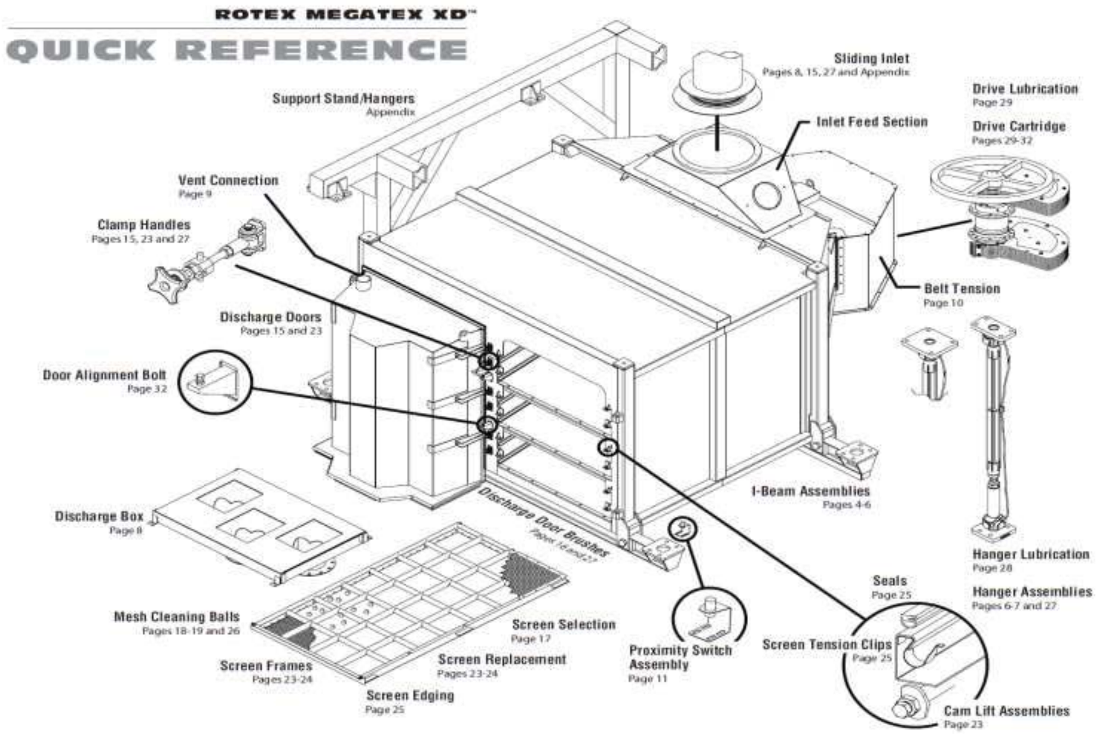
BEST SOLUTION OPTION

- **To select the suitable screening machines, the following bench marks were set in selection of machines.**

  - ❖No Gear box
  - ❖No ropes
  - ❖No couplings
  - ❖Higher Capacity (each screen capacity=3 times to CHAUVIN screen)
  - ❖Replacement of screen mesh shall be easy
  - ❖Weight of the screen shall not be more than 10 T

ROTEX MEGATEX XD-5300

ROTEX MEGATEX XD-5300



TECHNICAL SPECIFICATIONS OF ROTEX MEGATEX SCREENS

• Model	:Megatex –XD-5300-2
• Make	:Rotex, Europe
• No.of Decks	: 2 Deck
• Screening area of each deck	: 28 m2
• Capacity of the screening machine	: 2300 (final product)
• Screen frame size	:1219 X 2286 mm
• No.of screen frames per screen	: 20 Nos.
• Weight of the screen	: 8210 Kg
• Speed of the drive mechanism	: 1000 rpm
• Power	: 15 KW

ROTEX MOTION – WHY IT IS EFFECTIVE?

- **Gyratory motion at inlet end** : Quickly spreads & stratifies the material
- **Elliptical motion at centre section** : Provides gentle conveying
- **Linear motion at discharge end** : For effective near size separation

HOW ROTEX SCREENS RUNNING

CONCLUSION

- We have achieved the following benefits from the installed Rotex Megatex screens:

  - Higher capacity and now spare screen is available
  - Screen cleaning frequency is 40-50 days
  - Life of screen mesh is more than 2 Years
  - Life of PU balls is more than 2 Years
  - No major failures experienced
  - Highest reliability achieved
  - Product quality achieved 95% (2-4 mm)

SAFCO/IBB

RUBBING DETECTION IN A SYNTHESIS GAS COMPRESSOR

NOV 2015

By: Dr. Chinmaya Kar & Mr. Waleed J. Al-Sallom

CHEMISTRY THAT MATTERS™

PROBLEM STATEMENT

Large shaft vibration of

- 52μm persisting for last 1 year at HP DE in one proximity probe, and
- 40μm persisting for last 1 year at Turbine LP End for both proximity probes

HISTORICAL FAILURE

TA 2007

- The rotor had silica deposit at 5th, 6th and 7th stages and large unbalance
- HP gland at 5th stage was worn out
- Rotor and gland were replaced

TA 2011

- Slight sludge observed on seal housings at oil seal assemblies of both ends .
- Both ends of inner and outer seal rings are found scoring - replaced.
- NDE tilting pad seal clearance found out of tolerance.
- Parallel misalignment observed and corrected

May 2011

- Gear coupling failure at HP-Turbine side as oil supply nozzle is not directed towards lubricating zone
- Seal rings have been scored and HP DE side oil seals were replaced
- Parallel and angular misalignment found and corrected
- Thrust bearing of turbine replaced

Oct 2011

- Wiping of journal bearing bottom pads on both DE & NDE noticed.
- Sludge noticed on the inner seal rings on both DE & NDE.
- Parallel and angular misalignment found and corrected

HISTORY OF THE IBB SYNTHESIS GAS COMPRESSOR

2011 TA

- Slight sludge observed on seal housings at oil seal assemblies of both ends .
- Both ends of inner and outer seal rings are found scoring - replaced.
- NDE tilting pad seal clearance found out of tolerance.
- Parallel misalignment observed and corrected

May 2012 Shut down:

- Gear coupling failure at HP-Turbine side as oil supply nozzle is not directed towards lubricating zone
- Seal rings have been scored and HP DE side oil seals were replaced
- Parallel and angular misalignment found and corrected
- Thrust bearing of turbine replaced

Oct 2012 Shut down

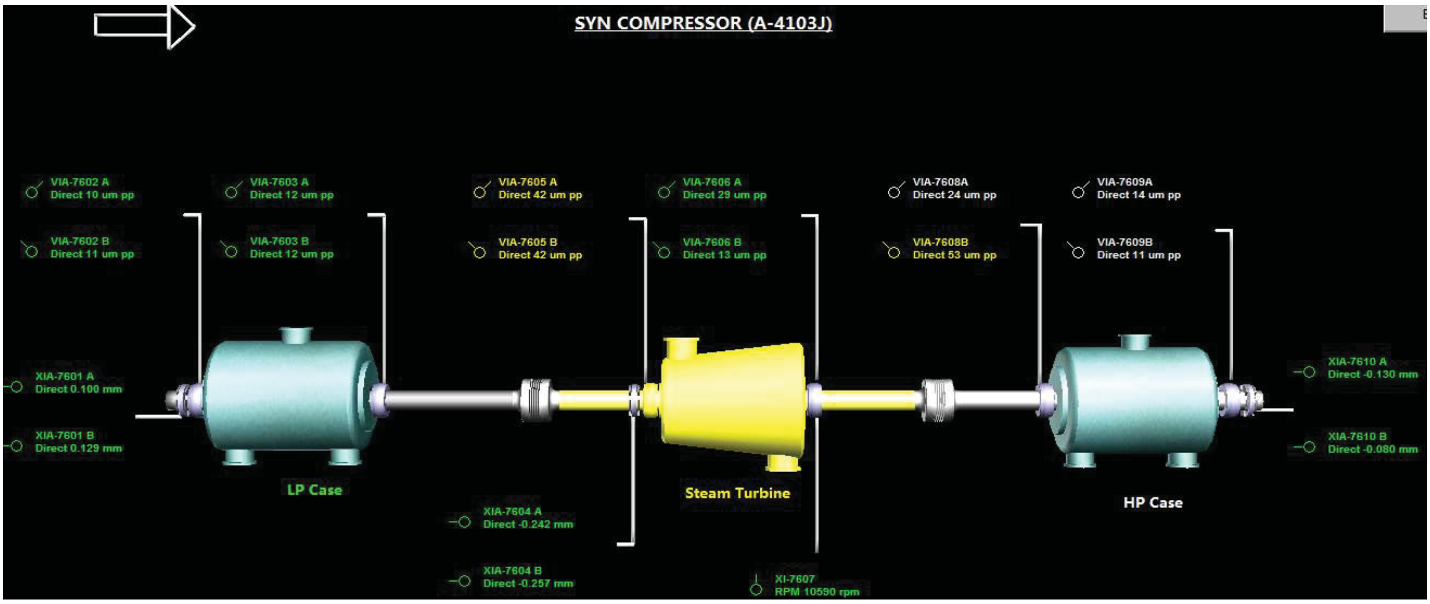
- Wiping of journal bearing bottom pads on both DE & NDE noticed.
- Sludge noticed on the inner seal rings on both DE & NDE.
- Parallel and angular misalignment found and corrected

Summary of the maintenance history:

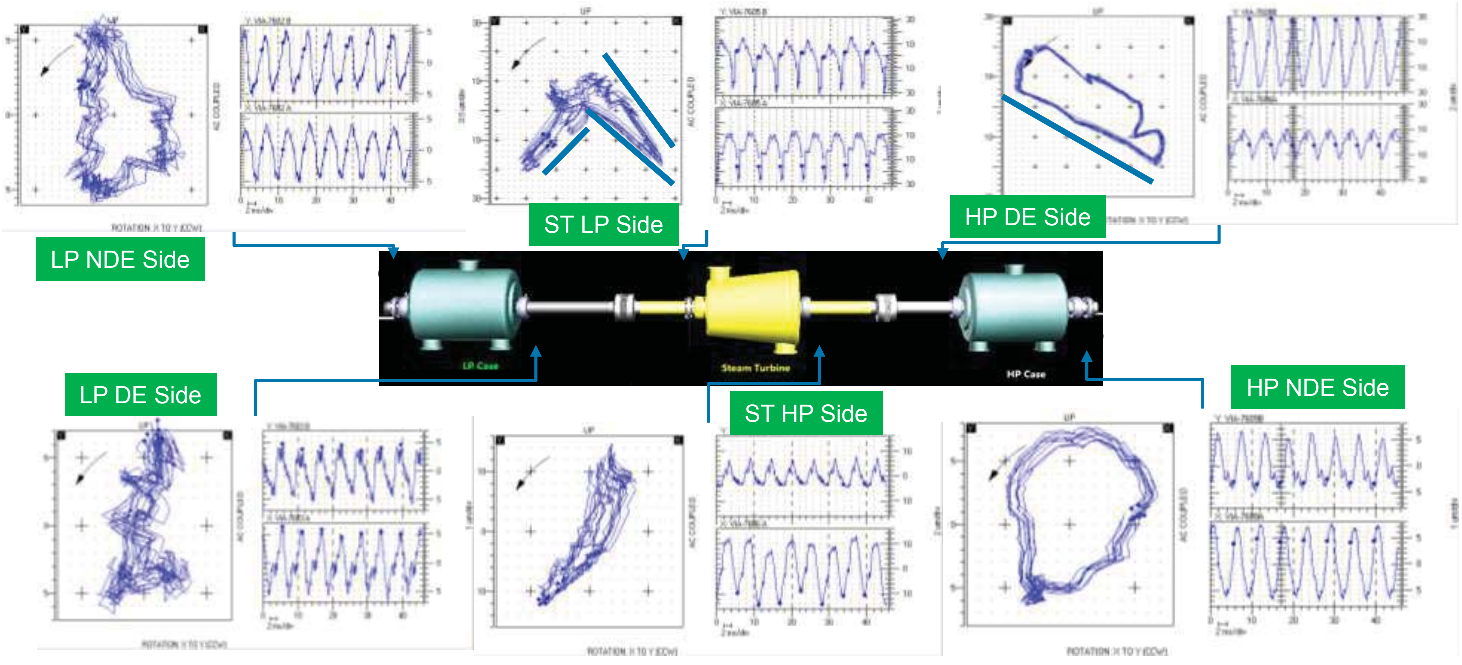
- A repeated parallel and angular misalignment is observed – Coupling can be the reason as evident in the coupling failure in May 2012
- Scoring of seal rings with sludge – One of the main reason is misalignment

OVERALL SHAFT VIBRATION IN MARCH 2014

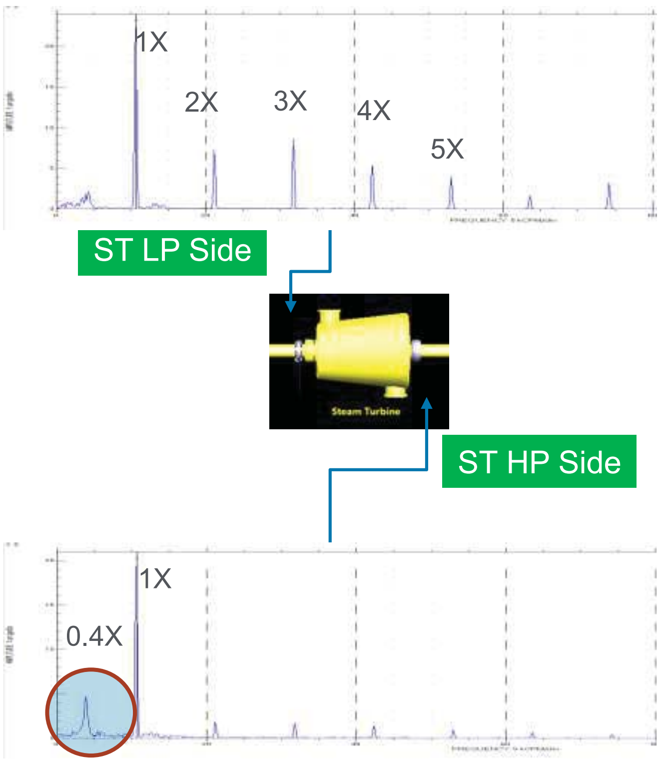
- The LP side of steam turbine vibration shows a large amplitude of 42μm pp in both the direction
- One of the HP side probe of the steam turbine shows 53μm pp



VIBRATION ANALYSIS – ORBIT PLOTS



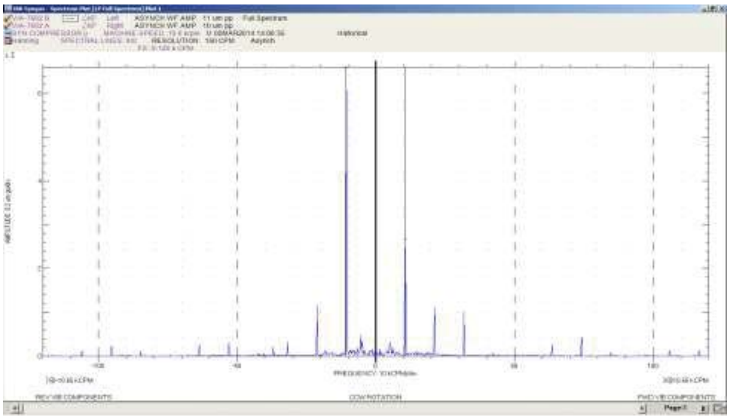
VIBRATION ANALYSIS – SPECTRUM PLOTS



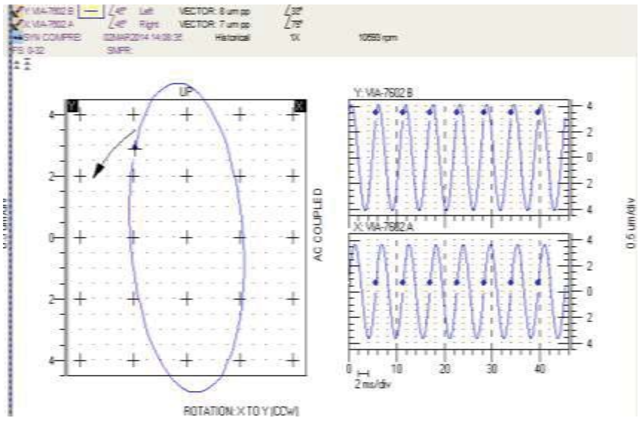
SHAFT VIBRATION AT LP COMPRESSOR

- The LP compressor's NDE probes indicate normal vibration
- There is a reverse precession observed (may be detrimental in future with large fatigue of the shaft) – this may be the reason of probe and key phasor placement as well

Full Spectrum



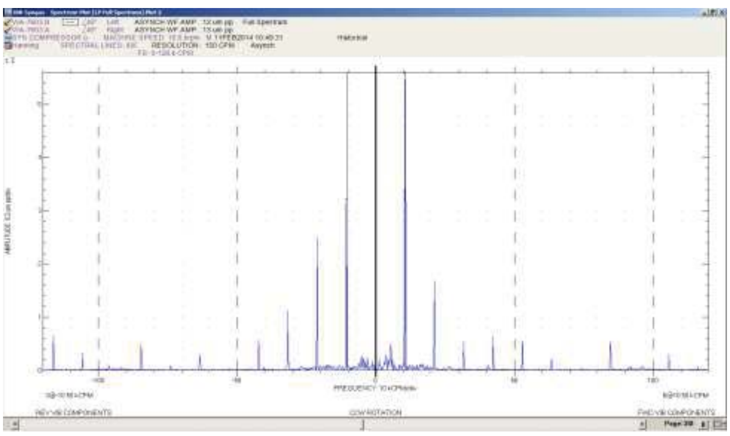
Filtered 1X Orbit plot



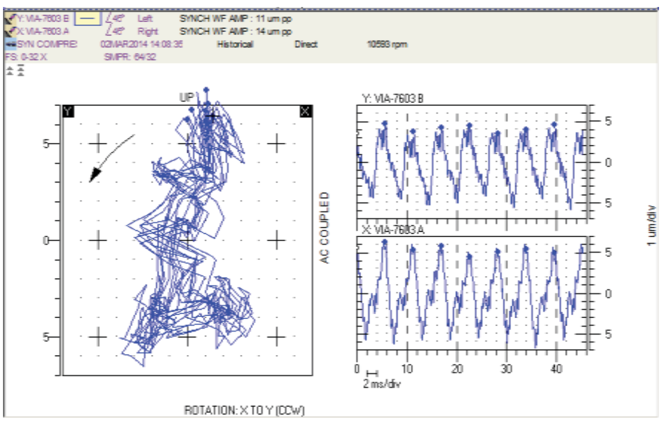
SHAFT VIBRATION AT LP COMPRESSOR

- The LP compressor's DE probes indicate normal vibration
- There are a number of 1X, 2X, 3X components shows either looseness or rubbing
  - The mild looseness / rubbing indicates that it may be in the journal / seal / coupling
- Though the orbit plot is very irregular, doesn't show rubbing (impact – with straight lines) – may be an effect of steam turbine's LP side vibration

Full Spectrum



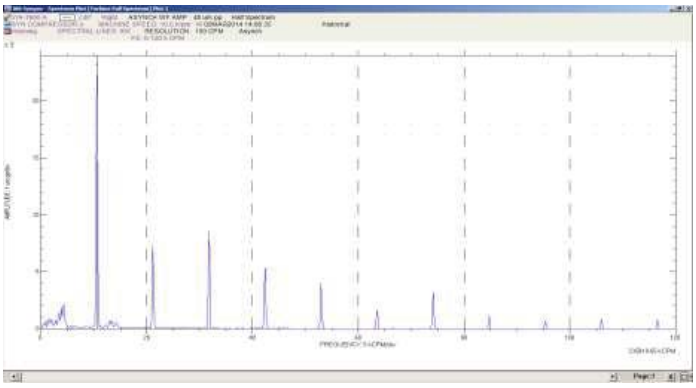
Orbit plot



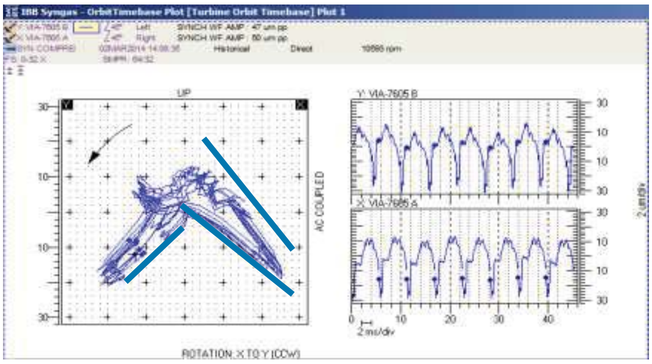
SHAFT VIBRATION AT STEAM TURBINE

- The Steam turbine's LP Side probes indicate large vibration of 42µm pp in both the direction
- There are 1X, 2X, 3X components and also sub-harmonic component (near rotor natural frequency of 4000rpm) - either looseness or rubbing at bearing / seal / coupling
- The orbit plot is very irregular with some impact and straight lines and hence shows some mild rubbing

Half Spectrum



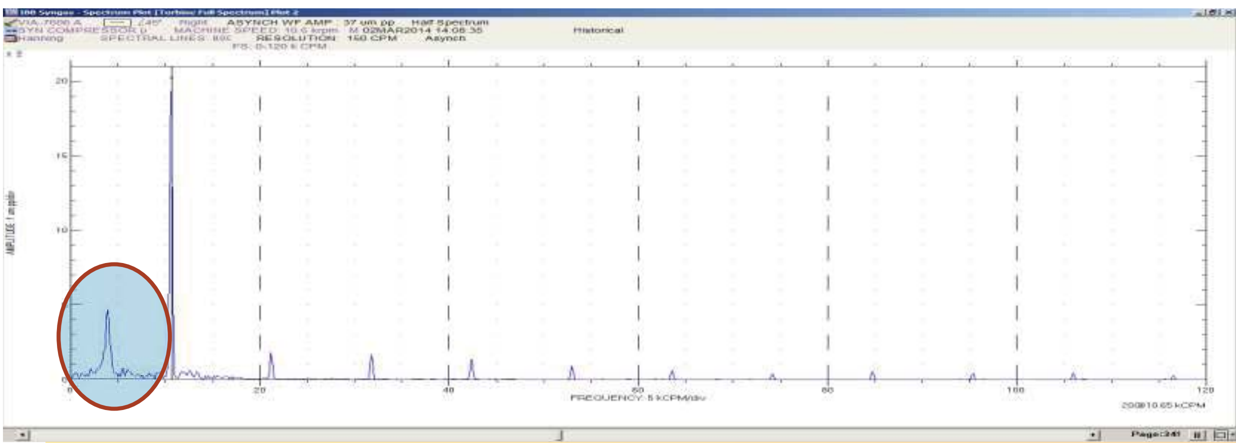
Orbit plot



SHAFT VIBRATION AT STEAM TURBINE

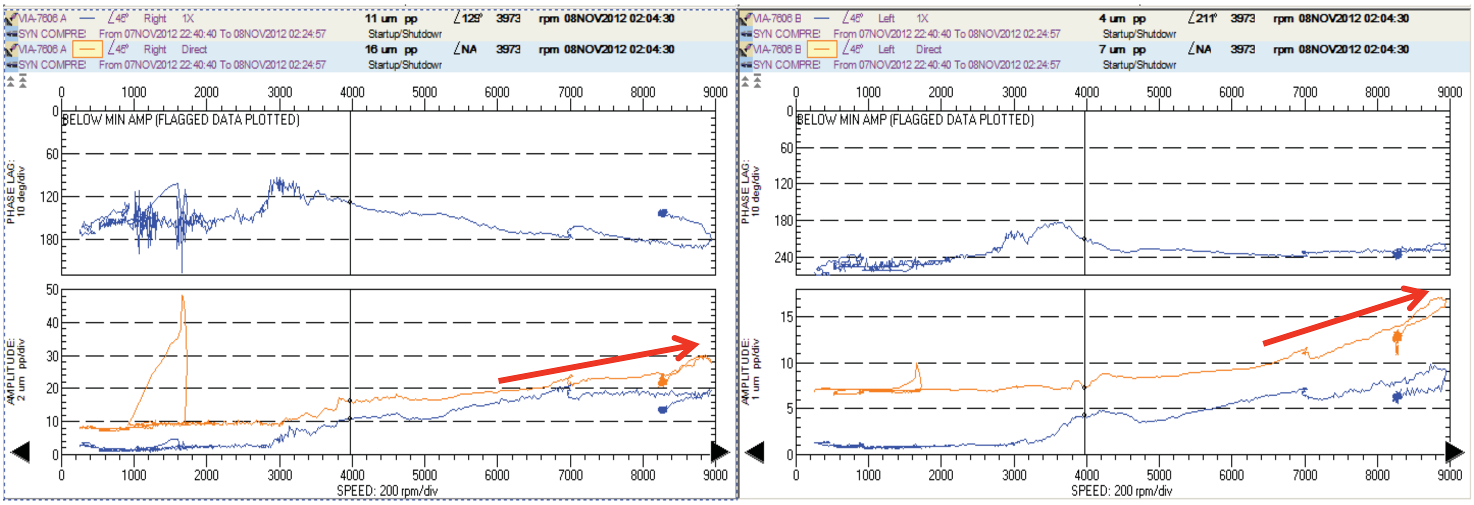
- The Steam turbine's HP Side probes indicate normal vibration
- However, large sub-harmonic components (particularly at exciting the rotor natural frequency is a concern
  - The sub-harmonic component even showing an amplitude of 5µm which is very large

Half Spectrum



BODE PLOTS

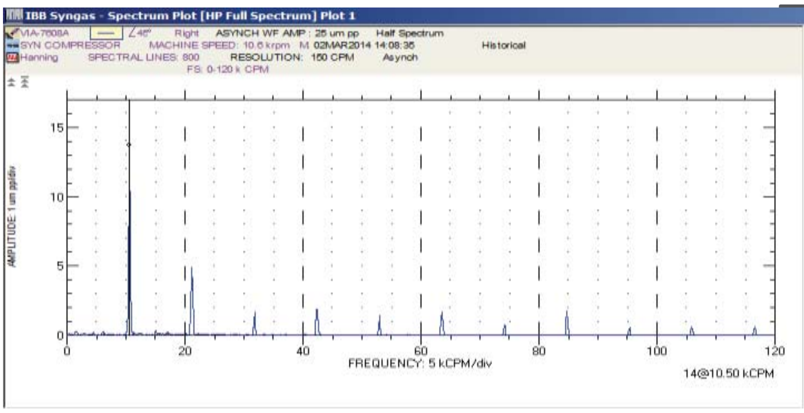
- The Bode plot reveals large unbalance only at turbine HP side end as seen in the trend below
  - The amplitude increases with speed and phase between the probes is nearly 90˚
- The other Bode plot have
  - Either large amplitude for some RPM range and then decreases with speed
  - Or have less amplitude



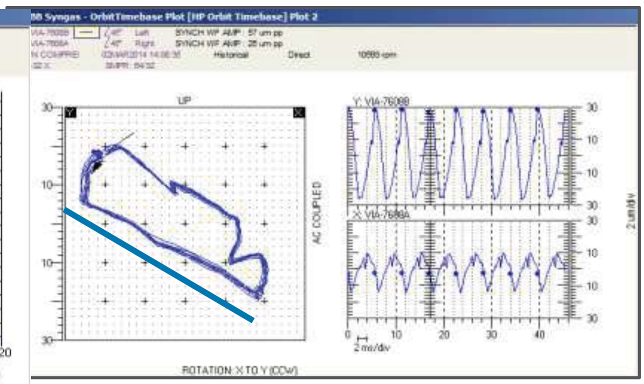
SHAFT VIBRATION AT HP COMPRESSOR

- The HP Compressor's DE Side probes indicate large vibration of 53µm pp in one direction (7608B)
- There are a number of 1X, 2X, 3X components shows either looseness or rubbing
- The orbit plot is very irregular with some impact and straight lines and hence shows some mild rubbing

Half Spectrum



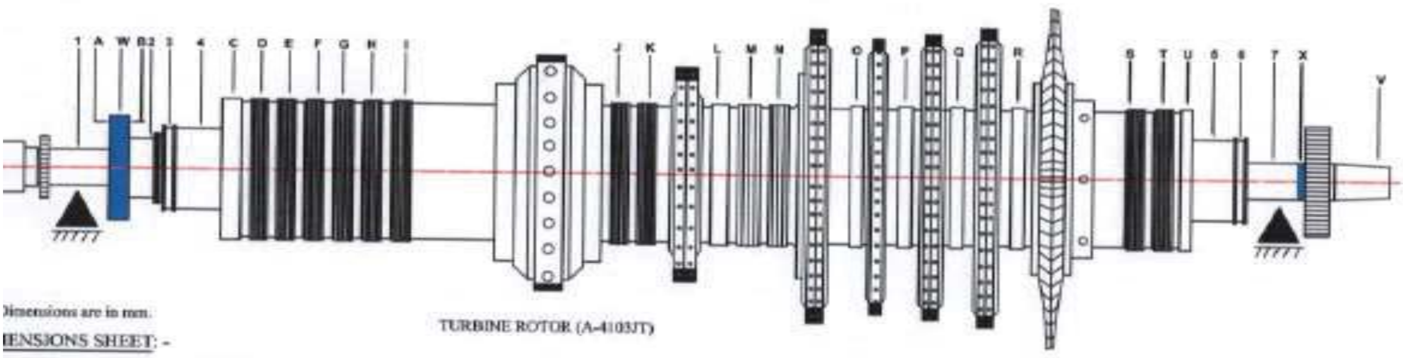
Orbit plot



FIELD OBSERVATIONS: RUBBING AT STEAM TURBINE

FIELD OBSERVATIONS: RUN-OUT OF STEAM TURBINE ROTOR

FINAL DIMENSIONS & RUN OUT REPORT



TURBINE ROTOR (A-4103JT)

Dimensions are in mm.

IENSIONS SHEET: -

n.	1	2	3	4	5	6	7
. Ø	119.85	200.01	200.01	200.02	200.10	180.05	119.84

OUT SHEET: -

.	1	2	3	4	5	6	7	A	B	C	D	E	F	G	H	I	J	K
R.	0.002	0.02	0.01	0.01	0.01	0.01	0.002	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

.	L	M	N	O	P	Q	R	S	T	U	V	W	X
R.	0.03	0.03	0.00	0.00	0.03	0.03	0.03	0.05	0.00	0.00	0.01	0.0015	0.0015

rks: Nil.

FIELD OBSERVATION: HP JOURNAL BEARING

CONCLUSION

There was evidence of rubbing from the vibration analysis

- Either at bearing or seals or gear coupling

Some looseness has also been noted

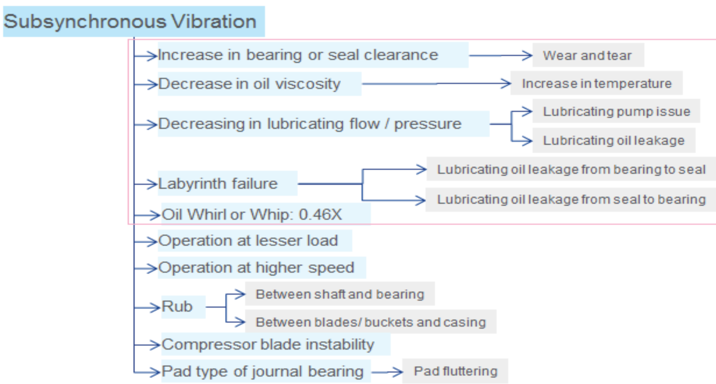
- The subsynchronous components and other 2X, 3X etc. components were found

There is an unbalance particularly near the turbine's HP side end only

- Only one side unbalance may indicate that the turbine's HP side coupling may have caused this effect as there is no unbalance effect in turbine's LP side

The sub-synchronous vibration with signs of rubbing may also be the effect of

- Either rubbing at the seal
- Or rubbing at the gear coupling



CONCLUSION

Benefits of this analysis are

- Rubbing could be detected prior to Turnaround leading to
  - Proper planning in maintenance of the turbine
- FMEA analysis could determine all the probable faults and proper fault detection

RELIABILITY IMPROVEMENT AND FAILURE REDUCTION OF COOLING TOWER FANS

Dr. Chinmaya Kar
Mr. Abdulmajeed A. Ba-Jandouh

CHEMISTRY THAT MATTERS™

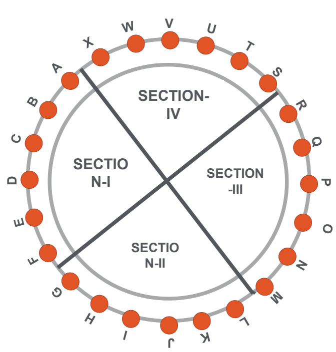
INTRODUCTION: COOLING TOWER

- **The cooling Tower is commissioned since 2006 and 1st failure was encountered in 2007**

- **The cooling tower is designed to cool the sea water coming from various heat exchangers**
- **The specification of the cooling tower is**

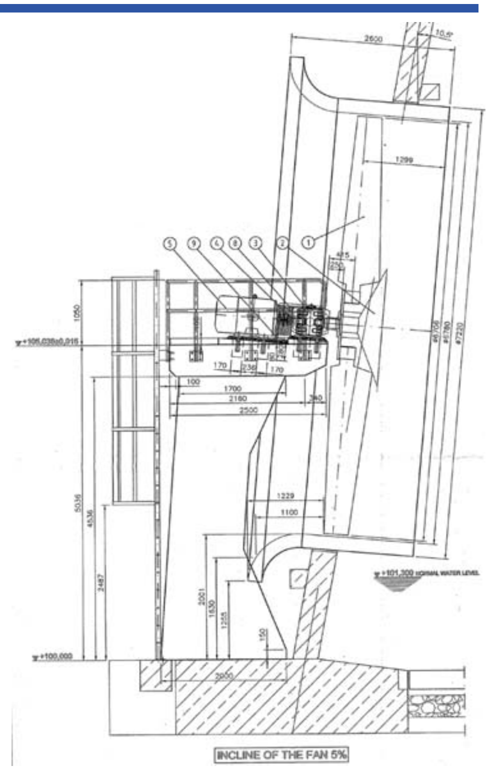
Height:	**51m**	**Total air flow:**	**9264 m^3/s**
Base diameter:	**70m**	**Inlet Temperature of water:**	**45C**
Water flow at inlet:	**67.9 T/hr**	**Outlet Temperature of water:**	**36C**

INTRODUCTION: COOLING TOWER FANS

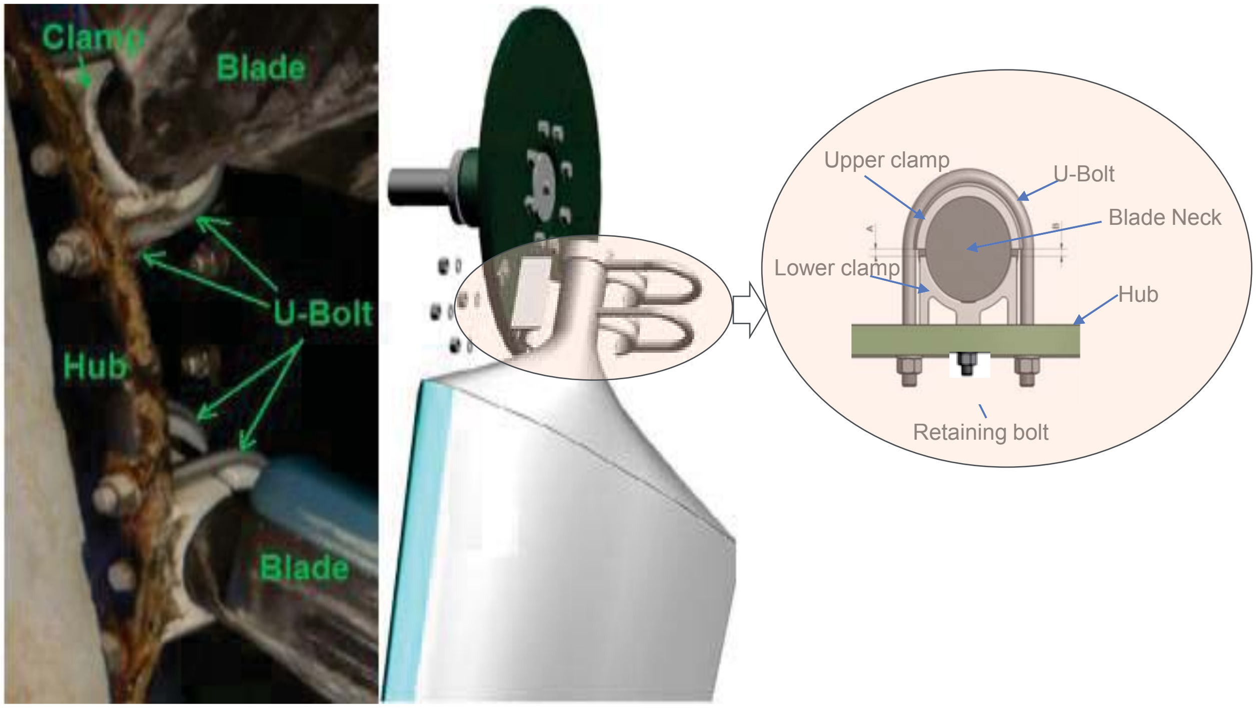


Fan Details:

1. **The cooling tower has 24 fans (A-X) distributed around 4 sections**
2. **Specification of the Fans**
   - Motor capacity: 160kW
   - Fan speed: 140 RPM
   - Number of blades: 8
   - Diameter of the blade: 6706
   - Diameter of the ring: 6760
   - Distance of the fan from the outer point of the ring: 1229
   - Angle of the gearbox / blade shaft axis: 5˚

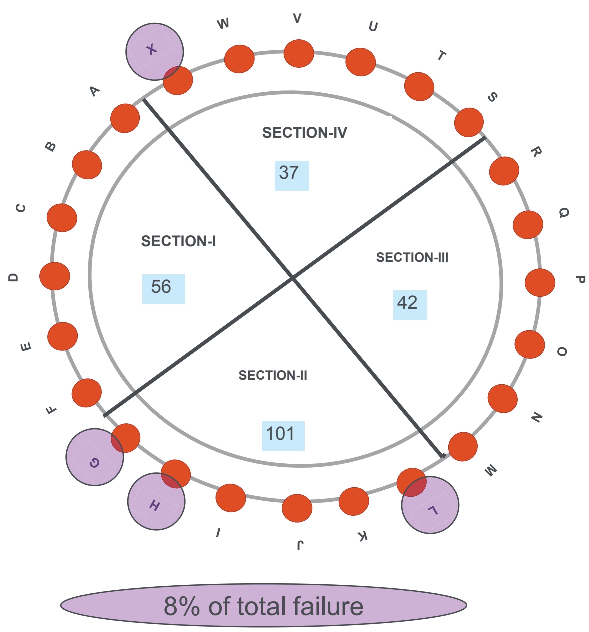


INTRODUCTION: COOLING TOWER FANS

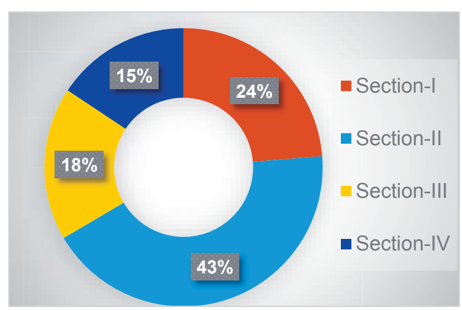


PROBLEM STATEMENT: FAILURE MODES OF FANS (TILL JUNE'13)

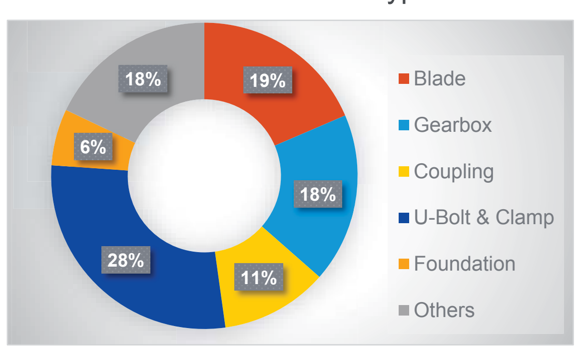
Blade-Wise Failure Distribution



Section-Wise Failure Distribution



Failure Modes Types



OBJECTIVE OF THE PROJECT

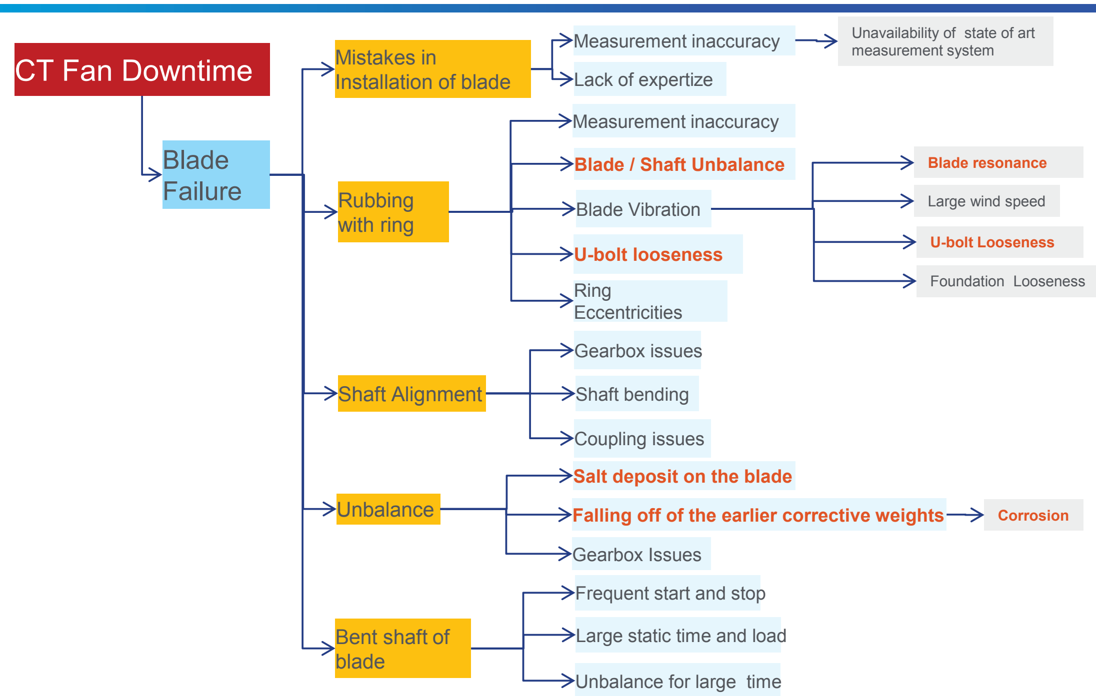
- **Analyze all the failure modes in details so as to mitigate**
  1. **The root causes of the failures**

- **Apply preventive maintenance measures so as to improve**
  1. **The life of the components**
  2. **Thus enhancing the reliability of the cooling tower fans**

- **Investigate the design and changes the design if required**

- **Analyze the effects of the above changes**

FAULT TREE ANALYSIS OF COOLING TOWER FANS



Two action plans have been initiated to reduce the root causes:
Design modification and revised PM Plan

DESIGN MODIFICATION PLAN

- Two Fans (Fan H and Fan L) were selected for designs as there were large failures in these fans

Existing Fans	Prototype -1	Prototype -2
U-Bolt, Nuts and Washers	Duplex U-bolts, Nuts and Washers	Straight Bolts, Nuts and Washers
Blades	Atlac Resin Blades (~7kg lighter than conventional blades)	Blades
Lighter Clamps		Heavier Clamps
1 Hub		2 Hubs
2 numbers of U-bolts per blade (16 number of U-bolts)	Other components same as existing Fan	4 numbers of straight bolts per blade (32 number of U-bolts)
Gearbox		Split Gearbox

PREVENTIVE MAINTENANCE PLAN INITIATIVES: SOME EXAMPLES

- For further reliability improvements, OEM suggested PM plans were revised using SAFCO's experience and failure mode analysis
  - 15-day PM plan: Regular visual inspection of the fan blades
  - 1-month PM plan:
    - Cleaning the blades : Online washing of blades,
    - Rechecking of blade angle,
    - Integrity checking of U-bolts and clamps
    - Gearbox oil checking
    - Coupling checking
  - 3-month PM plan: Retorquing of the U bolts
  - 1-year PM plan: Replacing the U-bolts and clamps

RESULTS: DESIGN MODIFICATION

	Prototype - 2	Prototype - 1
# of Failure	1 (Failed since: 23.11.2013)	1 (Two U-bolts on May'15)
Operation time	162 days	763 days
Availability	22.2%	99.7%
Maintenance time	18 hrs	5 hrs
Maintenance Cost	14 times more cost than Prototype 1	

- Failures of two fans have been reduced drastically
  - From 8% of total failures to less than 1% of total failures

Design of Prototype -1 (with change of materials) has been the best design as found from the experimental investigation

RESULTS: TYPES OF FAILURE IN PROTOTYPE -1 AND -2

Prototype-2 Failure

Prototype-1 (Fan L) Failure

- The rubbing of one blade of Fan H and the ring was found that caused large vibration

- The Fan L was found to have a broken Duplex U-bolt with crack at the threads (corrosion) and inherent defect
- However, it has less failure rate

RESULTS: PREVENTIVE MAINTENANCE PLAN IMPLEMENTATION

- **Total amount of failures in cooling tower fans has been reduced by 56%**
- **Maximum Failures are in Fan- K of Section -2 (with 10% of total failures)**
- **Failures in Sections as %age of total failures**
  - Section-1: 32%
  - Section-2: 32%
  - Section-3: 19%
  - Section-4: 17%
- Contribution of Section-2 to total number of failures have been reduced due to design modifications of its two important fans (Fan-L and Fan-H)

CONCLUSION

- The performance of Fan L (Prototype-1) was satisfactory with respect to that of other fans in Section II
  - Higher availability
  - Higher Mean Time Between Failure
- The PM plan has been effective in reducing failures by 56%

FUTURE PLAN

- The implementation of Fan L design (Prototype-1) in all the fans:

  It is expected to further improve the reliability of the fans
  - Fan blades will be changed to lighter Atlac Resin Blade (nearly 7 kg lighter blade)
  - U-bolt material will be changed to Duplex type for reducing the corrosion
- Gearbox and foundation failures are expected to be reduced after the installation of new design due to
  - The new lighter blades (with nearly 56 kg reduction per fan)
  - Lesser unbalance (with PM plan of cleaning of blades)
  - Lesser looseness (with new type of duplex U-bolts and looseness check during PM)
  - Improvement of the structure

2015 Asian Nitrogen + Syngas

Helium Leak Detection in High Pressure Urea Reactor

ALI AL SIYABI & ANKIT NIRANJAN

OMAN INDIA FERTILIZER COMPANY

OMAN

Oman India Fertilizer Company was commissioned in April – 2005. The performance in the first ten commercial years of operation has been very good and the entire envisaged project target has been accomplished.This paper discusses high pressure reactor liner leakage issue in Urea-I unit. Leakage location could not traced by conventional methods until OMIFCO strove for helium leak detection.

INTRODUCTION:

OMAN INDIA FERTILISER COMPANY S.A.O.C (OMIFCO) was set up as a joint venture project under the initiative of Government of Sultanate of Oman and Government of India. OMIFCO is owned 50% by Oman Oil Company, 25% by Indian Farmers Fertilizer Co-Operative Ltd (IFFCO) and 25% by Krishak Bharati Co-Operative Ltd (KRIBHCO). OMIFCO was registered in the Sultanate of Oman as a closed joint stock company in the year 2000.

The Ammonia Urea complex comprises two trains, each with a design capacity of 1750 MTPD Ammonia and 2530 MTPD granulated Urea, along with all supporting Utilities. It is designed to produce 1.65 million tones of granulated Urea and 0.25 million tones of surplus liquid ammonia annually for export, using natural gas as the raw material. Storage facilities for Urea (2X 75000 MT) and Ammonia (2X30000 MT) as well as jetty with ship loaders are part of the project.

The complex has two service Boilers of capacity 2 X 70 MT/hr and two HRSG boilers of capacity 2X 110 MT/hr. Also the complex has its own captive power plant with two 30 MW Frame 6B Gas turbine Generators and import power connectivity with the national grid for backup power.

Fig. 1: (OMIFCO Image)

DESCRIPTION OF THE SYSTEM:

OMIFCO owns and operates two Urea Plants designed by M/S SAIPEM, Italy (Previously Snamprogetti). The Urea manufacturing technology used at OMIFCO is based on the Ammonia Stripping Process.

As per the process steps involved for producing Urea, feed Ammonia is fed to the reactor at elevated pressure. In the Urea plant the liquid Ammonia at about 15°.C (59°.F) and 23.5 Bar G (340.84 psig) pressure is initially received in an Ammonia receiver (V-105). Later by using an Ammonia booster pump (P-105-A/B), liquid Ammonia is pumped to the suction of the high pressure Ammonia feed pumps (P-101-A/B). The high pressure feed Ammonia pump transfers liquid ammonia to the Urea reactor through an ejector where the liquid Ammonia acts as a propellant for the high pressure Ammonium carbamate solution. CO_2 gas from compressor discharge at 158 bar and at 104°C temp enters into the Reactor.(Figure-02)

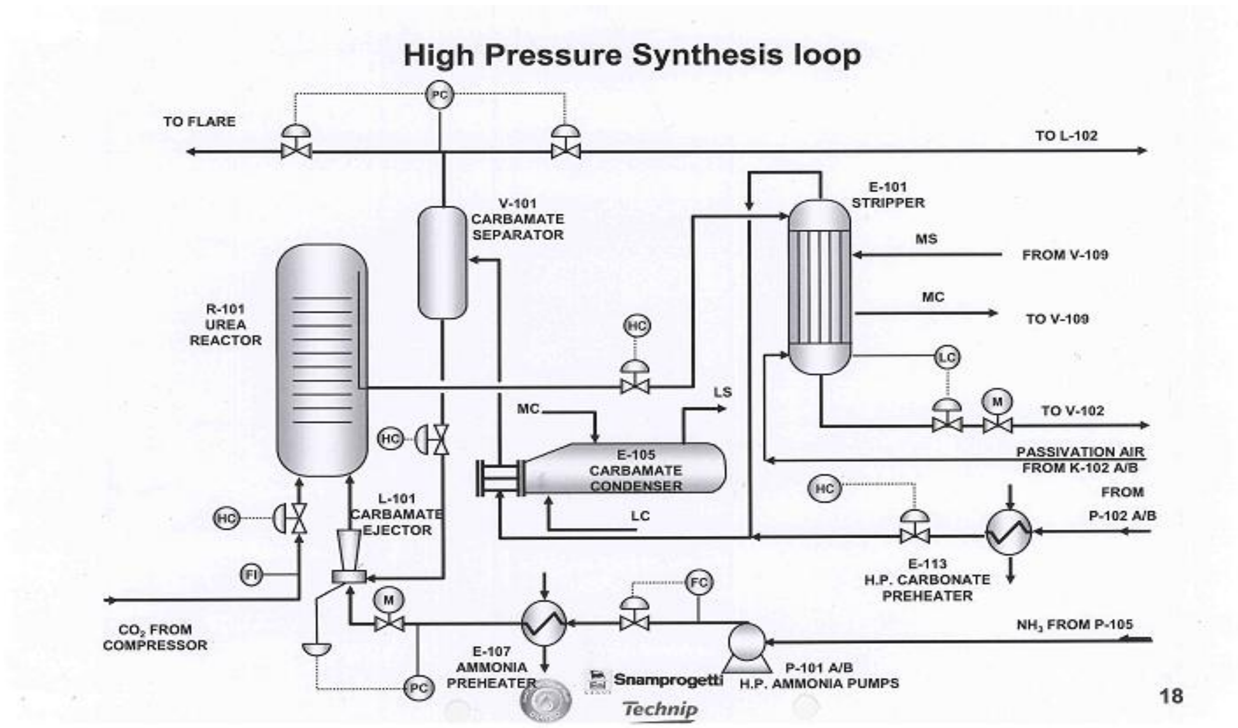


Fig. 2: (Urea HP Process Diagram)

INCIDENT SCENARIO OF HP REACTOR LEAKGE:

In Urea-11 unit during the plant shutdown inspection on 9th May 2014, a crystallized urea product is observed at the end of weep hole No.-56. This was the clear sign of leakage of the liner in progress during the operation of the plant. Also the same is confirmed by the lab reports. It was decided to ascertain the leakage location. No indication noticed on C-seam, L-seam & cleat joints by visual inspection & D.P.Testing corresponding to weep holes. (#55, 56, 23 & 24)

Fig. 3: (Leakage through Weephole)

REACTOR DETAILS:

Make: L&T
Design Code: AD-MERKBLATT 2000
Design Pressure: 167 Kg/cm2
Design Temp: 218 °C
Operating Pr: 152 kg/cm2
Operating Temp: 188 °C
Hydro test Pr: 238.91 Kg/cm2
Corrosion Allowance: Nil (5 mm thk liner)
Radiography: Full
Empty weight: 230650 Kg
PWHT: Yes
Shell Material: SA533 Gr. B Cl2
Shell Head (Top/Bottom): SA537 Cl2
Liner/Internals/Trays Material: SA240 Gr.316L MOD
Internal Bolting: 25.22.2

INVESTIGATION AND OBSERVATIONS:

Since the leakage was not traced by the visual inspection and dye penetrant testing, it was decided to perform conventional leakage detection test such as Soap solution test & Ammonia vapor leak test. Therefore the passage connection these weep holes were cleaned using steam from outside & subsequently by LW.

CONVENTIONAL TESTING'S:

First of all soap solution test was performed. In this test, air at 0.5 Kg/cm2 g pressurized through weep hole no. 55 & 56. Weep hole no. 23 & 24 kept plugged. No time given as soaking period. Soap solution was applied on inner surface of the liner. No leakage indication observed.

Further it was decided to perform ammonia vapor leak test as recommended by Saipem. In this test, ammonia at 0.5 Kg/cm2 g pressure is injected through weep hole no. 55 & 56. Weep hole no. 23 & 24 kept plugged. 6 hrs soaking time is given. Paper wetted in phenolphthalein solution was enveloped on the inner surface of liner. But no change in color is noticed.

Suspected Reason for No Detection may be low Test Pressure and Restriction in Air Flow

After getting gloomy results by above two tests, it was decided to start up the plant, but unfortunately leakage observed again from the same place (weep hole no. # 56). For few days plant was kept running in this condition. But after few days of plant running it is decided to stop the plant to pinpoint the leakage. Soap solution test & ammonia vapor leak test were performed again using same procedure but no positive indication came.

Now it is decided to perform helium leak testing. A vendor was called against the existing contract. On 10th Aug; Helium leak detection was performed.

HELIUM LEAK DETECTION:

Description

Helium Leak detection is based on mass spectrometry technique employing mass spectrometer sensitive to helium gas. It is commonly referred as Mass Spectrometer Leak Detector (MSLD). It is used to locate and measure the size of leaks into or out of a system or containing device. In this testing helium is used as tracer gas, and is introduced to a test part that is connected to the leak detector. The helium leaking through the test part enters in the helium leak detector. The amount of the helium is directly proportional to the leak rate of the part. The partial pressure of helium is measured by the leak detector and the measured value is converted to display the leak rate of the part. Presence of helium is detected by MSLD. Depending on the test methods, qualitative or quantitative information about leak and leakage rate is determined. Helium is the best choice of tracer gas to find leaks for number of reasons. It is non-toxic, inert, non-condensable, non-flammable and not normally present in the atmosphere (< 5 ppm). Helium is the smallest molecule which is inert. Due to its small atomic size, helium passes easily through leaks.

COMMON METHODS OF HELIUM LEAK TESTING:

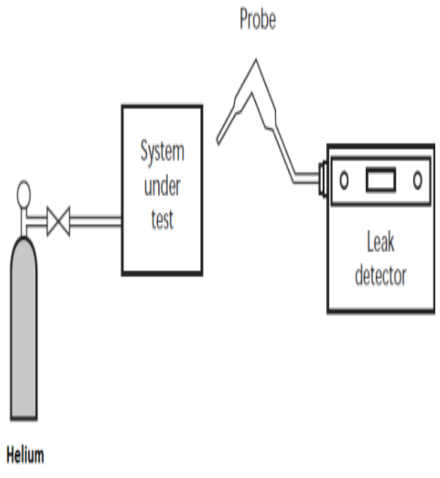
Mainly there are two methods to leak test parts using helium: Vacuum Testing (outside-in) and Pressure Testing (sniffer technique). The detection method should be selected based on the working conditions of the part to be tested. It is important to maintain the same pressure conditions during the test as they will exist during the actual use of the part. Vacuum systems should be tested with a vacuum inside the chamber. A compressed air cylinder should be tested with high pressure inside the cylinder.

Vacuum Testing (Outside-in)

In vacuum testing, the part is evacuated with a separate pumping system for larger volumes, or by detector itself for smaller volumes. To locate a leak, helium is sprayed to the suspected leak sites of the part using a spray probe with an adjustable flow.

Pressure Testing (Inside-out/Sniffer method)

In Pressure Testing, the part is pressurized with helium or a mixture of helium and air. To Locate a Leak, the potential leak sites of the part are scanned using a Sniffer Probe connected to the inlet of the leak detector.



Figs. 4&Fig 05: (Testing Machine)

PROCEDURE USED IN REACTOR:

It was decided to perform helium leak detection using Sniffer probe method. Suspected area circumferential seam # 7, 8, interconnecting long seam & cleat joints are masked with polythene sheet divided into a number of segment and edge of polythene sheet is sealed with suitable tape. This polythene envelope over leak susceptible area segment acted as a reservoir for accumulating leaking helium. Thus helium concentration in the envelope would increase with holding period and probability of detection of minute leakages is increased. Instrument air is injected to dry the annular space then Helium was instilled through weep hole no. # 55 & 56 (weep hole no. # 23 & 24 kept plugged).

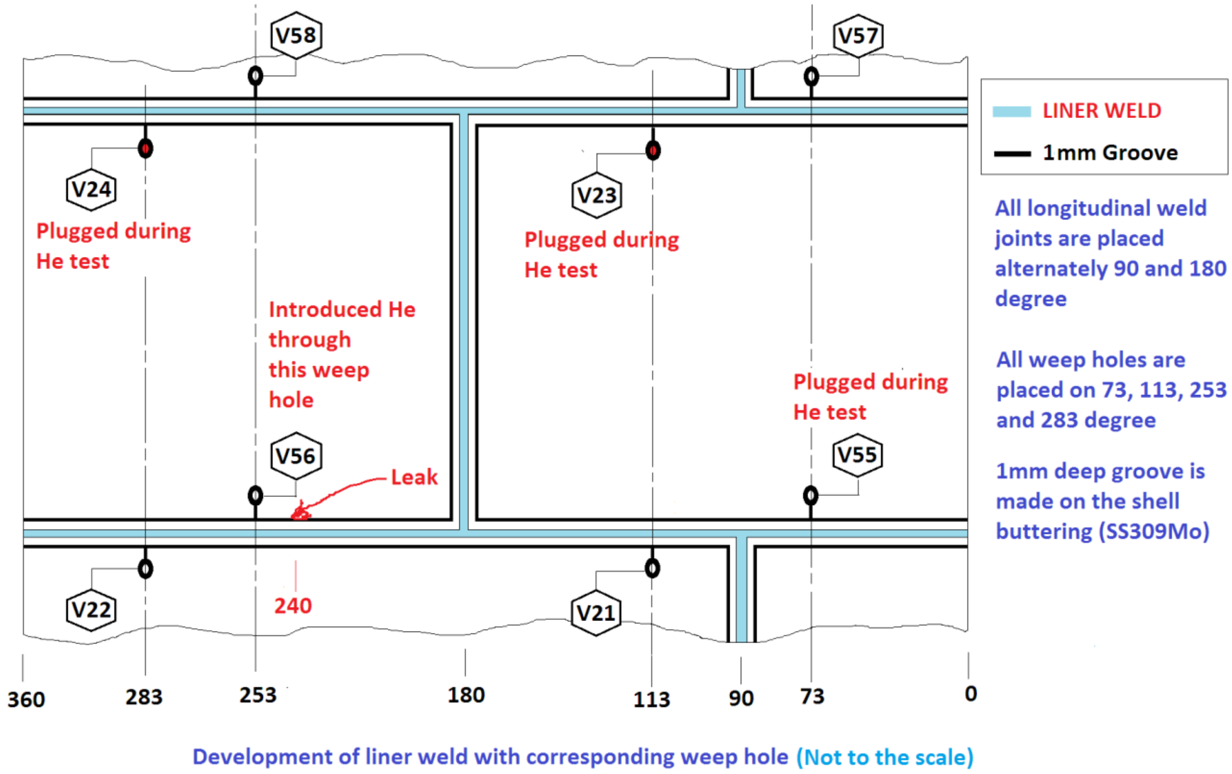
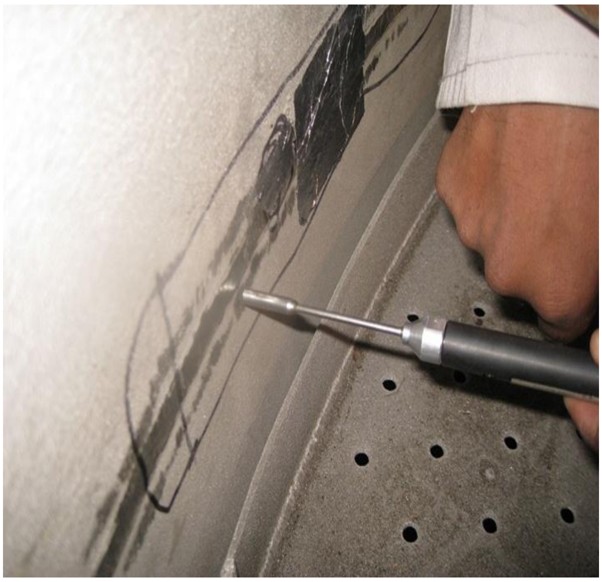
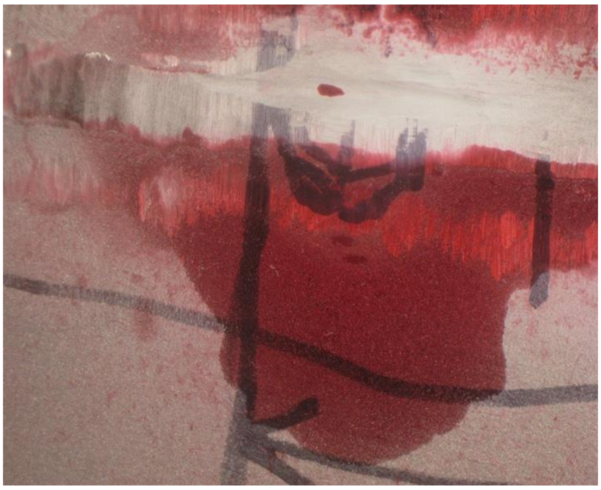


Fig. 6: (Liner Weld Area)

The annular space between inner lining and shell is pressurized with helium gas. Pressure is maintained around 0.5 Kg/Cm2 g. Since gas/air is already present in the annular space, concentration of helium gas reduces in the annular space. Four hour holding time was given. Presence of any helium under polythene sheet was checked by inserting tip of detector probe. Leakage is identified by Helium test in the 8th tray's circumferential liner weld joint. It was observed in the upper side wall of the weld approximately at 240 ° (Referred 0° from the internal overflow pipe clockwise).



Figs 7 & 8: (Test in Progress) & (Polythene sheet masked by sheet)



Figs. 9 & 10: (Leakage Area) & (Pinpoint Location)

REPAIR & REHABILITATION:

The suspected area (approx 150 mm weld length) was grinded and the area is checked by DP Testing which revealed a defect indication. It was arrested by welding and followed by DP test for root and final run. Repaired portion was checked with detector probe and no further indication was observed by Helium Leak testing.

Figs.11 & 12: (Repaired area) &(Repaired Weld)

CONCLUSION:

It was the first incidence of any HP vessel liner leakage in OMIFCO history.

Conventional testing's were failed to identify the leakage location.

This was the first time when any company in Middle East & India region used Helium leak detection for detecting such type of leakage.

Repair & recommendation procedure followed as per Saipem recommendation.

After OMIFCO experience, few companies in India tried helium leak testing for detecting such type of leakage and thrived.

OMIFCO used helium leak detection used again successfully in June, 2015 for detection of liner leakage in HP Carbamate Condenser.

OMIFCO is planning to buy above instrument in year 2016.

الإتحاد العربي للأسمدة
Arab Int'l Organization منظمة عربية دولية
Arab Fertilizer Association
Since 1975

الشركة العمانية الهندية للسماد
OMIFCO

Quality Control and Assurance in Maintenance in Fertilizer Industry Workshop

Day 3

Wednesday: Nov. 25, 2015

Muscat - Sultanate Oman

23-25 November 2015

SHARING OF MAINTENANCE EXPERIENCES IN MAJOR ROTATING EQUIPMENT.

Engr. Muhammad Sajid
Lecturer
University of Gujrat
Pakistan

AFA Workshop on "Quality Control & Assurance in Maintenance in Fertilizer Industries"
Oman 23 – 25/11/2015

Arab Fertilizers Association

CONTENTS

- Introduction
- Objectives
- Rotary Equipments
- Auxiliary and support system
- Safety of rotary equipments
- Maintenance of rotary equipments
- Case studies

LEARNING OUTCOME

Define safety needs and lockout procedures.

Identify rotating equipment.

List the major components of rotating equipment and explain their function.

Identify the auxiliary equipment required to maintain rotating equipment operation.

Define inspection and preventative maintenance techniques.

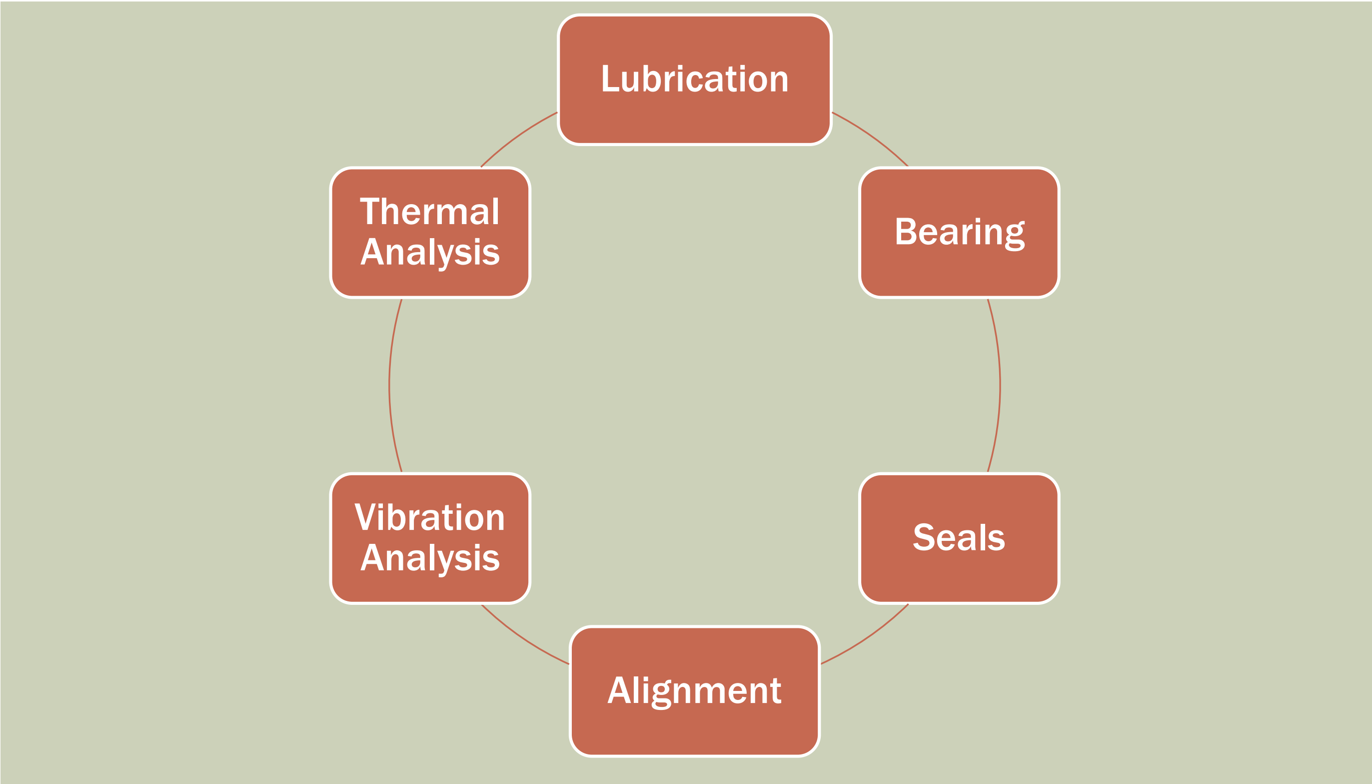
INTRODUCTION

- Critical part
- Precision and accuracy required
- Foundation
- Start up
- Alignment
- Operational safety
- Routine inspection
- Lubrication
- Bearing temperature
- Emergency exit

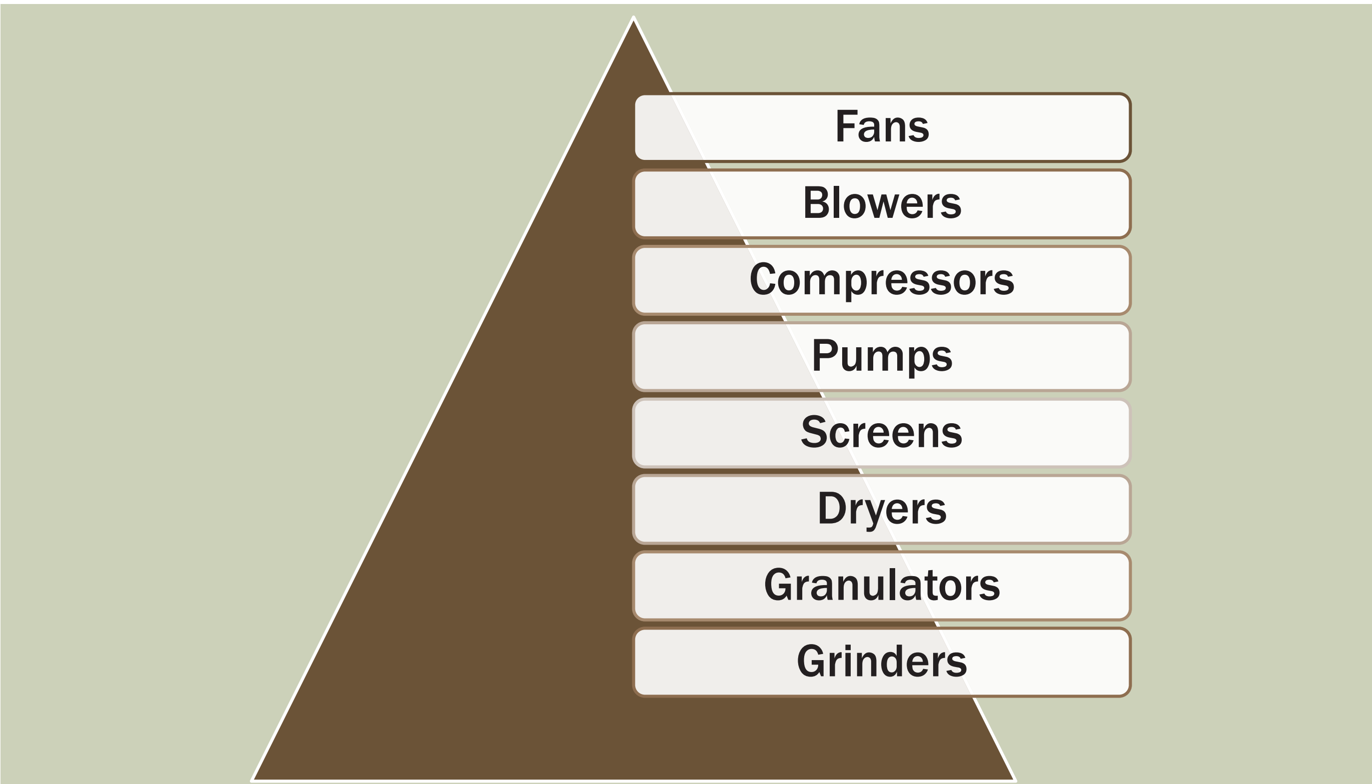
MAJOR ROTARY EQUIPMENTS

Compressors	• Rotating, screw and centrifugal types
Turbines	• Gas turbines • Steam turbines
Pumps	• Basic types and Centrifugal
Fans, Blowers, and Louvers	• Centrifugal, • Reciprocating, Screw

AUXILIARY AND SUPPORT SYSTEMS



MAJOR ROTARY EQUIPMENTS IN FERTILIZER INDUSTRY



ROTARY EQUIPMENT SAFETY

Crushed Hands and Arms

Injured Fingers

Blindness

All these are because of carelessness near rotary equipments

ROTATING EQUIPMENT SAFETY

All persons working near or around rotating equipment should be familiar with the location and operation of all stopping devices.

Be alert when in equipment areas, leaning against equipment, and where you put your hands.

Rotating equipment movements are often sudden and unpredictable

ROTATING EQUIPMENT SAFETY

- Maintain good housekeeping practices.
  - Clear work areas and pathways of debris and obstructions.
  - Properly clean up spilled lubricant and other slippery materials.
- If equipment is down for service, lock out per plant requirements.
  - Always assume equipment can start at any time.

ROTATING EQUIPMENT SAFETY

Restricted entry while maintenance in rotary equipments

When climbing around or following conveyor paths, be aware of hazards such as sharp edges, protruding objects, and low clearances.

ROTATING EQUIPMENT SAFETY

If potentially dangerous conditions exist, report it to the proper supervisor immediately.

Do not work around equipment while under the influence of alcohol, drugs, or narcotics.

Avoid entanglement in rotating equipment by:

- Removing loose items such as clothing and jewelry
- Tying back long hair

Leave repair functions to the properly trained maintenance personnel to perform.

ROTATING EQUIPMENT SAFETY

All maintenance personnel
- shall be qualified and trained
- proper repairs experience
- Safe maintenance procedures
- follow the established standards
- lockout energy control procedures.

ROTATING EQUIPMENT SAFETY

- Bypassing or jumping safety circuits will cause a hazardous condition and must never be done.
- Do not perform maintenance on a system while it is running unless the nature of the maintenance absolutely requires so.
- Use all recommended safety practices when using mechanical aids, hoists, cables, safety harnesses, and other equipment.

ROTATING EQUIPMENT SAFETY

It may be necessary to bleed lines to any pneumatically or hydraulically powered component of the system to prevent inadvertent operation to prevent injury inherent in stored energy. Lockout any associated electrical interlocked equipment.

When power needs to remain on for testing electrical components or mechanical functions all operators or personnel involved with the equipment should be made aware of the testing and work being done.

ROTATING EQUIPMENT SAFETY

Be aware of abnormal noises as they often precede mechanical problems and safety hazards. Investigate as soon as possible to protect people and machinery.

If abnormal noise is due to vibration, check for build-up of foreign material, misalignment, or failed internal rotating components.

ROTATING EQUIPMENT SAFETY

Equipment starting precautions

Do not restart the equipment unless all safety devices are working and all guards and fences are in place.

ROTATING EQUIPMENT SAFETY

Before restarting a piece of equipment that has been shut down for any reason, ensure that all personnel are clear and that everyone at risk within the area is aware that the machine is about to be started.

SHIFT CHANGEOVER

SHIFT CHANGEOVER

- Accident occurrence frequency
- Equipment wear and tear

SHIFT CHANGEOVER

- Proper shift change over
- Shift report writing
- Shift routines
- Special precautions for night shift
- Defined emergency team & team leader

SHIFT CHANGEOVER

- Check
- All equipments especially rotary equipment
- Their record of last shift
- Lubrication
- Gear box sounds
- Conveyers alignments
- Stand by pumps, compressors etc

CASE STUDY

- Granulator feeding conveyer belt
- Ruptured

MAINTENANCE OF ROTARY EQUIPMENTS

MAINTENANCE ACTIVITIES

Weekly Jobs

- Make-up governor oil (If required).
- Make-up bearing oil (If required).

Monthly Jobs

- Check dry gas seal filter.
- Check lube oil filter.
- Check air filter.

PREPARATION OF MAINTENANCE

- Work permit is the controlling document.
- Preparatory measures are aimed for safe work
- Internal operations after identifications includes following measures :
  - ✓Depressurization
  - ✓Cooling
  - ✓Isolation
  - ✓Removal of contents (Solid, Liquid, Gas)
  - ✓Cleaning

PREPARATION OF MAINTENANCE

Identification of plant:

- Prevention of accidents
- Attaching a permanent ID or temporary to equipments
- ID tags for pipe joints
- ID tags should be provided along the work permit
- Systems can be followed for identification for equipment such as BS1710:1984, Specification for identification of Pipelines and Services.

PREPARATION OF MAINTENANCE

➢ Depressurization:

- Avoiding excessive flash-off
- Liquids above boiling points (cooling required)
- Flammable and toxic gases transferred to alternate storage.
- Inert gases to vent stack.

➢ Cooling :

- Hazard of vacuum collapse
- Inert gas injection as a guard

PREPARATION OF MAINTENANCE

➢ Isolation:

- When maintenance work is subjected to risk from noxious materials, energy sources and electrical equipment it should be isolated to ensure safety.
- Isolation may be required prior to inspection, servicing, repair, cleaning.
- Isolation of valves and pipes
- Isolation of machinery
- Isolation of electrical equipments

PREPARATION OF MAINTENANCE

✓Isolation of valves and pipes:

- Locks and tagging
- A closed and locked valve, a double lock and bleed valves system, a slip plate and physical disconnection.
- For pressurized hydrocarbon system and isolation of relief valves and vent lines physical disconnection is the most preferred system.
- The closed and locked isolation valves should only be used for low hazard fluids.
- Split plates should be correctly identified and should be carefully removed after maintenance jobs.

PREPARATION OF MAINTENANCE

PREPARATION OF MAINTENANCE

✓Isolation of machinery:

- Source of power should be first isolated
- In pneumatic and hydraulic systems, first preliminary isolation should be effected by closing the valve .
- Then the supplies and return pipes should be disconnected.
- Isolation of engine driven system should be isolated by shutting off the engine fuel supply and then cutting off all starting points.

PREPARATION OF MAINTENANCE

✓ Isolation of electrical equipment:

- Electrical isolation is required for immobilization of machinery and personal safety.
- Electrical isolation is effective for the equipments with rotary machines, machines with moving parts, and vessel with stirrers and agitators.
- Most methods consists of withdrawing fuses, lock off isolator or electrical disconnection.

PREPARATION OF MAINTENANCE

➢ <u>Removal of contents:</u>

- Emptying liquid, transferred to other containers, storages or drained.
- Solids may includes raw materials, product, catalyst and adsorbents.
- Raw materials generally converted to products while other transferred to suitable containers.
- Flammable dust particles or residues dealt technically example of wet iron sulfide in oil refinery.
- Number of methods to remove gas and vapors consisting of (1) Forced ventilation (2) Flushing with water (3) Purging (4) Steaming

PREPARATION OF MAINTENANCE

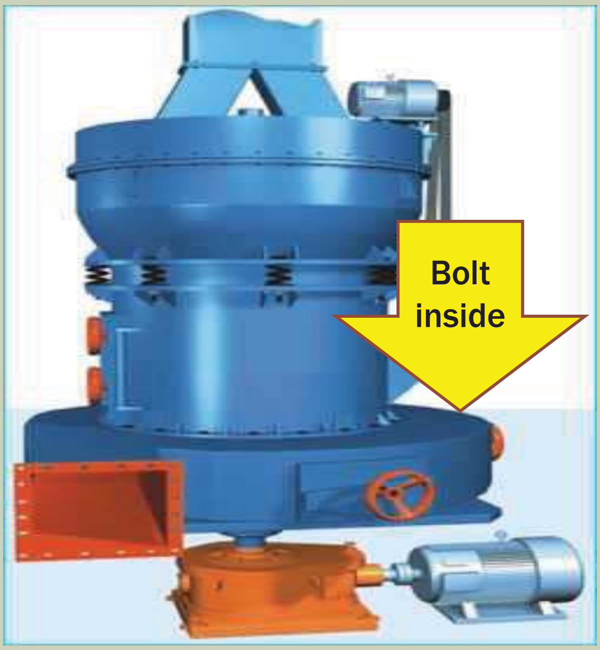
➢Cleaning:

- Wide variety of cleaning methods
  1. Water washing
  2. Chemical cleaning
  3. Steaming
  4. Water jetting
  5. Solvent jetting
  6. Shot blasting
  7. Manual cleaning
  8. Cleaning in place (CIP) ↔
  9. Line cleaning

•Water pre rinse
•Detergent circulation
•Intermediate water rinse
•Sterilant circulation
•Final water rinse

CASE STUDY 1

Roller Grinder

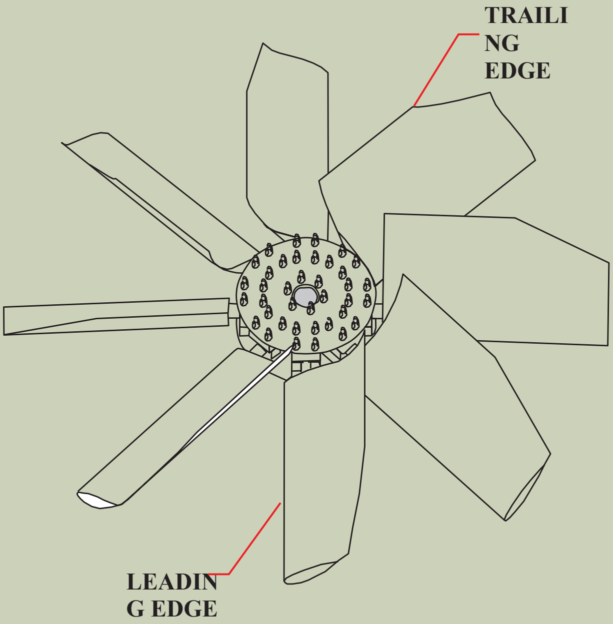


Foundation bolt broken

- Vibration
- Change in operating electric load
- During inspection, one bolt didn't properly fixed

CASE STUDY 2

- Blower Accident
- RCA
  - Vibration not observed by operator
  - Impeller cleaning issue
  - Coupling Nut was not properly fixed



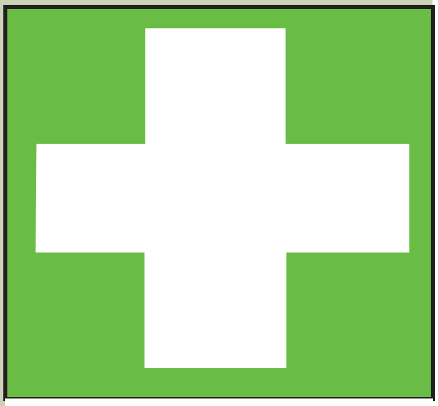
CASE STUDY 3
DRUM DEN ACCIDENT

Improper fixing

MANDATORY SIGNS

Attention, When Entering

- Signs are for posting at the entrances to all production facilities
- Special sign with rotary equipment indicating their associated hazards



WARNING SIGNS

Warning signs mean

- Caution
- Risk of Danger
- Hazard ahead

AFTER MAINTENANCE

Before pack up

- Ensure all personal removal
- All tools removal
- Cleaning
- Physical breaks
- Always thoroughly check before fixing the door

AFTER MAINTENANCE

Before start up

- Mark check lists
- Include each and every necessary item in check list
- Follow manufacturer check list or prepared your own
- construct check lists before maintenance
- Don’t believe verbal assurance only rely check lists
- Review check list and then restrart

AFTER MAINTENANCE

EQUIPMENT RECORD SHEET

Equipment Code		**Plant identification number**		
Date of commissioning		Location of the Department		
Date	Detail of parts replaced/repaired	Manhours spent	Down time	Signature

CASE STUDY 4

BUCKET ELEVATOR GEAR BOX

- When started bucket elevator of vibratory screen feeding system
- Gear box damaged after 08 hrs. only

- **Oil level was not marked**

BRAIN STORMING

- Your are a maintenance engineer
- Maintenance task is "repairing of lifts in rotary dryer"

- Plan this activity and enlist requirements

ALBAYRONI
"Affiliate"

LESSON LEARN FROM FAILURES: FAILURE OF MIXED FEED COIL IN PRIMARY REFORMER

Nov. 2015

By: Saad Mohammed Al-Qahtani

CHEMISTRY THAT MATTERS™

CONTENTS

RCA TEAM

SN.	Organization	Name	Job Title
1	ALBAYRONI	1. Hussain Al-Hajari 2. Sanjay Nehete 3. Hadi Al-Zerea 4. Lokesh Pandya 5. Saad Al-Qahtani 6. Nassir Abbas 7. Virendra Gupta 8. Ajmal Abdullah 9. Ahmed Al-Mulhim	1. Sr. Manager, ESD (Team Leader) 2. Manager, Inspection 3. Manager, Ammonia 4. Manager, Process 5. RCA Specialist 6. Inspection Engineer 7. Machinery Engineer 8. Instrument Engineer 9. Process Engineer
2	SAFCO	Akbar Ali	Inspection Engineer
3	SABIC MCE (Through Consultancy)	1. Khalid Rahil Sheltami 2. Mudayeq, Fahad M. 3. Schrijen, Harry	1. Section Head, Static Equipment 2. Sr Engineer inspection & NDT 3. Advisor Material & Welding
4	SABIC E&PM (Part Time)	1. Deepak Dhankani 2. Khan, Ejaz Ahmed	1. ABEOP Project Engineer 2. QA/QC Staff Engineer

PROBLEM STATEMENT

Location : Ammonia Plant – Primary Reformer

Date : 21 October 2014

Description : At 04:30 AM on 21st October, 2014; Ammonia plant was shut down as the primary reformer furnace box lost the vacuum due to leakage in mix-feed coil of the hot leg convection section.

Ammonia and Urea plants were shutdown safely as per SOP. This resulted in 0.81 day downtime equivalent to production loss of 768 MT of Ammonia product and 1234 MT of Urea product.

PRIMARY REFORMER

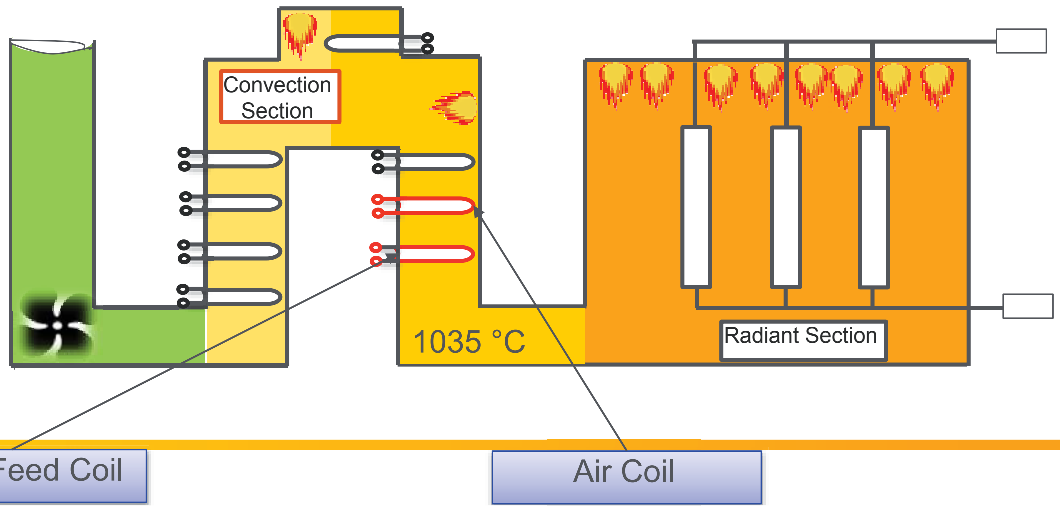
- Ammonia Plant was established in (1983). It was revamped in 2002 to produce 1300 MT/D of liquid ammonia
- Albayroni Energy Optimization Project (ABEOP) was executed and commissioned on June 30, 2013 to save energy by 15 % total complex consumption
- Mix feed coil was modified during ABEOP for recovering more heat from the flue gases

DATA GATHERED

- Process parameters and Report
- Engineering Documents
- Inspection & Test Plan and Records of ABEOP
- Site inspection records for failed coils
- Results of metallography for failed pieces by MCE Laboratory, Jubail

PRIMARY REFORMER PROCESS DESCRIPTION

- Primary Reformer Furnace is a conventional Top Fired Furnace having radiant and convection sections
- Radiant section houses the catalyst tubes for reforming of natural gas with steam over Nickel catalyst
- Convection Section has series of seven coils to recover the heat for process duties
- Induced Draft fan maintains the vacuum in the radiant section
- Forced draft fan provides combustion air to burners



PICTURES OF FAILED JOINTS

Cracked Weld

INCIDENT TIMELINE

ABEOP PROJECT ACTIVITIES

25 August, 2011

EPC contract for ABEOP awarded

→

16 May, 2013

Achieved mechanical completion of ABEOP

→

30 June, 2013

Ammonia Plant commissioned after ABEOP.

→

21st October, 2014

At 04:30 AM Primary reformer lost vacuum. Plant was shutdown following SOPs.

↓

22 October, 2014.

Seven (7) Dissimilar Metal Weld (DMW) joints were found damaged in Mix Feed Coil.

LOGIC TREE

- Total number of failure modes:1
- Total Number of causes: 5
  - Latent causes: 2
  - Physical Cause:1
  - Human Cause: 2

- Total Number of observations: 6

Logic Tree Analysis

ROOT / CONTRIBUTING CAUSES

ROOT CAUSES

- Inspection Procedure most probably not Followed (Manufacturing Defect not identified by liquid penetrant inspection and visual inspection and not reported)

- NDT technique (RT) not fully effective (ASME V & MCE) for this type of defect geometry (lack of side wall fusion)

WHAT WENT WRONG?

- EPC contractor for ABEOP had awarded the supply of mixed feed coil to a sub-contractor including engineering. The sub-contractor awarded the mixed feed coil fabrication to one tubes Shop.
- Based on documents submitted by EPC contractor for ABEOP , it was observed that all weld defects (7 out of 28) were clustered in one area and all 28 joints were done by one welder.
- It was found from the documents supplied by EPC contractor for ABEOP , that welder's homologation was not meeting the regulatory requirements of ASME IX. Welder No. D3 submitted certificate WPQ-204.3 shows it was last done in 18/12/2006, six years before. This would have affected the continuous performance of welder.
- ALBAYRONI Inspection observed that some joints welding were not done as per WPS. This observation was also endorsed by MCE welding specialist.
- ALBAYRONI Inspection has also identified lapses during fabrication of the nozzles of mixed feed coil in spite of the "visual & dimensional examination report accepted by all parties with respect to the associated drawings for fabricated MFH Convection coils". EPC contractor for ABEOP has confirmed that the sub-contractor and its inspectors couldn't identify this mistake at shop.
- From the above findings and observations, it is evident that Quality Control by fabrication shop as well as the Quality Assurance by the Inspection Agencies in both EPC contractor for ABEOP and the respected sub-contractor was improper (even not complying with codes) and ineffective.

Shop Fabrication Mistake

shop

RECOMMENDATIONS

Root/Contributing Cause(s)	Action Item	Responsibility	Target Date
Inspection Procedure not Followed (Manufacturing Defect not identified by Radiographic inspection and not reported)	Communicate with E&PM PMT on Inspection and Test Plan for mega projects to be reviewed for eliminating the recurrence of such deviations.	ESD	Feb 2015
NDT technique (RT) not fully effective (ASME V & MCE)	Raise ESTS to review the relevant SABIC Engineering Standards (SES)	ESD	Feb 2015

KEY LEARNINGS

TECHNICAL

- Dissimilar Material Welding (DMW) joints have statistically more failure rates than normal welding joints and therefore:
  - It demands mandatory application of more stringent and additional QA/QC techniques e.g. liquid penetrant testing and hydro-test at prescribed pressure prior to putting into service
  - Application of DMW should be avoided at project stage by appropriate design substitutes like break flange

ADMINISTARTIVE or PROJECT MANAGEMENT

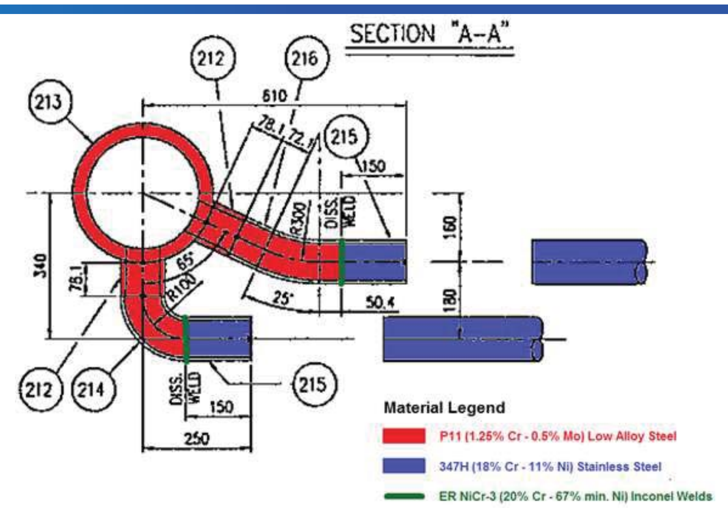
- For all DMW joints:
  - More stringent ITPM plan like essential witnessing and approval by owner (not to be substituted by third party)
  - Any waiver of the above technical and administrative requirements to be approved by senior management of E&PM and Affiliate
  - Revisit and revision of SES to accommodate the above technical and administrative lessons learnt for all new projects

MIX FEED COIL HISTORY

#	Parameter	Unit	1983	Year 2002	Year 2008	Year 2013
1	Case Description		Original	Debottlenecking Project	Reliability Project	ABEOP
2	Rows x Coils/Row		4 x 10	2 x 10	2 x 14	2 x 28
3	Coil Material of Construction		A335 Gr22	A335 Gr22	A213 TP347H	A213 TP347H
4	Header Material of Construction (In/Out)		A106 GrB	A106 GrB	A335 P11	A335 P11
5	Operating Pressure	BarG	35.9	34.5	33.74	33.6
6	Operating Temperature (In/Out)	°C	349/510	424/511	391.9/459.7	341.3/495

MIX FEED COIL TECHNICAL DETAILS

#	Parameter	Detail
1	Rows x Coils/Row	2 x 28
2	Coil Material of Construction	A213 TP347H
3	Header Material of Construction (In/Out)	A335 P11
4	Operating Pressure, BarG	33.6
5	Operating Temperature, °C (In/Out)	341.3/495



FIELD INSPECTION FINDINGS

#	Major Findings
1	Total Seven (7) Dissimilar Metal Weld (DMW) joints were found damaged in Mix Feed Coil.
a	One DMW Joint (between P11 & 347H) on Mixed Feed Outlet Header side, found completely cracked & detached from WELD TOE at P11 side, in Visual Testing.
b	Cracks were revealed in Four DMW joints in other rows of the same coil, in Penetrant Testing.
c	One DMW joint was found cracked in the Radiography results.
d	Another DMW joint in same coil was found leaking during Hydro test when pressure reached to 8.0 BarG.
2	One DMW joint in Steam-Air coil was found having crack on Outlet Header side, during visual inspection.

Inspection Report-03NOV2014

THANKS

ALBAYRONI
"Affiliate"

LIFE TIME EXTENSION STUDY OF HIGH PRESSURE UREA PIPING

May 2013 Ref. Paper # XXXX

By: M. Nasir Abbas & Mohammed A. Al-Omar

CHEMISTRY THAT MATTERS™

CONTENTS

FACILITY INTRODUCTION

- Al-Jubail Fertilizer Company (Albayroni) is SABIC affiliate formed in 1979 by a 50/50 joint venture with Taiwan Fertilizer Company (TFC).

- It is situated in the Al-Jubail Industrial City in Eastern Province of Saudi Arabia with coordinates 27°3'54"N 49°33'30"E and comprises of Fertilizer & Petrochemical complexes. Main products are Ammonia, Urea, 2-Ethyl Hexanol (2-EH) & Di-Octyl Phthalate (DOP).

- Fertilizer Complex comprises of Ammonia Plant, Urea Plant and associated utilities. This case study relates to Urea Plant. Albayroni urea plant is a Stamicarbon CO_2 stripping plant with a falling film HP Carbamate Condenser. Plant was commissioned in March 1983 and the name plate capacity is 1600 MT/day.

STUDY DETAILS

- Study for the Life Time Extension was based on Desk Study as well as Field Inspections, both by the Licensor .

- Desk study of all relevant data received from Albayroni with respect to inspection and maintenance history, average weather conditions in Al Jubail (to assess the risks for atmospheric corrosion) and other relevant data, such as failure investigation reports; was conducted in Licensor office .

- On-site inspections were planned & performed during an already planned TA in April/May 2013 by Licensor team himself. These inspections consisted of visual examination, endoscopic examination and ultra-sonic thickness measurements (both by point-thickness readings and surface-scanning).

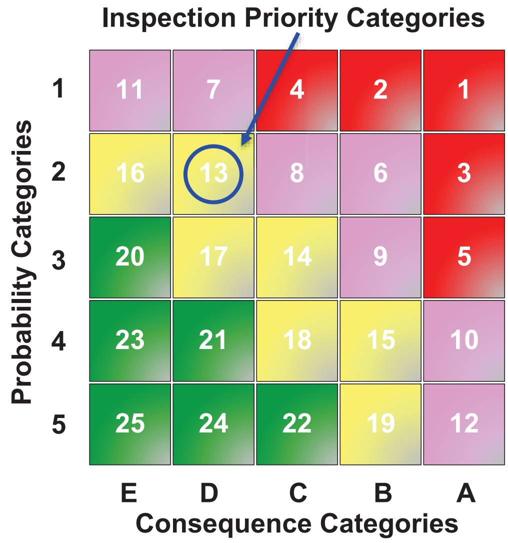
STUDY DELIVERABLES

- Licensor was requested to study the residual life time of the HP piping in the synthesis loop of the Albayroni Urea Plant. This study was based on a RBI methodology where following aspects are considered;
  - Possible failure modes.
  - Probability of failure of each failure mode.
  - Criticality ranking.
  - Inspection of HP piping during planned TA May 2103.

- Based on this assessment and inspection results, recommendations for future inspections and maintenance / replacement activities were also requested in order to secure the reliability and availability of the urea plant in future.

METHODOLOGY

- Criticality ranking of the HP pipelines was based on a RBI methodology. In this methodology the possible failure modes, probability of failure (PoF) and consequences of failure (CoF) are considered.
- Criticality of the HP pipelines in this study has been based on the probability of failure (PoF) alone, since the consequences of failure (SHE, availability and economical consequences) are considered equal for all HP piping included in this study. A distinction has been made between the PoF for internal (process related) degradation mechanisms (PoF-int) and (PoF-ext) for atmospheric corrosion.
- Effective on-stream time of 27.7 years is used for corrosion rate calculations purposes.



LIST OF LINES STUDIED

CB-9001	6"	NH_3 & carbamate from 301-L HP Ejector to 303-C HPCC top
CB-9003	10"	303-C HPCC liquid to 301-D Urea Reactor bottom inlet
CB-9005	6"/10"	304-C HP Scrubber outlet to 301-L HP Ejector
CB-9006	4"	301-D Urea Reactor lower funnel to 301-L HP Ejector
CB-9007	4"	307-J/JA carbamate pumps discharge to 304-C HP Scrubber top
CB-9007	3"	307-J carbamate pump discharge to scrubber top 304C
CB-9007A	3"	307-JA carbamate pump discharge to CB-9007
CB-9002	10"	302-C HP Stripper off gas to HPCC-top
CB-9004	10"	303-C HPCC bottom gas to 301-D Urea Reactor
PV-9001	6"	301-D Urea Reactor off gas to 304-C HP Scrubber sphere
PV-9001A	3"	301-D Urea Reactor off-gas to relief valve RV-301D1
PV-9001B	3"	301-D Urea Reactor off-gas to relief valve RV-301D2
PV-9001C	3"	301-D Urea Reactor off-gas to relief valve RV-301D3
PV-9001D	2"	301-D Urea Reactor off-gas to relief valve RV-9203
PV-9002	6"	304-C HP Scrubber sphere to bottom of 304-C HP Scrubber
U-9001	10"	301-D Urea Reactor liquid outlet to 302-C HP Stripper top inlet
U-9002	10"	Liquid outlet 302-C HP Stripper to PR valve LV-9203
U-9002	6"	Downstream PR valve LV-9203
CO-9003	6"	301-J/JA CO_2 Compressor to 302-D H_2-Converter
CO-9004	2"	Relief valve of 301-J/JA CO_2 Compressor to RV302-D
CO-9005	6"	302-D H_2-Converter outlet to 301-C CO_2 Cooler
CO-9006	6"	301-C CO_2 Cooler outlet to 302-C HP Stripper bottom inlet
CO-9010	6"	by-pass line of 301-C CO_2 Cooler
NH-9002	4"	from 304-J/JA NH_3 pumps to 301-L HP Ejector
NH-9002A	4"	from 304-JA NH_3 pump to pipeline NH-9002

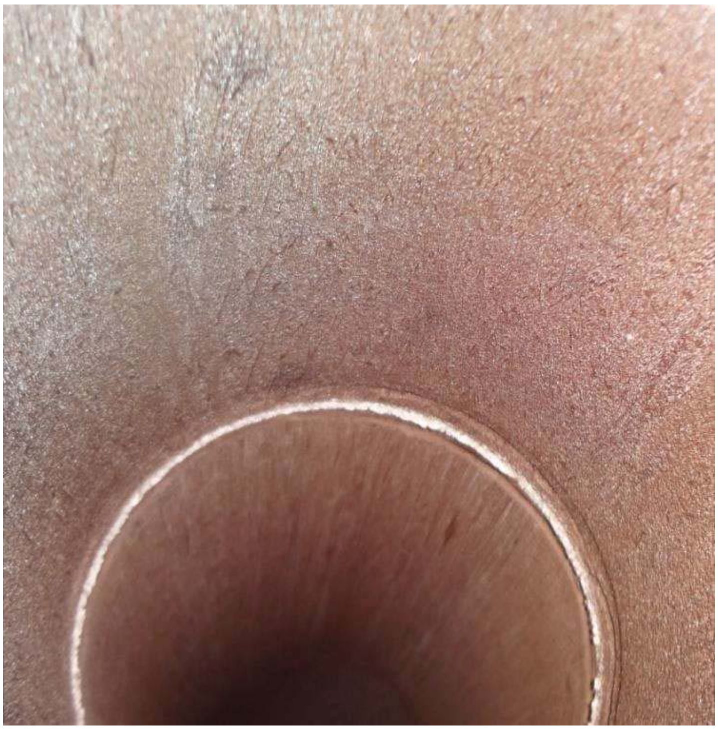
OBSERVATIONS & FINDINGS

Uniform Corrosion observed in CB-9005 & other liquid lines

OBSERVATIONS & FINDINGS

Condensation Corrosion observed in Wet Gas Lines

OBSERVATIONS & FINDINGS

PV-9002 found with salt deposits & without inner protective oxide layer

OBSERVATIONS & FINDINGS

Mechanical damage (rubbing) observed on CB-9007 between Platforms 4 & 5

OBSERVATIONS & FINDINGS

TE-9051 weld-o-let found severely corroded from inside

OBSERVATIONS & FINDINGS

Damaged painting & atmospheric corrosion observed on NH-9002

OBSERVATIONS & FINDINGS

Preferential atmospheric corrosion observed at support locations of CO-9005

OBSERVATIONS & FINDINGS

Condition of insulation & cover sheeting found poor

CONCLUSION & RECOMMENDATIONS

EXTERNAL CORROSION

- Overall satisfactory condition given 30 years of operation
- Non-insulated C-steel lines:
  - Repainting required
  - Minor corrosion only
- Corrosion-Under-Insulation of C-steel lines:
  - Minor risk for localized and uniform corrosion
  - Satisfactory condition because of dry desert climate
- Corrosion-Under-Insulation of stainless steel lines:
  - Risk of Chloride Stress Corrosion Cracking (SCC)
  - DPT-checks performed are satisfactory
  - Insulation samples found in good quality

CONCLUSION & RECOMMENDATIONS

INTERNAL CORROSION

- Satisfactory condition given 30 years of operation
- Process Gas Lines (CB-9002/9004, PV-9001/9002):
  - Risk of condensation corrosion
  - Thinning due to condensation corrosion (CR: 0.25 mm/y)
  - CB-9002 and PV-9001 need replacement in 2016
  - PV-9002 need replacement in 2019
- Process Liquid Lines (other CB-lines, U-lines):
  - Expected life time > 15 years
  - Risk for Carbamate Corrosion (CR: 0.10 mm/y)
  - Lines are in satisfactory condition while weld-o-lets are facing thinning
  - Some weld-o-lets need replacement during next TA in 2016
- Other Lines (CO & NH):
  - Low Risk; expected life time > 15 years

GENERAL RECOMMENDATIONS

- In case of replacement of insulation material maximum allowable chloride content of 10 ppm may be specified in contrast to 30-years old specification (Chloride content < 600 ppm). Higher Chloride contents up to 100 ppm are acceptable in case inhibitors like nitrates and sulphates are present in the insulation in sufficient amounts.

- 9 bar steam with a temperature of 172 °C is being used for the tracing of the HP pipelines. This temperature is in most cases; below the dew point of the gases in the pipelines. It is advised to use MP steam (20 bar) for tracing the gas lines (including the HP Scrubber sphere) to minimize condensation. However, 9 bar steam tracing is sufficient for liquid lines to avoid crystallization, and 20 bar steam tracing shall not be used.

- Condition of the insulation and cover sheeting is poor in general. Higher priority and more funds / resources are required to keep the protective paint system, insulation and cover sheeting in good condition.

- Detailed Inspection of all the lines latest by 2019, including ultrasonic wall thickness measurements, checking all weld-o-lets visually internally, etc.

QUESTIONS & ANSWERS

THANKING YOU

Inspection Department

Ankit Niranjan
Sr. Inspection Engineer

High Temperature Corrosion

As per API 571, Corrosion which occurs above 204°C, consider as high temp corrosion

1. Oxidation
2. Carburization
3. Metal Dusting
4. Sulfidation
5. Nitriding

Oxidation

Oxidation

Highlights:

1. Oxygen reacts with carbon steel and other alloys at high temperature converting the metal to oxide scale.

2. Affected metals: All iron based materials including carbon steel and low alloy steels, All 300 Series SS, 400 Series SS and nickel base alloys also oxidize to varying degrees, depending on composition and temperature.

3. The primary factors affecting high temperature oxidation are metal temperature and alloy composition.

4. Oxidation of carbon steel begins to become significant above about 1000°F (538°C). Rates of metal loss increase with increasing temperature.

Highlights:

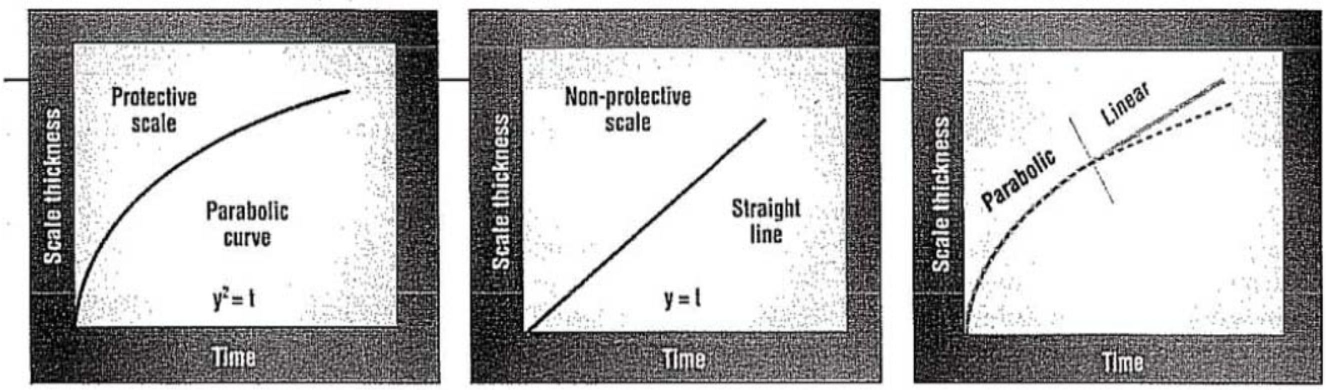
5. In general, the resistance of carbon steel and other alloys is determined by the chromium content of the material. Increasing chromium levels produce a more protective oxide scale. The 300 Series SS are resistant to scaling up to about 1500°F (816°C).

6. The presence of water vapor can significantly accelerate oxidation rates of some steels.

7. Most alloys, including carbon steels and low alloy steels, suffer general thinning due to oxidation. Usually, the component will be covered on the outside surface with an oxide scale, depending on the temperature and exposure time.

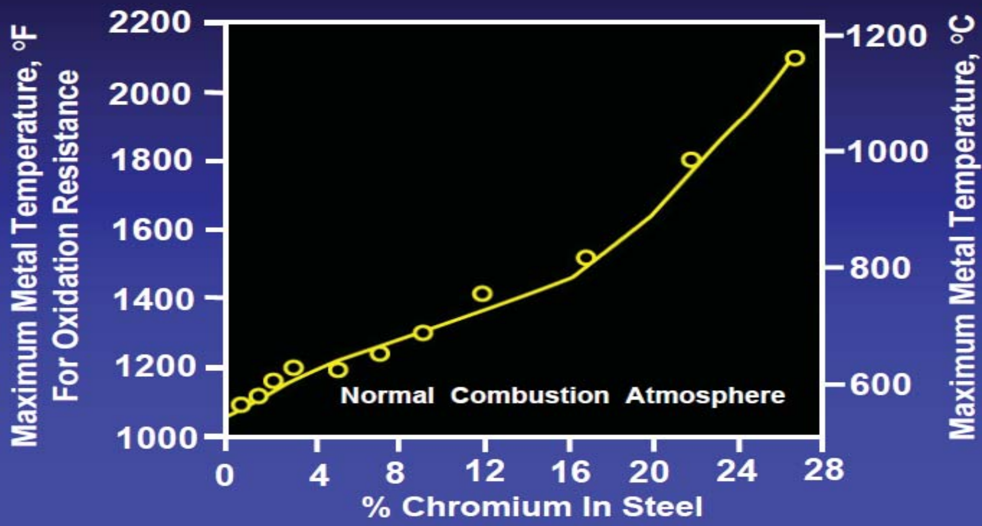
8. Chromium is the primary alloying element that affects resistance to oxidation. Other alloying elements, including silicon and aluminum, are effective but their oncentrations are limited due to adverse affects on mechanical properties. They are often used in special alloys for applications such as heater supports, burner tips and components for combustion equipment.

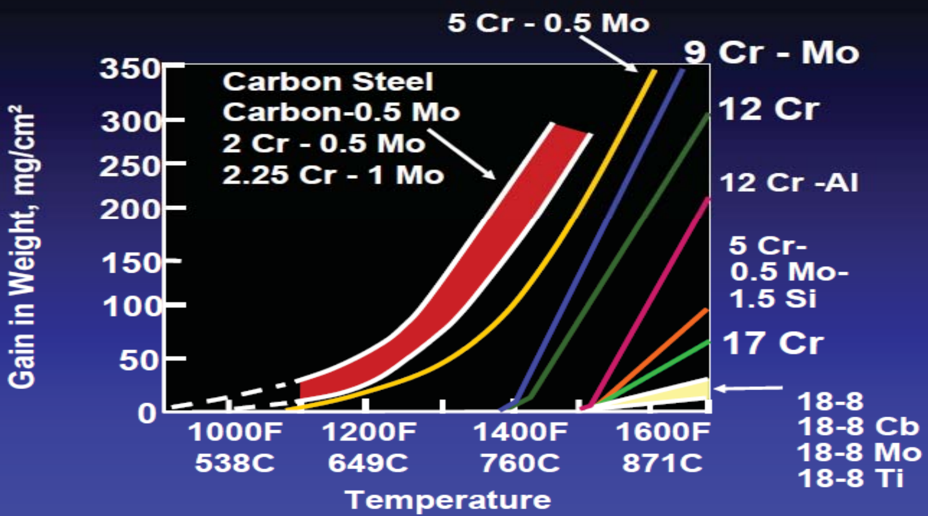
Oxidation



Material	Maximum Metal Temperature (°C)											
	496	524	552	579	607	635	663	691	718	746	774	802
CS	0.05	0.1	0.15	0.23	0.36	0.56	0.84	1.22	--	--	--	--
1 1/4 Cr	0.05	0.08	0.1	0.18	0.3	0.46	0.76	1.17	--	--	--	--
2 1/4 Cr	0.03	0.03	0.05	0.1	0.23	0.36	0.61	1.04	--	--	--	--
5 Cr	0.03	0.03	0.03	0.05	0.1	0.15	0.38	0.89	1.65	--	--	--
7 Cr	0.03	0.03	0.03	0.03	0.03	0.05	0.08	0.15	0.43	0.94	1.52	--
9 Cr	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.13	0.28	0.58	1.02
12 Cr	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.08	0.2	0.38	0.76
304 SS	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.08	0.1
309 SS	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.08
310 SS / HK	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05
800 H / HP	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05

Effect Of Chromium On Oxidation Resistance of Steel





Amount of oxidation (scaling) of carbon, low-alloy, and stainless steels in 1000 hours in air from 1000° to 1700°F (538° to 926°C)

Carburization

Carburization

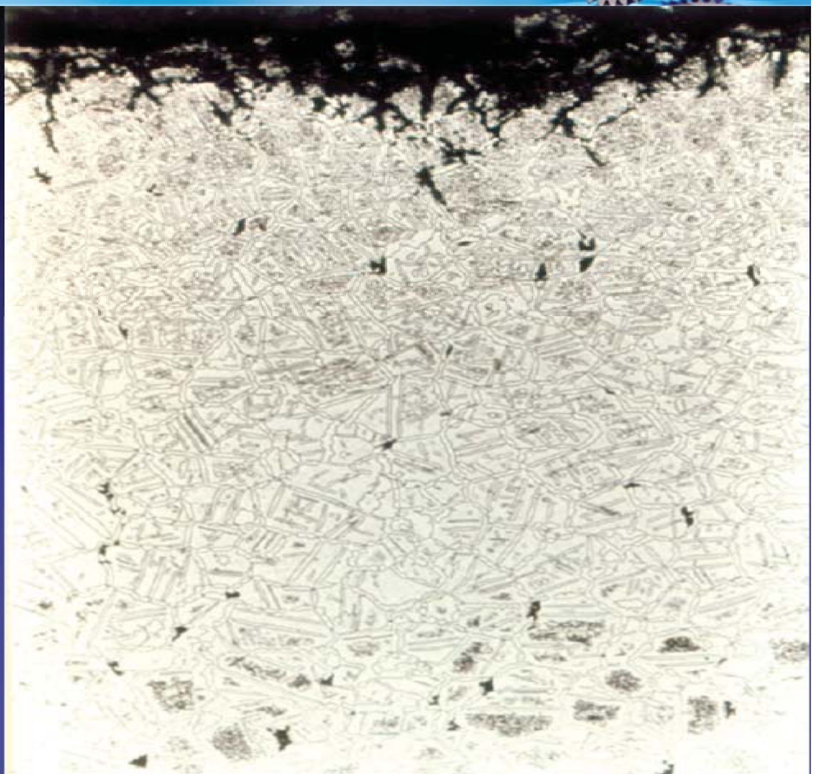
Highlights:

1. Carburization occurs when metals are exposed to carbon monoxide, methane or any hydrocarbon at elevated temp.
2. During process, carbon combines primarily with chromium and forms carbide, this process is called carbon uptake.
3. Since these carbides are brittle, they can reduce the alloy overall ductility especially at temp below 550 deg cel.
4. Carbide formation causes metal to increase its volume.
5. The stress of localized bulging in tubes reduces the creep strength and contributes to mechanical failure.
6. By tying up with chromium, carburization also reduces the metal resistance to high temp. to oxidation.

- Occurs in CH_4, CO and other hydrocarbon environments at elevated temperatures
- It is highly embrittling
- Grain boundary and internal carbides form
- Reduction or prevention:
  - Smooth surface finish
  - Inject low levels of S compounds into the process stream (to poison the carburizing reaction)
  - Modify the composition:
    - Increased Ni: reduces C diffusion
    - Increased Si: forms SiO_2 scale
    - High levels (4%) of Al
    - Minor element additions – Ti, Nb, W, Mo, rare earths

Austenitic stainless steel exposed to carburizing conditions

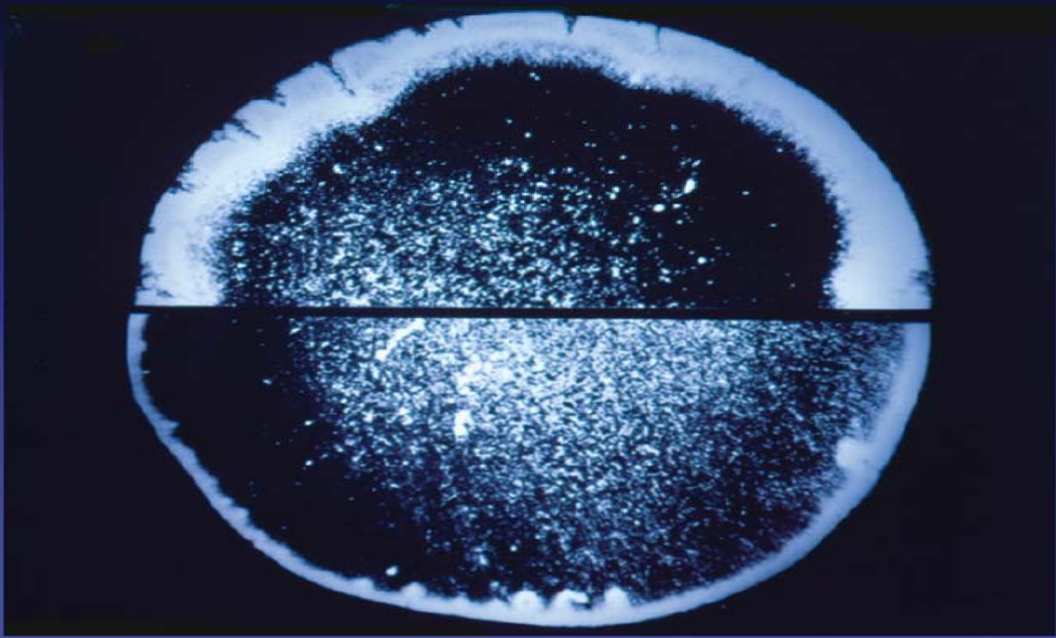
Carbon combines with chromium to form chromium carbides leaving behind Ni and Fe, both of which are magnetic



Two alloys exposed to the same carburizing conditions

Top:

Alloy 601
(61% Ni)

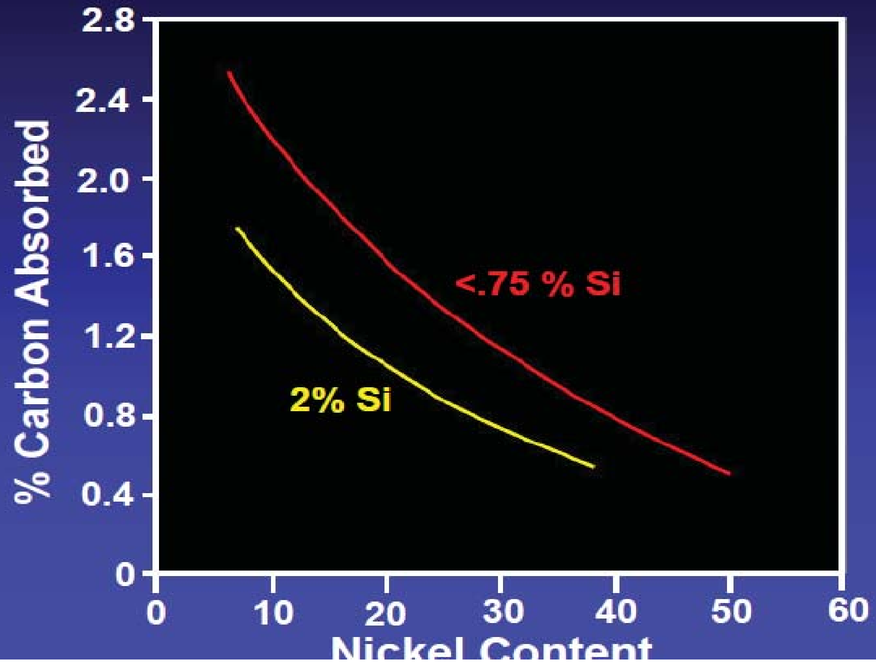


Bottom:

Alloy 600
(76% Ni)

Effect of Si and Ni On Carburization Resistance

1832°F (1000°C) For 200 Hours in Carbon Granulate



Cast HP-Mod ethylene furnace tubes after magnetic particle inspection – the dark areas are carburized

Note the variability:

some sections are heavily carburized

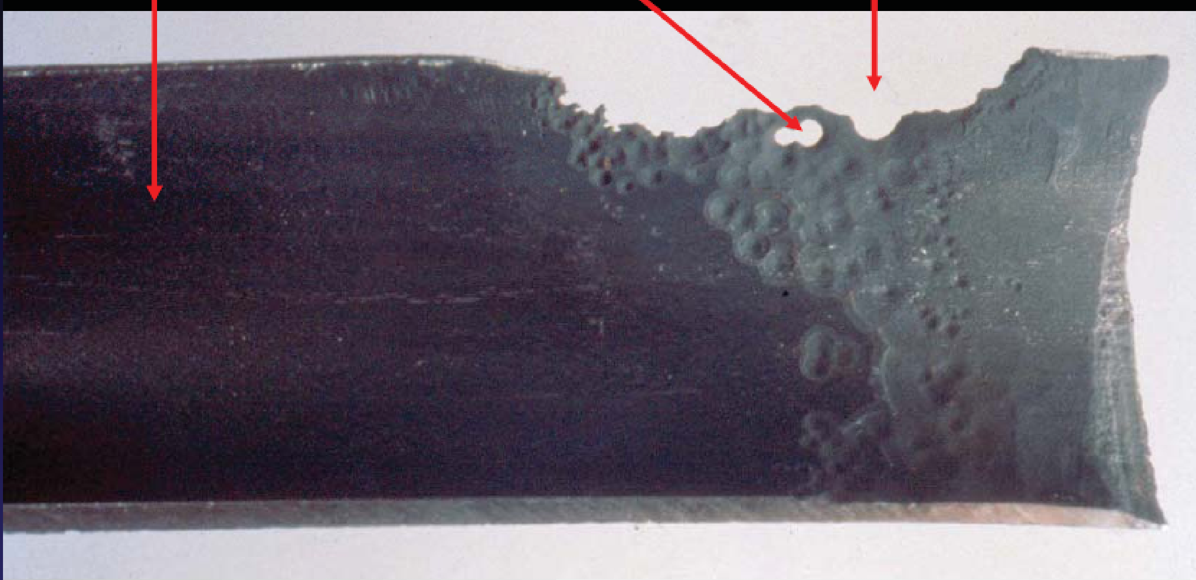
other nearby sections are largely unaffected

Metal Dusting

It is a catastrophic carburization phenomenon which occurs when the carbon activity in the gaseous atmosphere is greater than1

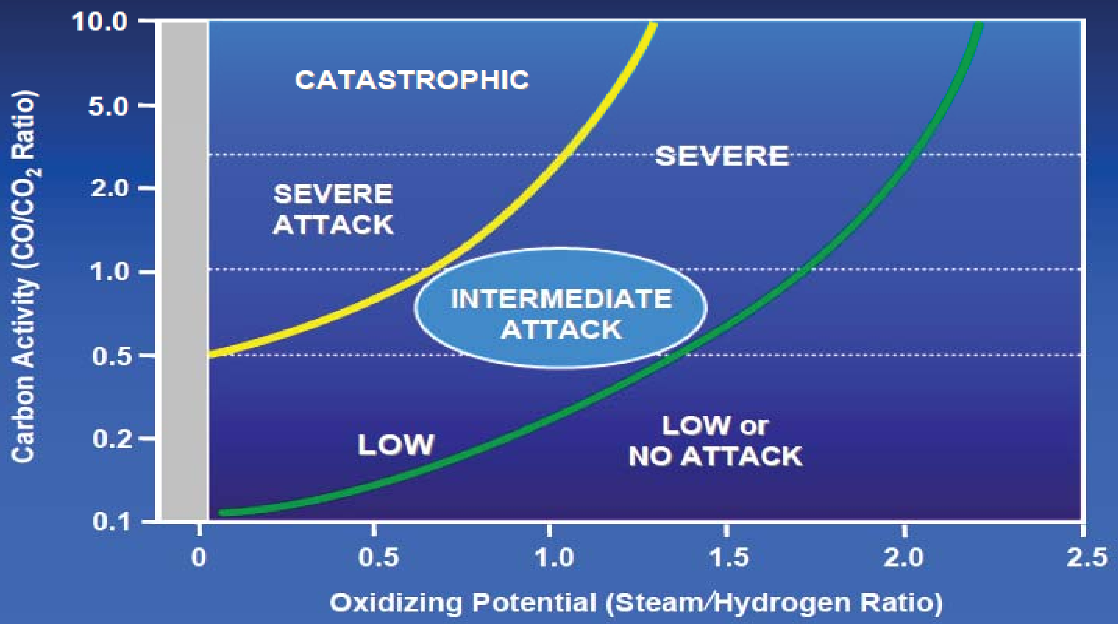
- **Catastrophic carburization – very rapid**
- **Occurs in CO, CO_2, and H environments at 900-1650°F (480-900°C)**
- **Stagnant areas are more prone to attack**
- **Round bottom pits**
- **Surface of remaining area is heavily carburized**
- **Most alloys are attacked**
- **Unpredictable**
- **Steam and S additives are sometimes effective controllers**

Unaffected Perforation Complete metal loss

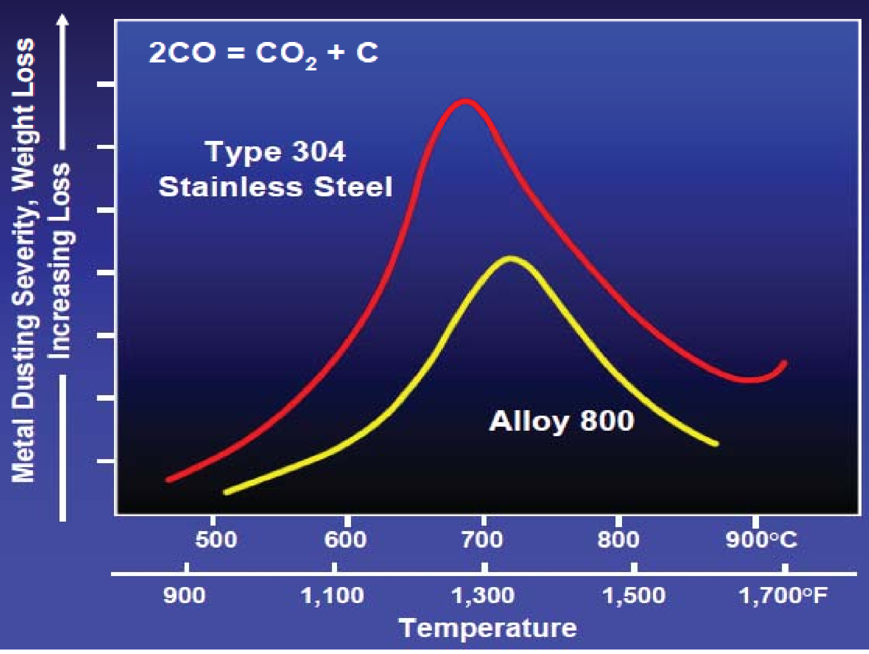


HP-Mod cast ethylene furnace tube showing metal dusting
Note its localised nature

EFFECT OF CO/CO_2 RATIO ON METAL DUSTING IN CRITICAL TEMPERATURE RANGE VERSUS STEAM/HYDROGEN RATIO (AS APPLICABLE TO STAINLESS 304 AND ALLOY 800)



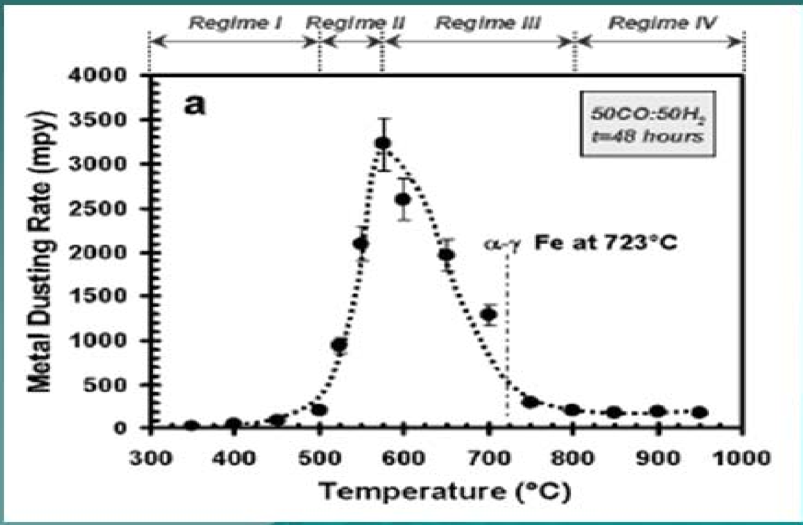
METAL DUSTING CAN RESULT IN SEVERE ATTACK IN CERTAIN TEMPERATURES



METAL DUSTING RATE

VS TEMPERATURE

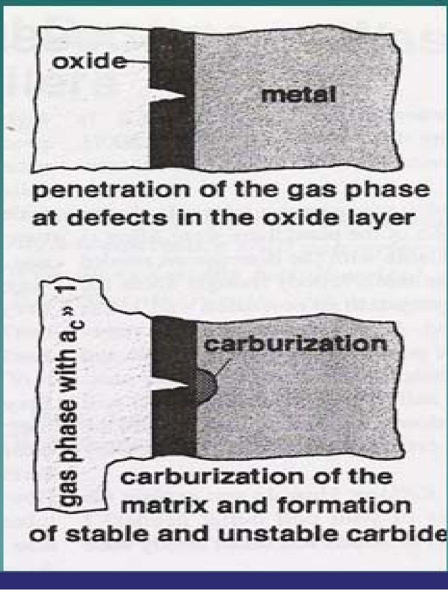
In regime I the corrosion rate gradually increases with temperature,
In regime II the corrosion rate undergoes a rapid rise,
In regime III the corrosion rate decreases with temperature and
In regime IV, the rate is more or less constant.

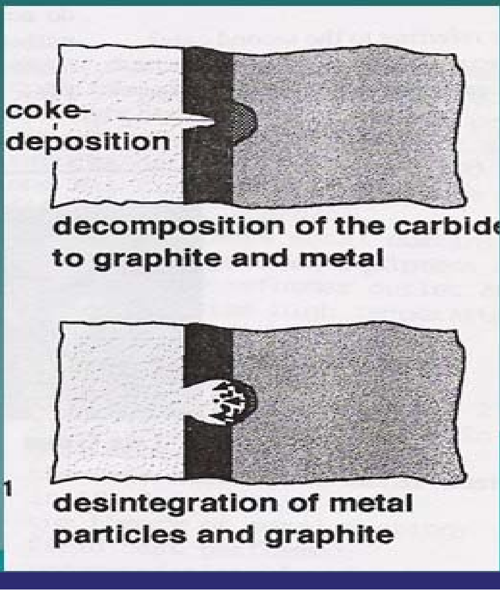


MECHANISM OF METAL DUSTING

CARBON DEPOSITION BY BOUDOURD REACTION :

$2CO = CO2 + C$

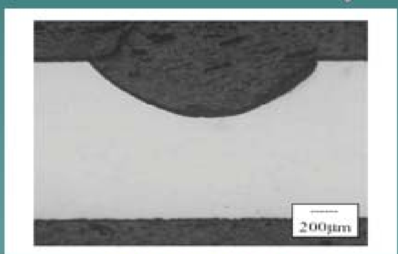




Metal Dusting Control – Process Modification

- Adding sulphur to the RG or reducing the CO/CO_2 ratio by adding extra CO_2 in the feed to the primary reformer. Both these are not feasible because the sulphur is poison for the catalyst and no additional CO_2 is available in the urea base fertilizer plant.
- Because of extra CO2 availability this has been used in Methanol plant

CONDITION OF SPECIMEN AFTER TEST



ALLOY 6600
After 6600 Hrs

ALLOY 693
After 15816 Hrs.

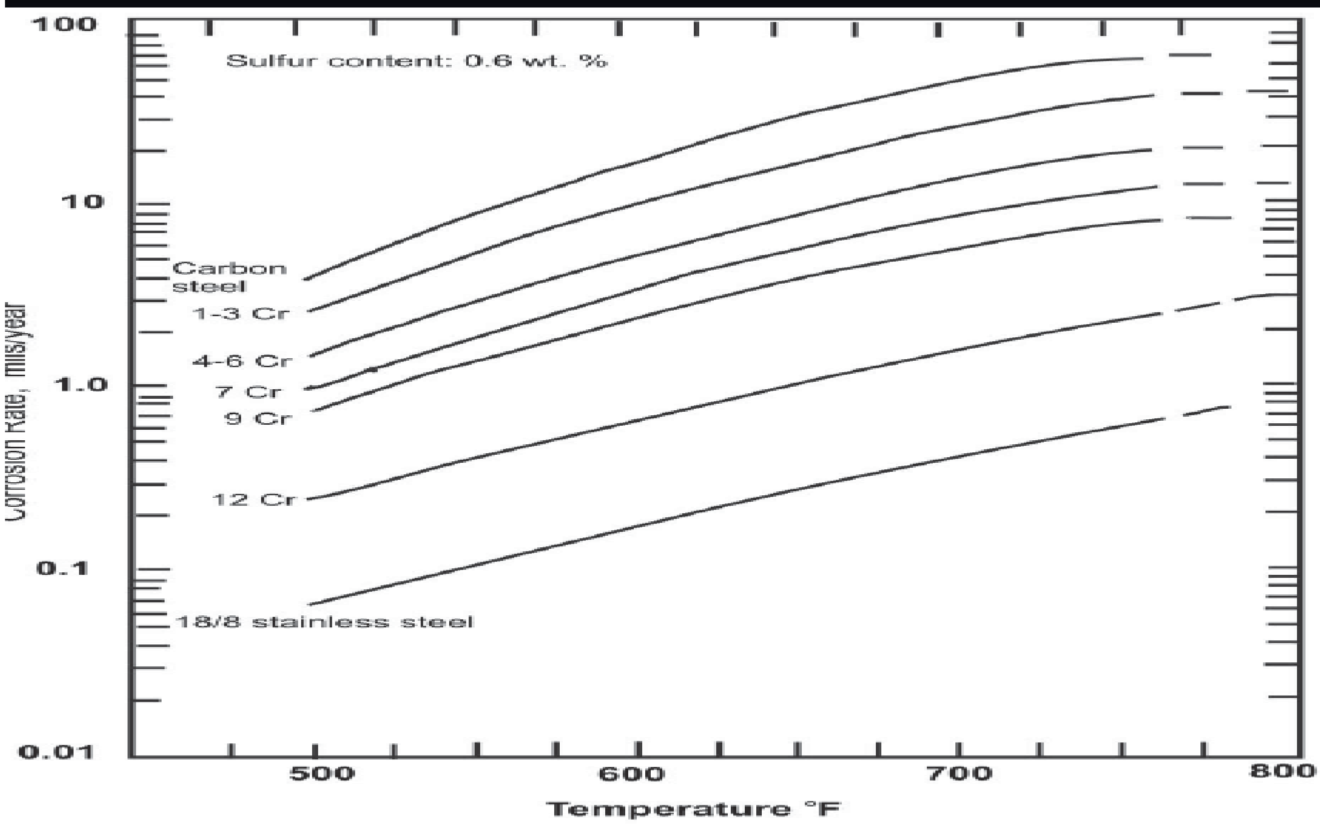
CHROMIUM EQUIVALENTS
VARIOUS WROUGHT AND CAST ALLOYS
Cr eq = Cr% + 3 x (Si% + Al%)

UNS Number	Alloy	Composition (wt %)					Metal Dusting Resistance
		Cr	Ni	Si	Al	Cr eq	
Wrought alloys							
N08810	800H	20	32	.3	.3	22	poor
S31000	310SS	25	20	.3	-	26	fair
N06600	Inc. 600	15	72	-	-	15	fair
N06601	Inc. 601	22	60	-	1.5	27	good
	Kanthal APM	22	-	-	6.0	40	best
Cast alloys							
J94204	HK-40	25	20	1.0	-	28	good
N08705*	HP-mod	26	35	1.5	-	30	good
	Manoir XTM	35	48	1.5	-	40	best

Sulfidation

Highlights:

1. Corrosion of carbon steel and other alloys resulting from their reaction with sulfur compounds in high temp. environment
2. Susceptibility of an alloy to sulfidation is determined by its ability to form protective sulfide scales.
3. Sulfidation of iron-based alloys usually begins at metal temperatures above 500°F (260°C).
4. Heaters fired with oil, gas, coke and most other sources of fuel may be affected depending on sulfur levels in the fuel.
5. Depending on service conditions, corrosion is most often in the form of uniform thinning but can also occur as localized corrosion or high velocity erosion-corrosion damage



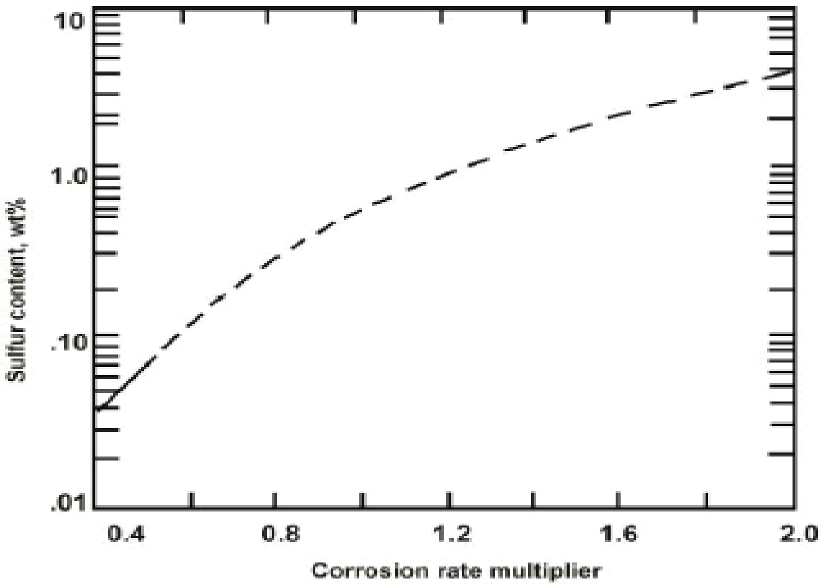
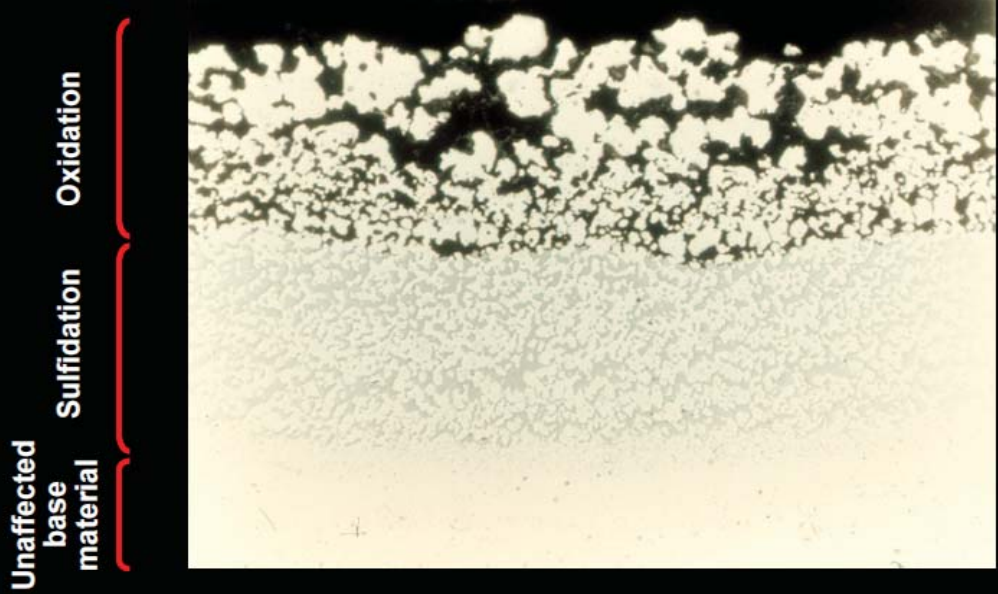


Figure 4-116 – Sulfidation failure of NPS 8 carbon steel pipe. Note the relatively uniform thinning that resulted in a sizeable rupture.



Austenitic stainless steel showing sulfidation (grey phase)

S combines with the Ni and Cr, leaving behind Fe which is not oxidation resistant, causing oxidation on the surface

Result: combined oxidation and sulfidation

- S is an impurity in fuels / feedstock
- Fe, Ni, Co, Cr all form sulfides
- Reducing conditions
  - Most severe (H_2S)
- Oxidizing conditions (SO_2)
  - Less severe
  - Oxide barrier layer formed

For increased sulfidation resistance:

- High Al, Si, Fe and Cr
- Presence of some oxygen
- Low Ni / Fe ratio

High Ni content not generally desirable for sulfidation resistance

Exception: high Ni + high Cr together
eg. 50Ni, 50Cr wrought INCONEL alloy 671; cast IN-657

Nitridation

Highlights:

1. Nitridation usually occurs cs, low alloy steel and ss are exposed to an ammonia bearing environment at elevated temp
2. The end surface result is hardened surface in which chromium is tied up in form of nitrides.
3. Nitriding begins above 600°F (316°C) and becomes severe above 900°F (482°C).
4. High gas phase nitrogen activity (high partial pressures of nitrogen) promotes nitriding.
5. A loss of high temperature creep strength, ambient temperature mechanical properties (specifically toughness/ductility), weldability and corrosion resistance may result.

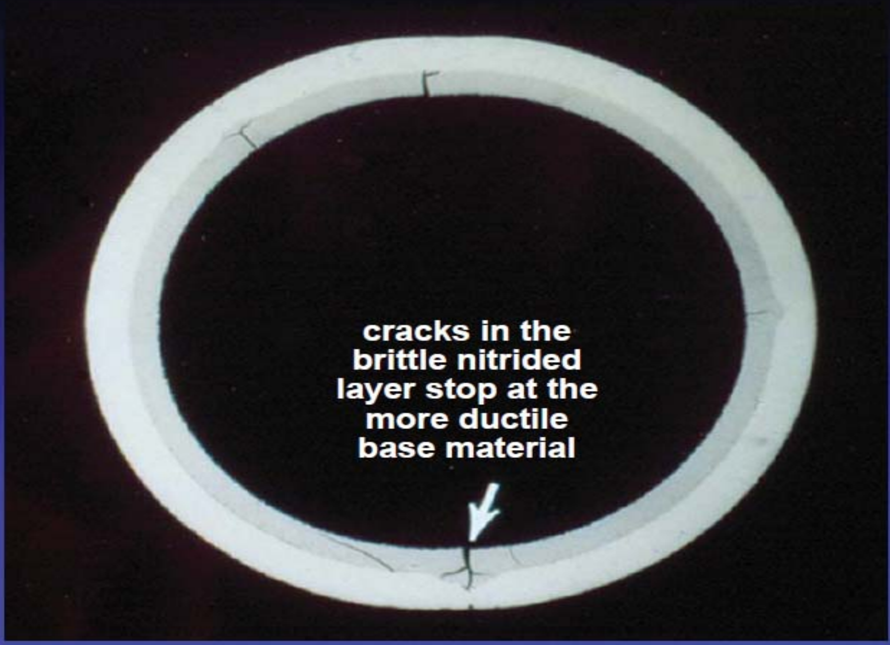
Highlights:

6. In a more advanced stage, the material will exhibit very high surface hardness. In most cases, a slightly harder surface layer of a vessel or component will not affect the mechanical integrity of the equipment. However, the concern is for the potential development of cracks in the nitrided layer that could propagate into the base metal.

7. Nitrogen diffuses into the surface and forms needle-like particles of iron nitrides (Fe3N or Fe4N) that can only be confirmed by metallography.

8. Hardness testing of the affected surfaces (400 to 500 BHN or higher) can help indicate nitriding.

9. Nitrided layers are magnetic. Therefore, 300 Series SS should be checked for magnetism as an initial screening.



Type 304 stainless steel transfer pipe in an ammonia plant
Grey area is the nitrided layer

Peak Vue™ Technology Detects Faulty Bearing at OMIFCO, Preventing Costly Downtime

Inspection Department

Presented By : Salim Baalwi

Session Abstract

- OMIFCO is state-of-the-art Ammonia-Urea manufacturing complex in Oman.
- We were experiencing turbine thrust bearing failure problems frequently for last few years and were unable to detect issues through our old vibration system.
- This changed after we started measuring vibration using CSI 2130. We saved a critical machine & production downtime.
- This session is about detecting failure of turbine thrust bearing using PeakVue Technology before any symptoms of Journal or rotor failure occurred.

Introduction

- OMIFCO Overview of the Facility
- OMIFCO Company Introduction
- OMIFCO Challenge
- Application
- Emerson Solution
- Case Study – BFW Turbine, Avoided Catastrophic failure
- Business Results Achieved
- Summary

OMIFCO Introduction

- Oman India Fertilizer Company S.A.O.C (OMIFCO) is a joint-venture business established to operate a state-of-the-art two-train ammonia-urea fertilizer manufacturing facility in the SUR Industrial Estate in the Sultanate of Oman.

- Plant capacity is 1,750 X2 tons per day of anhydrous ammonia and 2,530 X2 tons per day of granular urea.

OMIFCO Challenge

- The two turbine-driven pumps, which are critically important in providing steam at the rate necessary to maintain fertilizer production, had a history of thrust bearing failures.

- Even though vibration and temperature checks were done periodically, We were never able to detect severe problems in time to prevent sudden failures.

- This happened every year or two, causing damage in the journal bearing area. During the last failure, a turbine rotor was damaged as well.

Application

- There are four BFW pumps in utilities supplying boiler feed water to Ammonia plant to generate steam in order to run various large turbines like syn gas.
- Out of above four pumps, two are turbine driven and other two are motor driven.
- Two out of four is mandatory to run all the time.
- Vibration Data Collection and Analysis - Frequency – Fortnightly

Solution

- We began using the CSI 2130 Machinery Health Analyzer in October 2012 to gather vibration data from Boiler Feed pumps every two weeks.
- Data collected by the CSI 2130 can be uploaded to AMS Suite Machinery Manager software where detailed analysis takes place. This includes advanced detection of bearing and gear faults using Emerson’s patented Peak Vue technology.

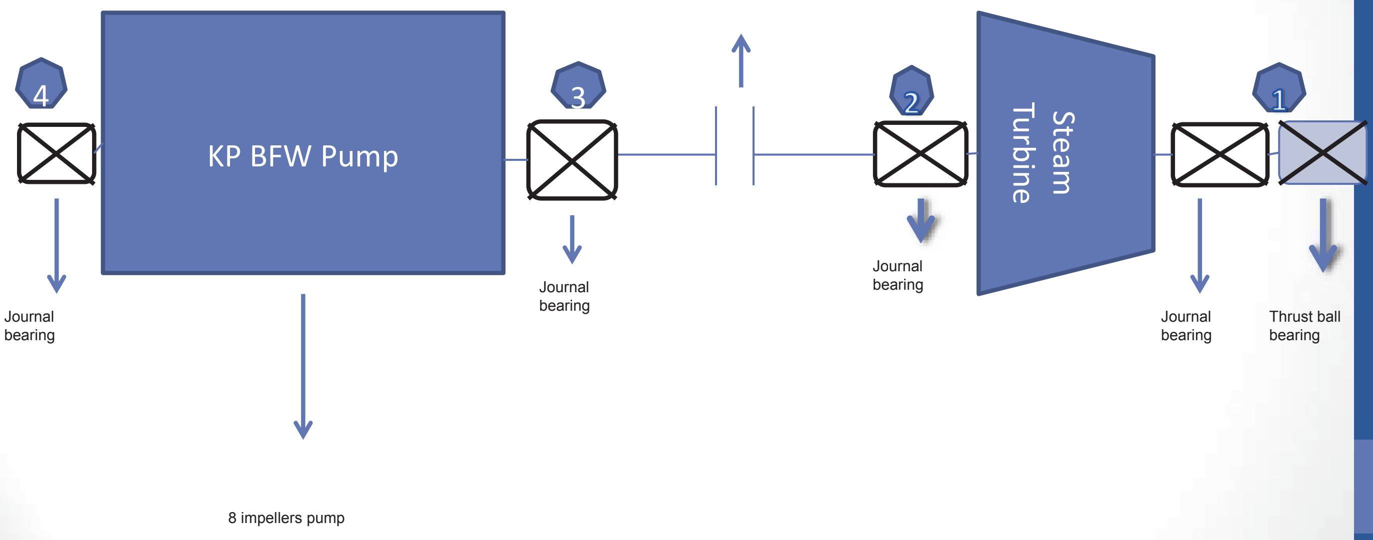
Solution…(Continued….)

- This portable analyzer quickly and accurately identified developing faults in rotating machinery – and helped get to the root cause of the problem.
- Impacting faults are readily visible in Peak Vue waveform long before there is any significant increase in overall vibration.
- Using Peak Vue technology, we were able to detect Turbine thrust bearing failure.

Case Study – Boiler Feed Water Turbine

- Machine: Boiler Feed Water Pump –Turbine Driven
- Area: Utility & Offsites
- Function: Supplying BFW at 135 Kg/Cm2 for steam generation.
- Criticality: Very High
- Bearing: Four Journal Bearings and One Rolling Contact Thrust Bearing
- Impact:
  - Costly downtime, damage to associated equipment.
  - Heat/energy losses.
  - Potential safety issues.

Case Study – Boiler Feed Water Pump

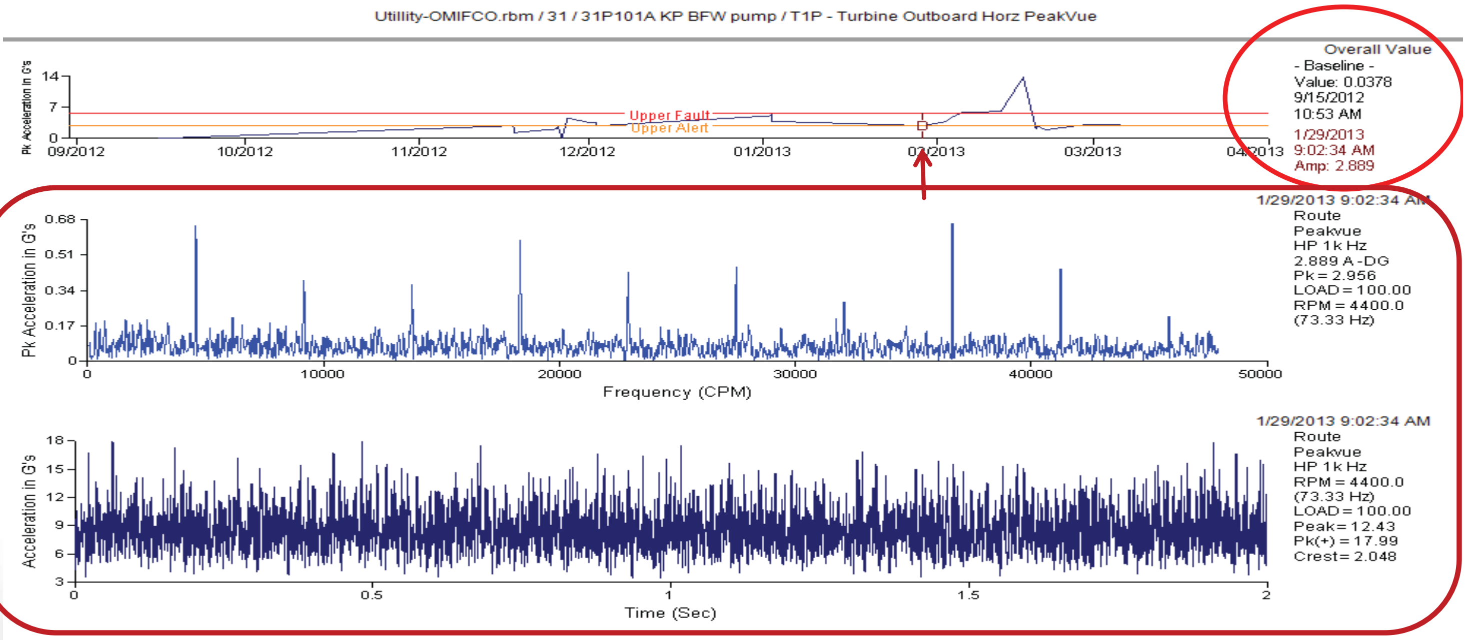


Problem

- KP Boiler feed water turbine had been experiencing thrust bearing failure problem frequently without giving any symptom on increase in casing and relative vibration.

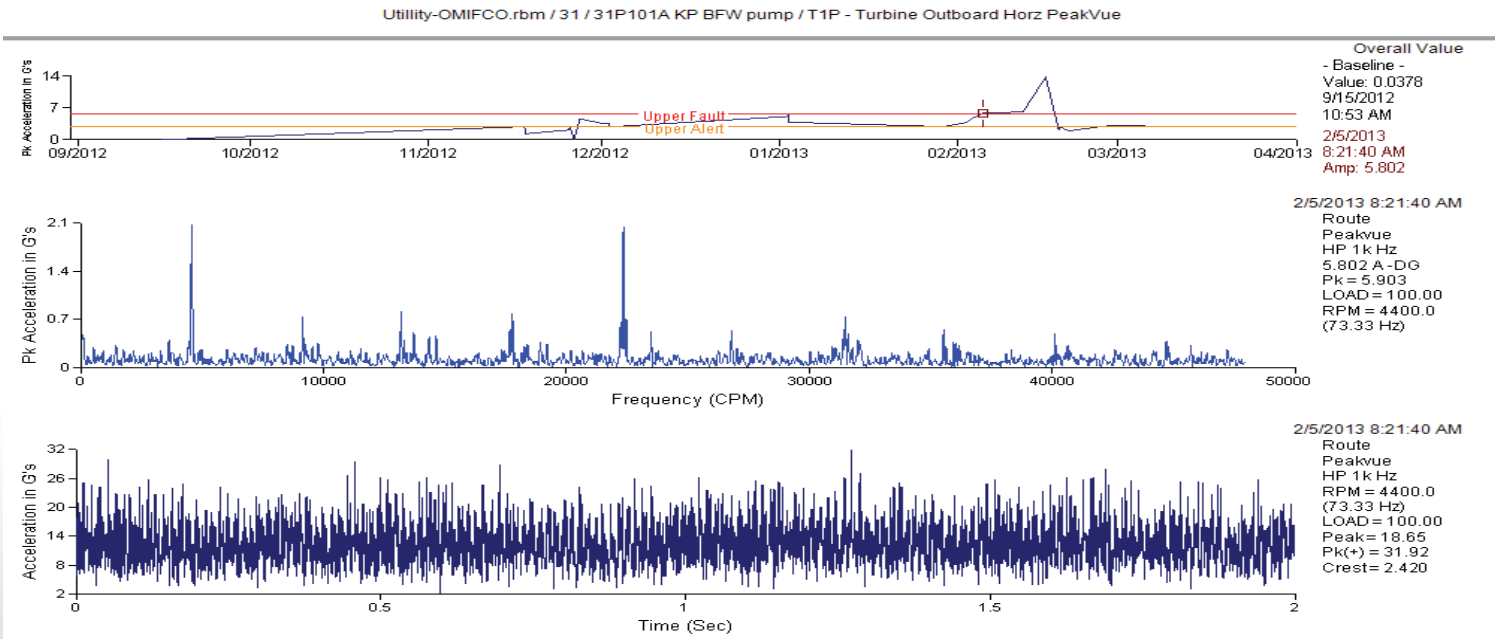
PeakVue Trending…..

- On **29th Jan,** 2013; PeakVue readings were same as earlier.



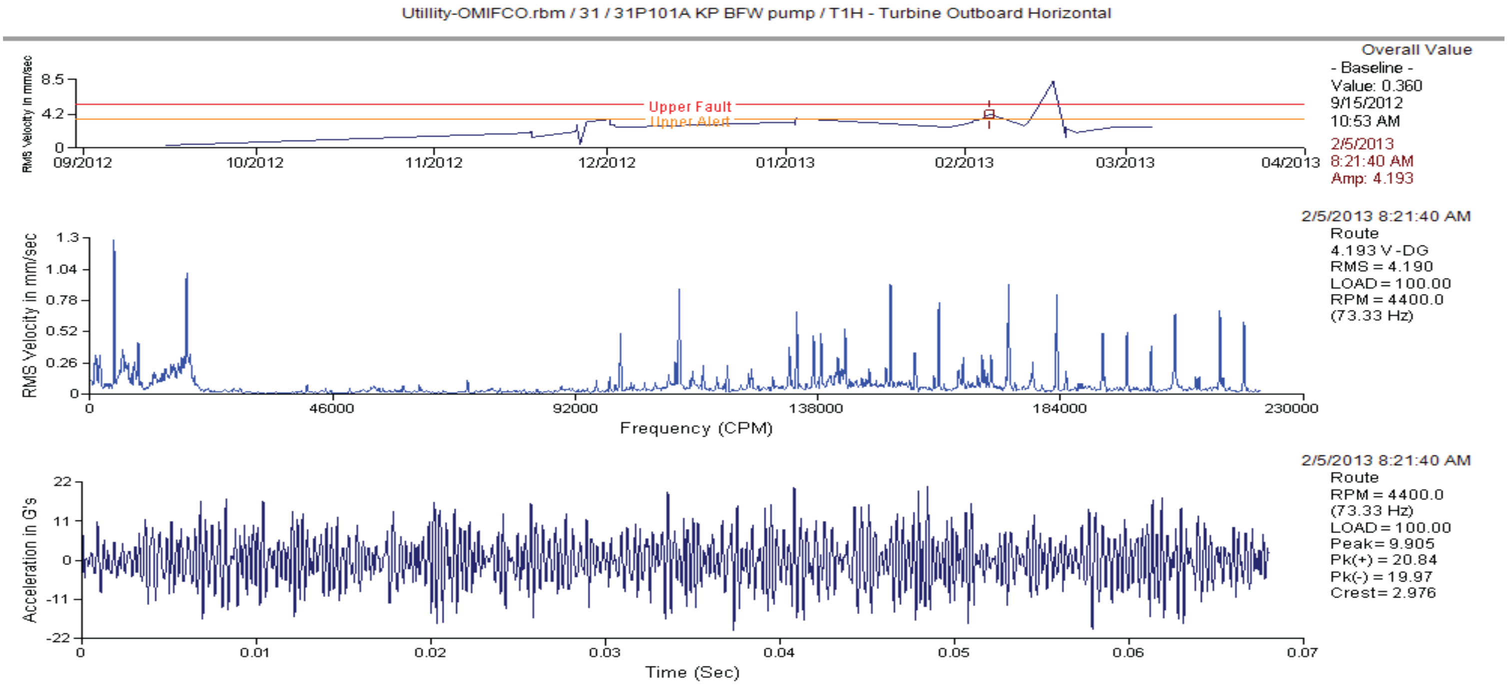
PeakVue Trending…..

- On **05th Feb,** 2013. There was 100% rise in PeakVue spectrum and waveform; we kept machine under observation.



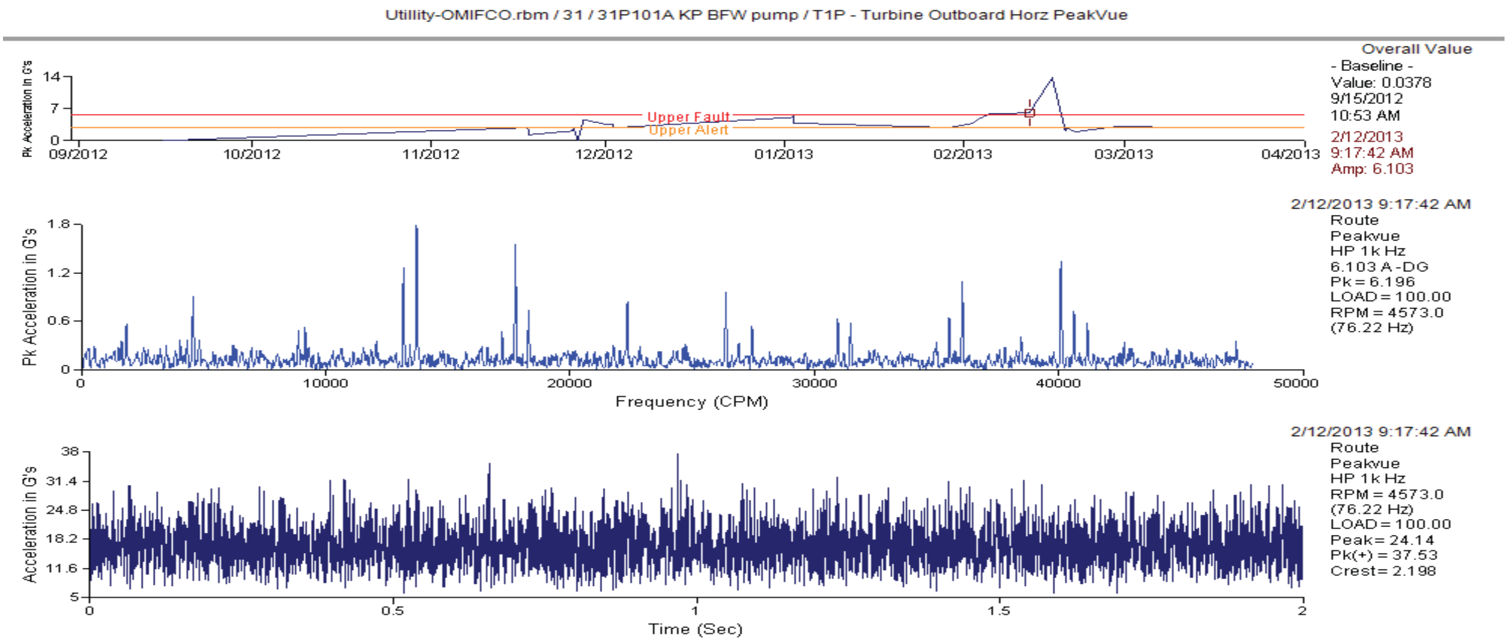
Overall Vibration reading

- However on **05th Feb,** 2013. There was normal casing vibration



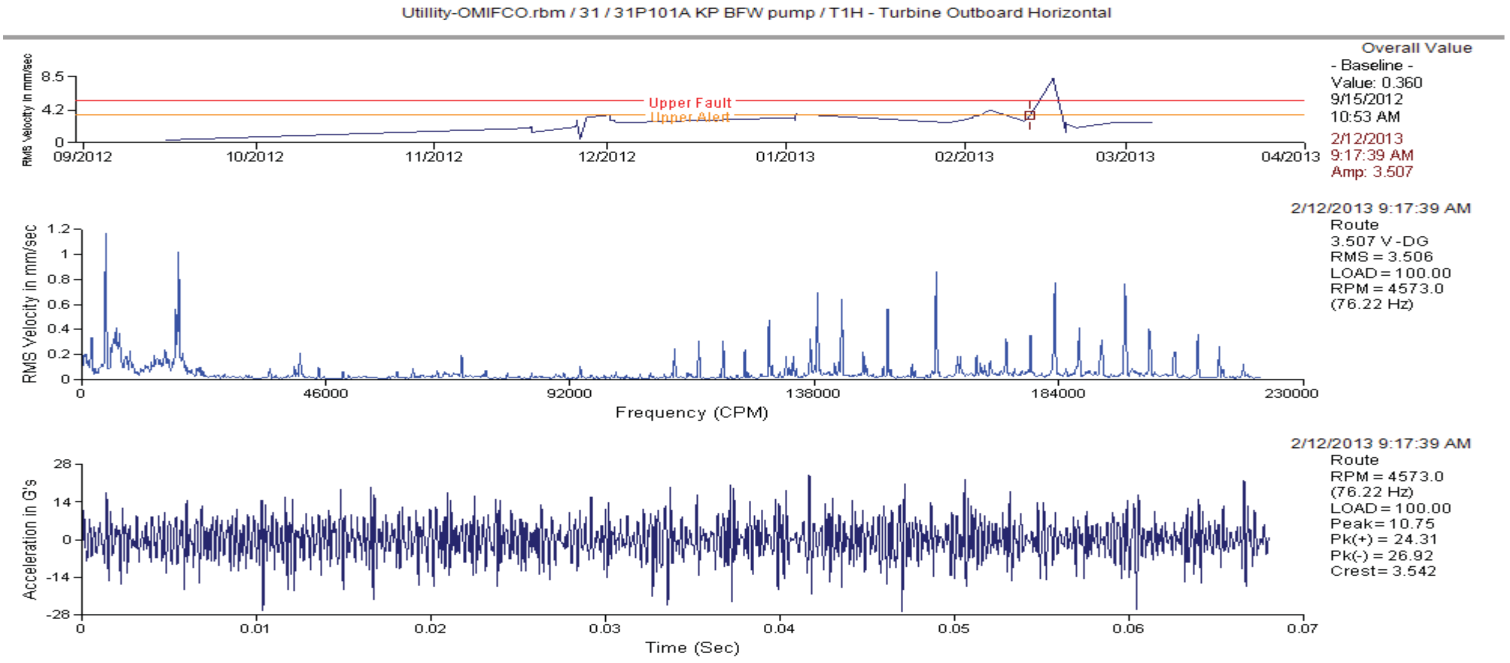
PeakVue Trending…..

- On **12th Feb,** 2013. There was again rise in PeakVue spectrum and waveform; we kept machine under close observation.



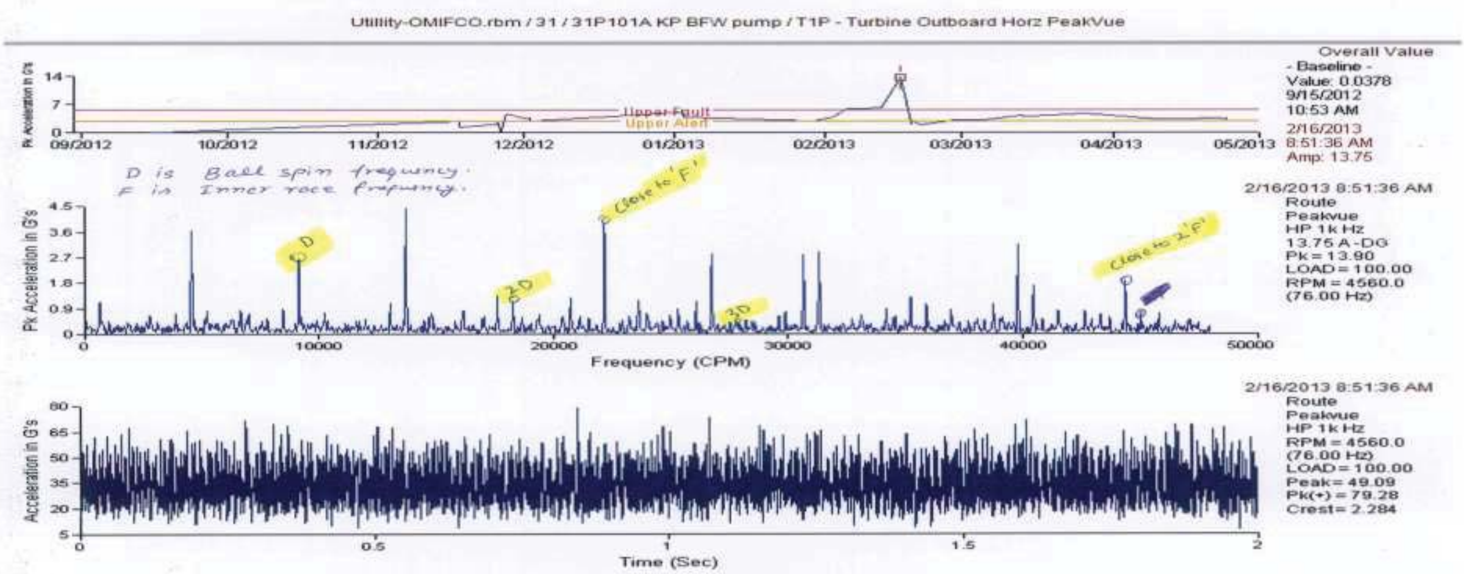
Overall Vibration reading

- However, on **12th Feb,** 2013. Turbine outboard horizontal vibration found normal.



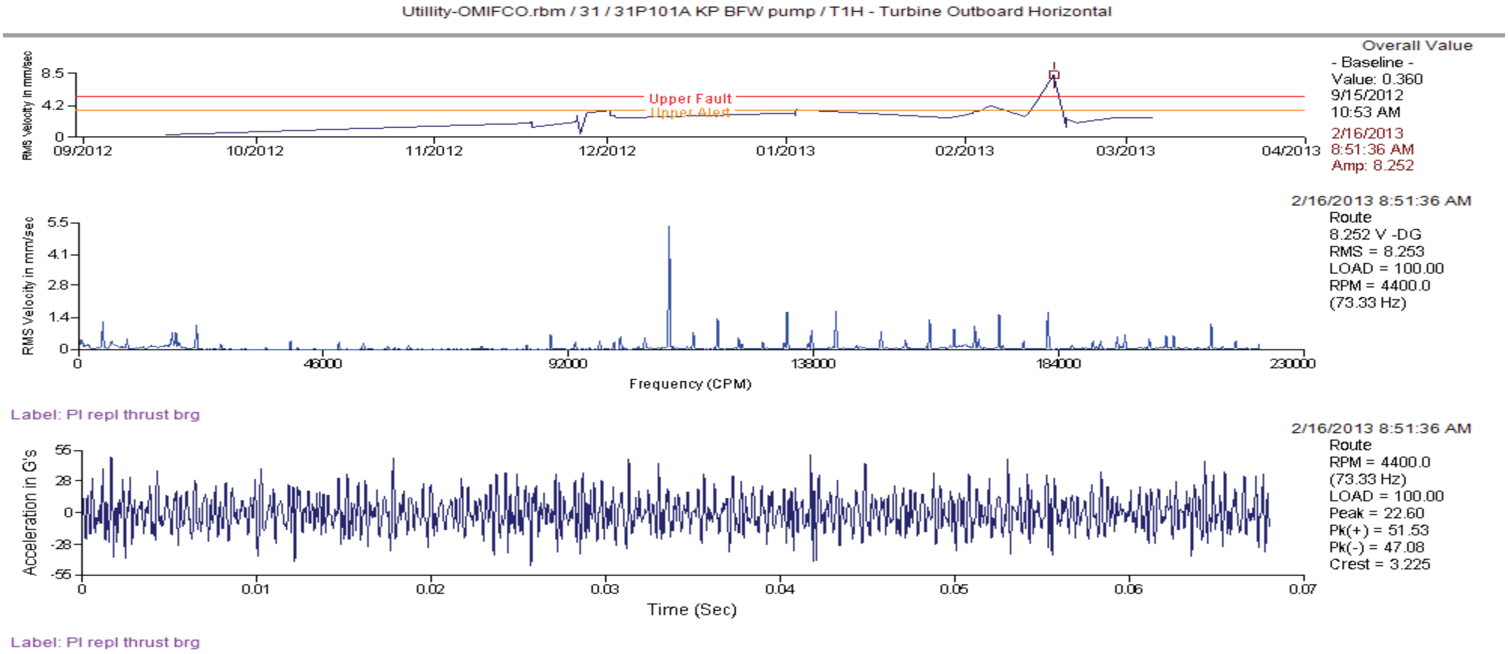
Peak Vue Trending…..

- On **16th Feb,** 2013. We measure the vibration because of keeping machine under close observation. There is again 100% rise in Peak Vue spectrum and waveform. We told to stop the machine immediately.



Overall Vibration reading

- On **16th Feb,** 2013. We measured overall vibration because of keeping machine under close observation. There was rise in Turbine outboard horizontal vibration spectrum and waveform.



FINDINGS

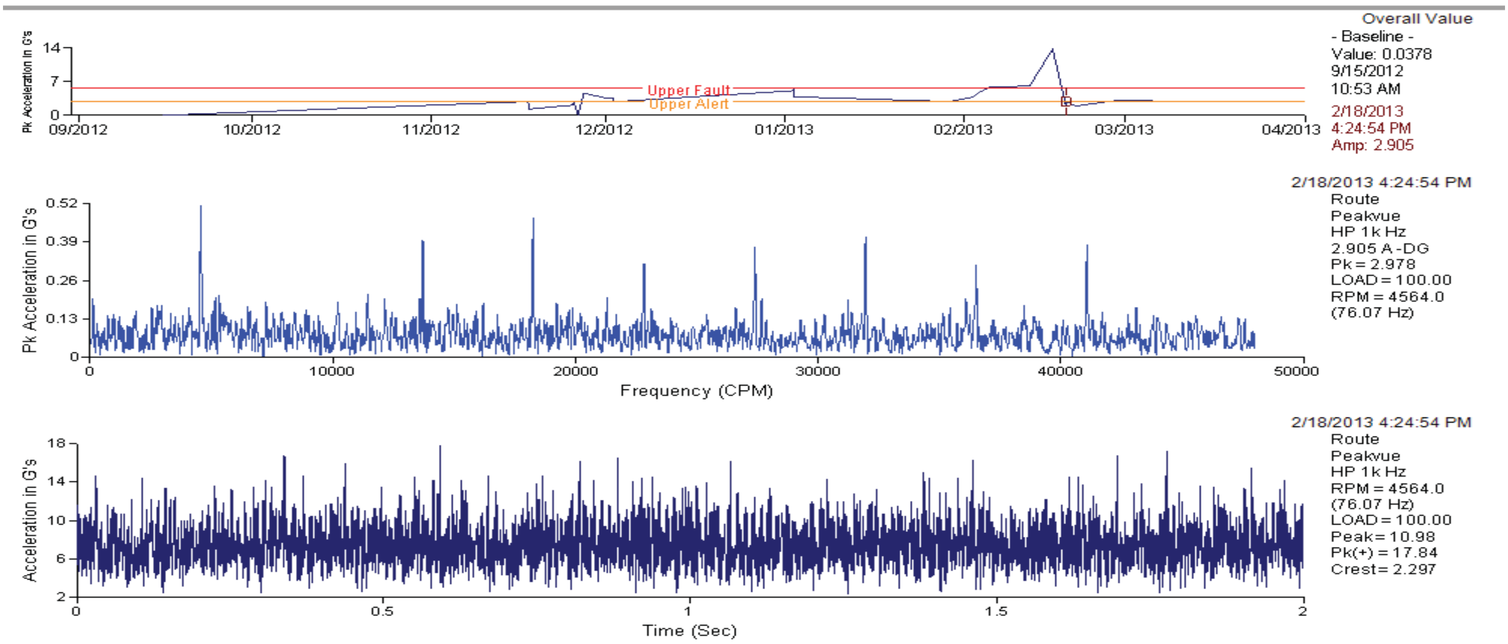
- Severe pitting in inner race and slight pitting in balls are observed.

FINDINGS....(Continued.....)

PeakVue readings after bearing replacement

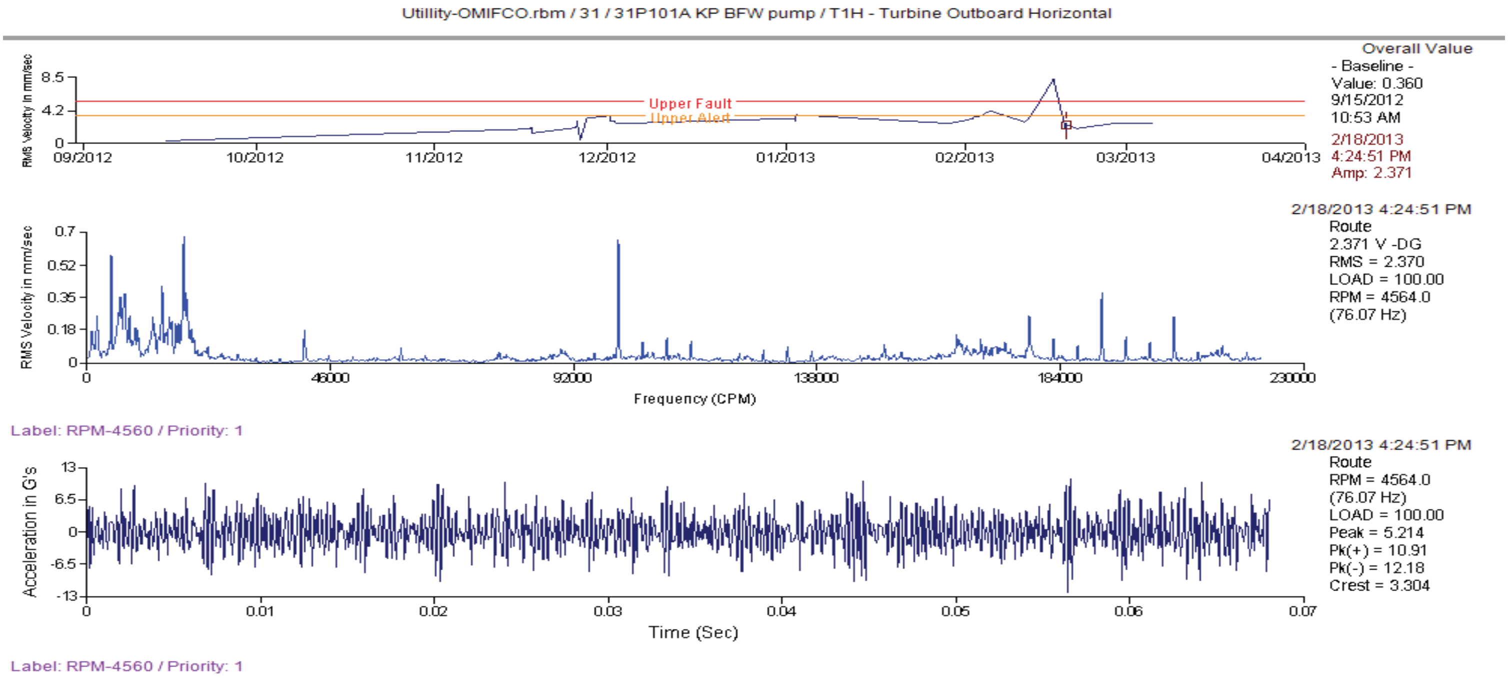
- On **18th Feb,** 2013. After replacing the thrust bearing, we found there was significant drop in PeakVue readings.

Utility-OMIFCO.rbm / 31 / 31P101A KP BFW pump / T1P - Turbine Outboard Horz PeakVue



Overall readings after bearing replacement

- On **18th Feb,** 2013. After replacing the thrust bearing, we found there was significant drop in Turbine outboard horizontal vibration as well.



Business Results Achieved

- Prevented catastrophic pump-turbine breakdown
- Solved persistent sudden turbine thrust bearing failures
- Initiated route analysis to avoid failures in the future
- Saved probable extensive production losses
- Improved plant uptime and overall reliability

Summary

- OMIFCO has avoided equipment breakdowns, improved reliability and availability.
- OMIFCO continues to utilize Emerson power tools and methodology to keep high reliability while avoiding costly breakdowns.
- Very fast return on investment.
- OMIFCO Management praised the PeakVue technology, saying that it saved a critical machine from severe damage and prevented substantial production losses.

OMIFCO Proven Result Flyer

CHEMICAL

Emerson's PeakVue™ Technology Detects Faulty Bearing at OMIFCO, Preventing Costly Breakdown

RESULTS

- Prevented catastrophic pump-turbine breakdown
- Solved persistent turbine thrust bearing failures
- Initiated route analysis to avoid failures in the future
- Saved probable extensive production losses
- Improved plant uptime and overall reliability

"Using the PeakVue technology, we saved a critical machine and avoided production downtime."

Ali Al Siyabi
Inspection Manager

APPLICATION

Four KP KPW heavy-duty boiler feedwater pumps operate in the utility plant which produces steam used in processing ammonia and urea fertilizers. One of the two turbine-driven pumps must be in service at all times to assure full production of steam. There are also two motordriven backup pumps.

CUSTOMER

Oman India Fertiliser Company S.A.O.G (OMIFCO) is a joint-venture business established to operate a state-of-the-art two-train ammoniaurea fertilizer manufacturing facility in the Sur Industrial Estate in the Sultanate of Oman. Plant capacity is 1,750 tons per day of anhydrous ammonia and 2,530 tpd of granular urea. All production is shipped to India to support that country's growing agriculture industry.

CHALLENGE

The two turbine-driven pumps, which are critically important in providing steam at the rate necessary to maintain fertilizer production, had a history of thrust bearing problems. Even though casing vibration checks were done fortnightly, and proximity and RTD monitoring were done continuously online, OMIFCO maintenance personnel were never able to detect emerging problems in time to prevent sudden thrust bearing failures. This happened every year or two, causing damage in the journal bearing area. During the last failure, a turbine rotor was damaged as well. The boiler had to be taken out of service, resulting in substantial production losses.

The vibration data collection system in use ignored high frequency data and did not recognize the warning signs of imminent bearing failure.

For more information:
www.assetweb.com/mhm

EMERSON. Process Management

CHEMICAL

SOLUTION

OMIFCO began using the CSI 2130 Machinery Health Analyzer in October 2012 to gather vibration data from these machines every two weeks. This portable analyzer quickly and accurately identified developing faults in rotating machinery – and helped get to the root cause of the problem. Data collected by the CSI 2130 can be uploaded to AMS Suite where detailed analysis takes place. This includes advanced detection of bearing and gear faults using Emerson's patented PeakVue technology.

Rolling element bearings have specific failure modes that can be observed in the spectral and waveform data. PeakVue technology uses a unique method of separating very high frequency, short duration stress waves from regular vibration data. These stress waves are generated from faults that cause impacting, friction, and fatigue, particularly in gearbox and rolling element bearings. If the rolling element in a bearing passes over a defect, which may still be below the surface of the inner or outer race, the metal of the race will deflect and spring back. The energy created is detected using PeakVue.

With this vibration technology, OMIFCO technicians quickly identified a potential problem in a turbine thrust bearing. The impacting faults were readily visible in PeakVue waveform long before any significant increase in overall vibration was noticed. As a result, OMIFCO engineers began to carefully monitor that machine. In February 2013, a sudden 50 percent increase in PeakVue spectrum and waveform was observed, followed a few days later by another large increase. At this time, a slight increase in turbine horizontal vibration velocity was evident for the first time.

At this point, the machine was taken out of service to check the thrust bearing, which was found to be severely damaged with large pitting in the inner race and additional small pitting in the balls. After the thrust bearing was replaced and the machine put back into service, all of the vibration readings returned to normal levels.

OMIFCO officials praised the PeakVue technology, saying that it saved a critical machine from severe damage and prevented substantial production losses.

"PeakVue trend data enables us to stop critical turbine-driven pumps before catastrophic failure and rotor damage occurs."

Ankitniranjan
Inspection Engineer

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EMERSON. Process Management

Thank You for Attending!

Enjoy the rest of the conference.

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Arab Fertilizer Association
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الشركة العمانية الهندية للسماد
OMIFCO

Quality Control and Assurance in Maintenance in Fertilizer Industry Workshop

Delegate List

Muscat - Sultanate Oman

23-25 November 2015

Quallty Control and Assurance In Maintenance In Fertilizer Industry Workshop

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