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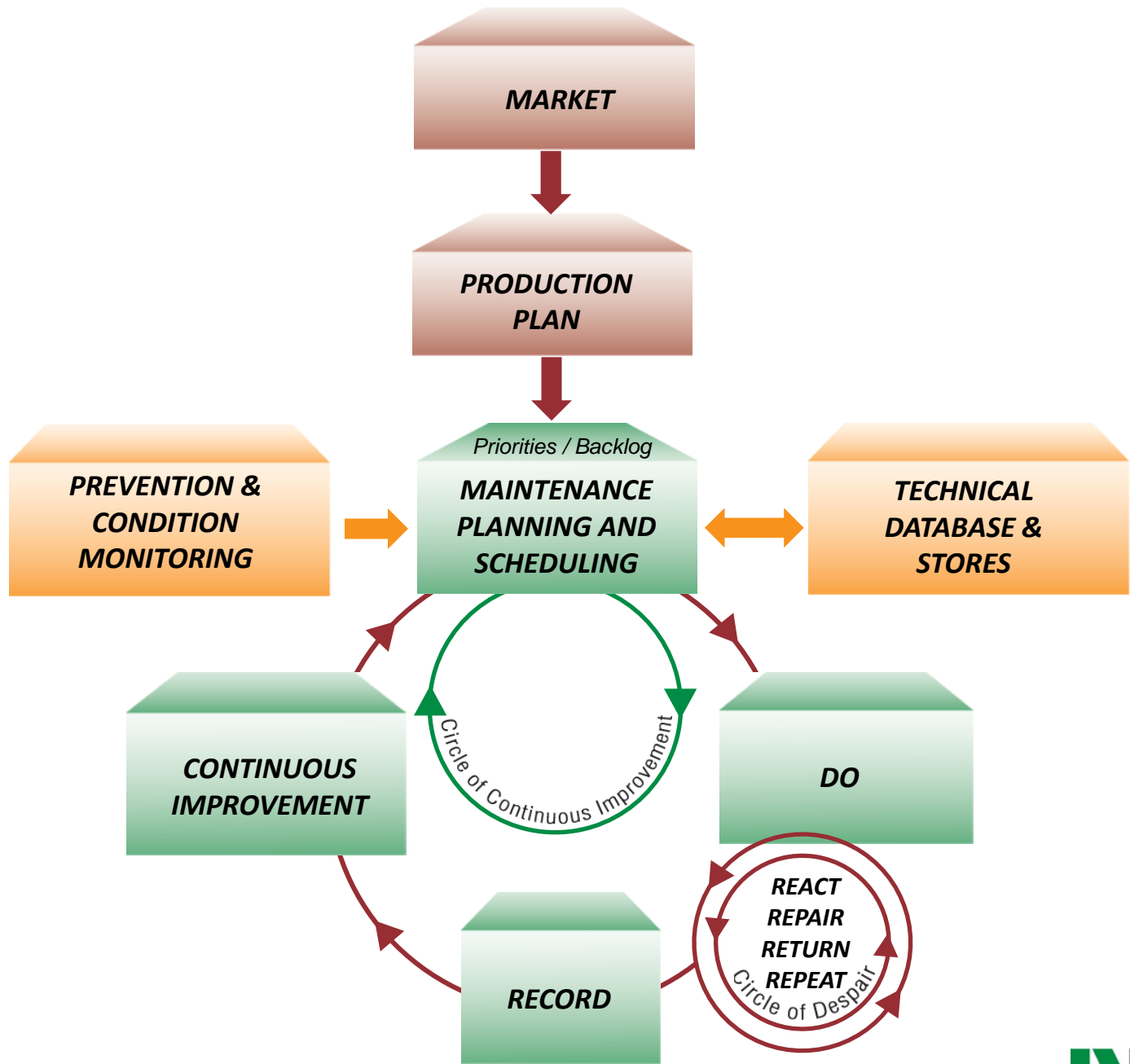


*Optimization of  
Preventive Maintenance  
and Operator Essential  
Care*

*Results Oriented  
Reliability and Maintenance  
Consulting and Training*

## *Rate your Current Operator Essential Care & Preventive Maintenance System*

- On a loose sheet of paper please write a number between 1 and 10.
- Using your personal definition of what Operator Essential Care & preventive maintenance (PM) is in your plant. Please rate how well you currently do OBR & PM at the plant.
  
- 1 – Non existent
- 2
- 3
- 4
- 5 – Average in industry
- 6
- 7
- 8
- 9
- 10 – Not cost effective to improve



*Exercise!*

How is Preventive Maintenance  
Defined?

How is Operator Essential Care  
Defined?

*Preventive Maintenance & Operator Essential Care Definition?*

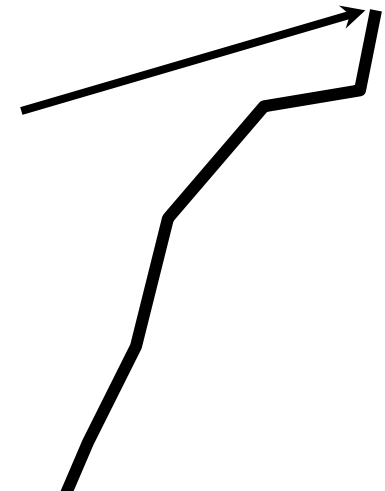
“All actions to prevent a failure  
or  
detect a failure early”

# Failure & Break Down

When the failure has developed to the point that the equipment is unable to operate  
**BREAK DOWN**



**FAILURE**



**SOURCE** Event that initiate Failure developing  
When the equipment condition reaches an unacceptable level

The failure is detected and reported





# *IDCON Definition - Preventive Maintenance / Essential Care and Condition Monitoring ( PM/ECCM )*

## Essential Care

*Prevents Failures*

---

- Lubrication
- Alignment
- Balancing
- Detailed Cleaning
- Operating Practices
- Installation Practices
- Filtration
- Adjustments
- Fixed Time Maintenance

## Condition Monitoring

*Detects Failures*

---

### Objective

*Provides a comparable reading*

### Measuring

Pressure  
Flow  
Current, Voltage  
Distance  
Vibration  
Temperature  
Decibels

### Using

Infrared Cameras  
Vibration Sensors  
Shock Pulse Measurement  
Ultrasonic Thickness Test  
Ultrasonic Listening (leaks)  
Oil Analysis  
Gauges, etc

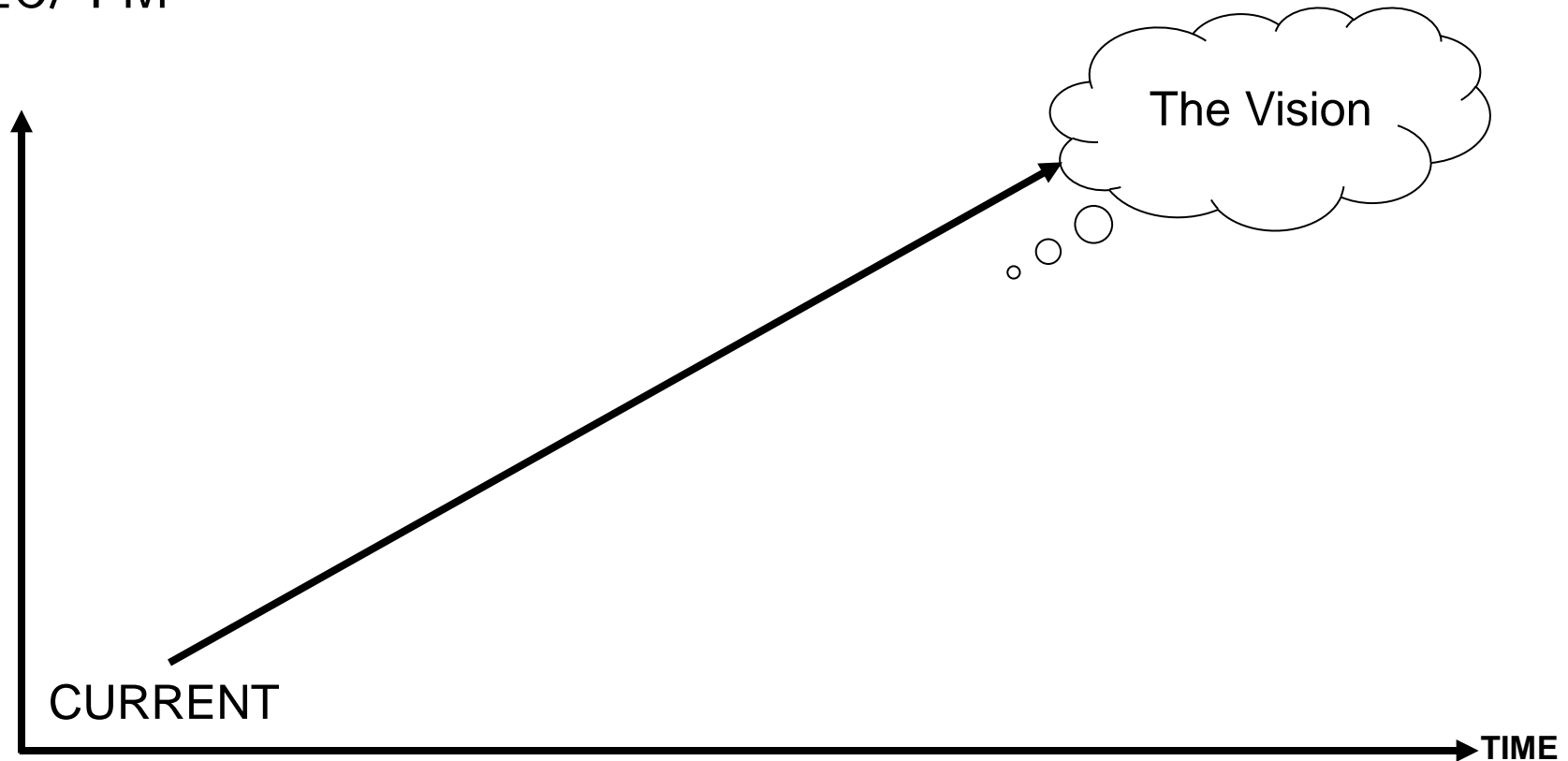
### Subjective

*Provides no reading*

Look  
Listen  
Feel  
Smell

# *Do We Know Exactly where We are Going?*

OEC/ PM





## *Communicate a Vision to the Plant*

- If want people to buy into the concept of OEC or PM, you must “paint a picture” of the future. *What will this system look like when we are done.*
- [An Example](#)

## *What Exactly is it We Want Operations To Do?*

- You need to decide for your plant

### Typically

1. Inspections of running equipment, mostly mechanical inspections
2. Detailed cleaning of equipment & housekeeping
3. Operate equipment with reliability in mind
4. Minor maintenance tasks
5. *Coordinate Production Schedule & Maintenance Schedule*
6. *Joint Root Cause Elimination*

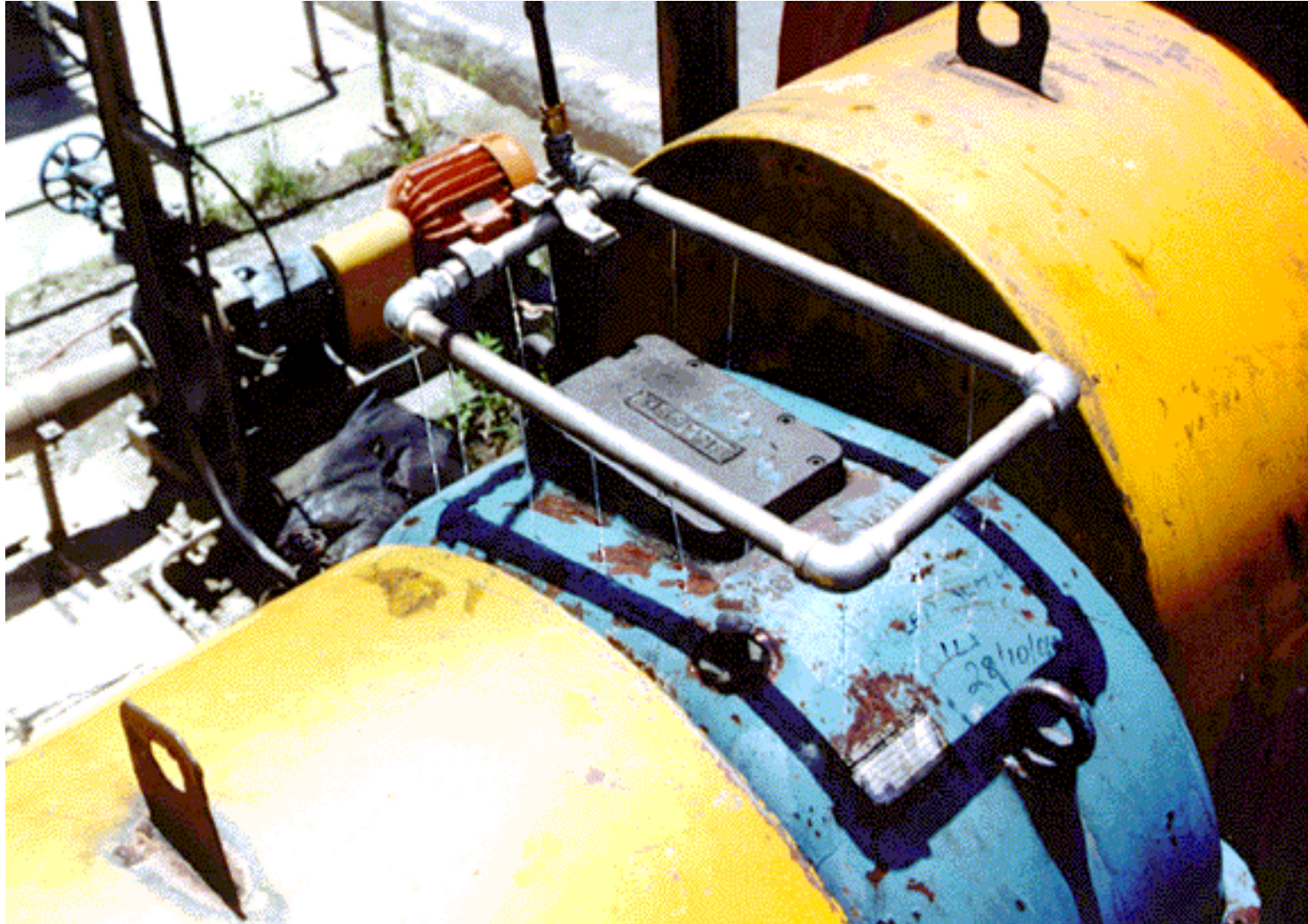
*What's more important?*

Do the right thing

OR

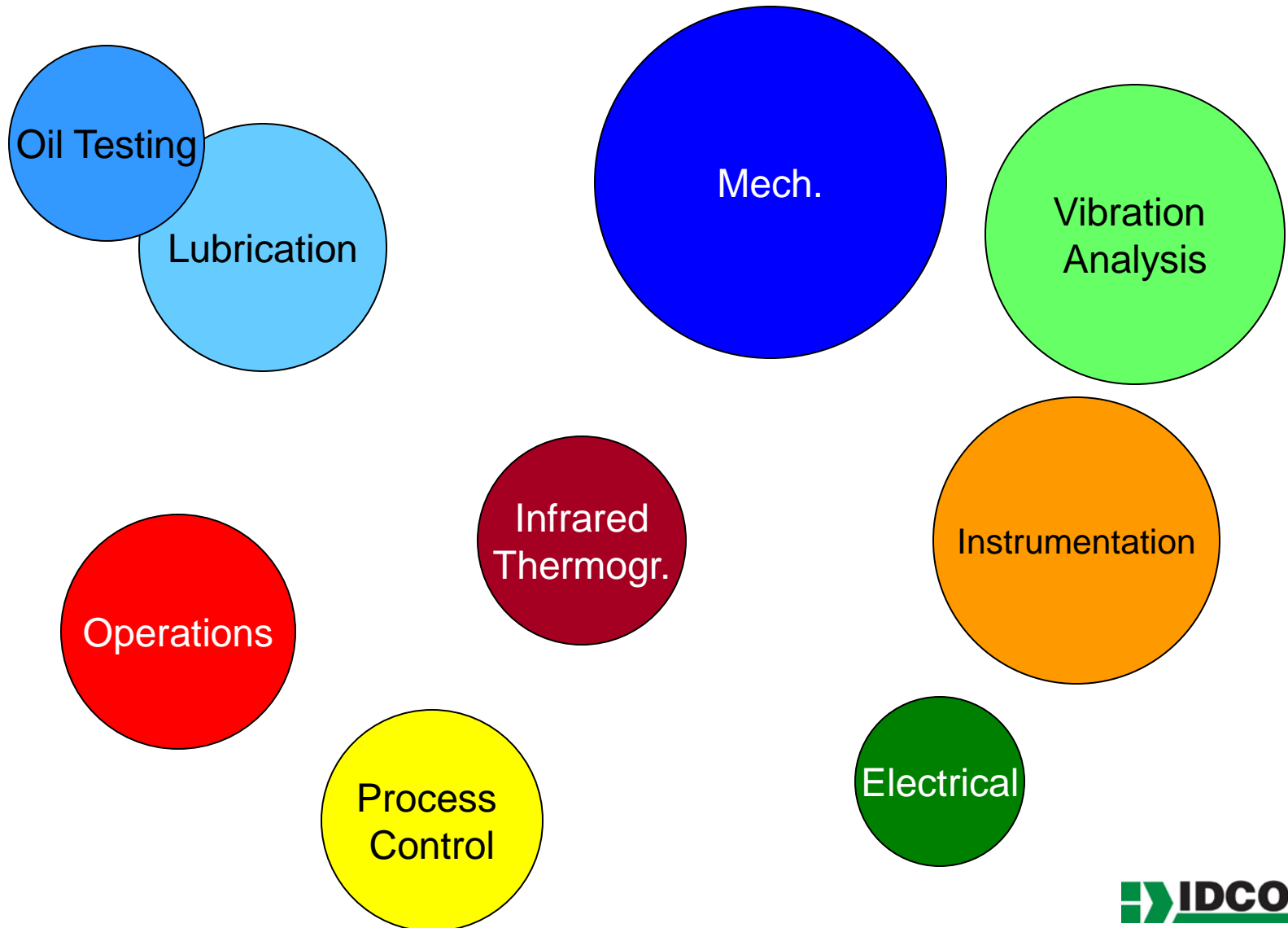
Do things right

*Do you see a problem?*



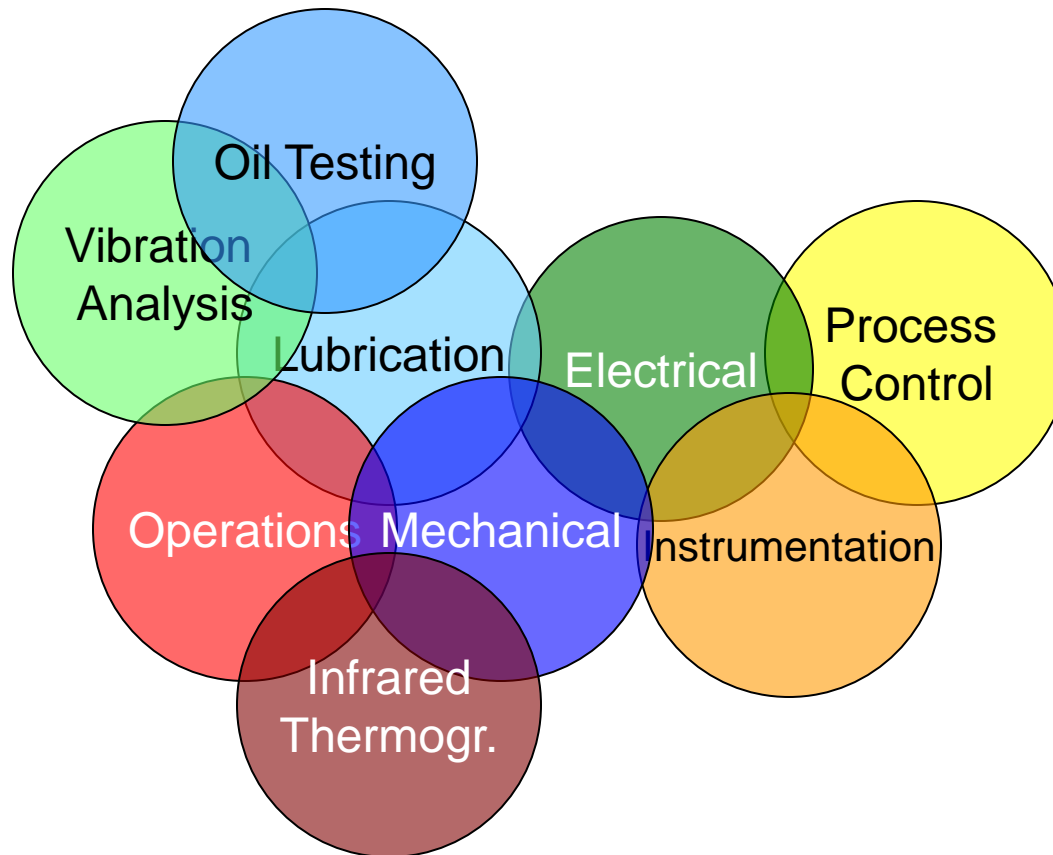


*Preventive Maintenance  
Common PM (including OEC) Before Improvement*





## *Preventive Maintenance Painting the Picture of Finished Product*



- Many PM's moved from off-line to on-the-run
- Coordinated PM process between skills reduces PM process size
- Essential Care reduces amount corrective work , not necessarily Preventive



*Operator Essential Care, Preventive Maintenance, Root Cause, Planning and Scheduling, Spare Parts Management*

- Making any of the above an isolated effort is a mistake.
- Focus on one temporarily can work
- They have to be integrated



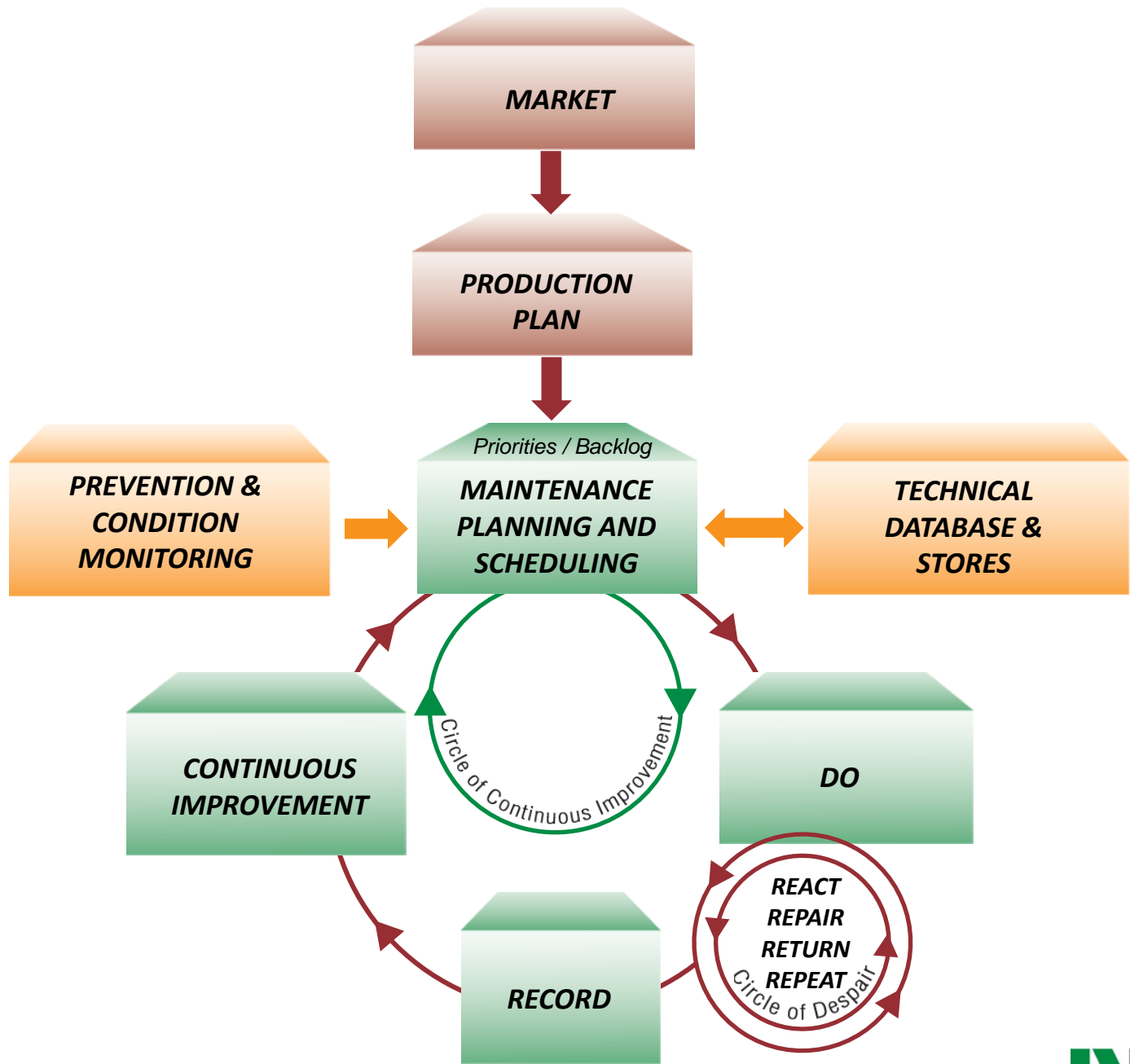
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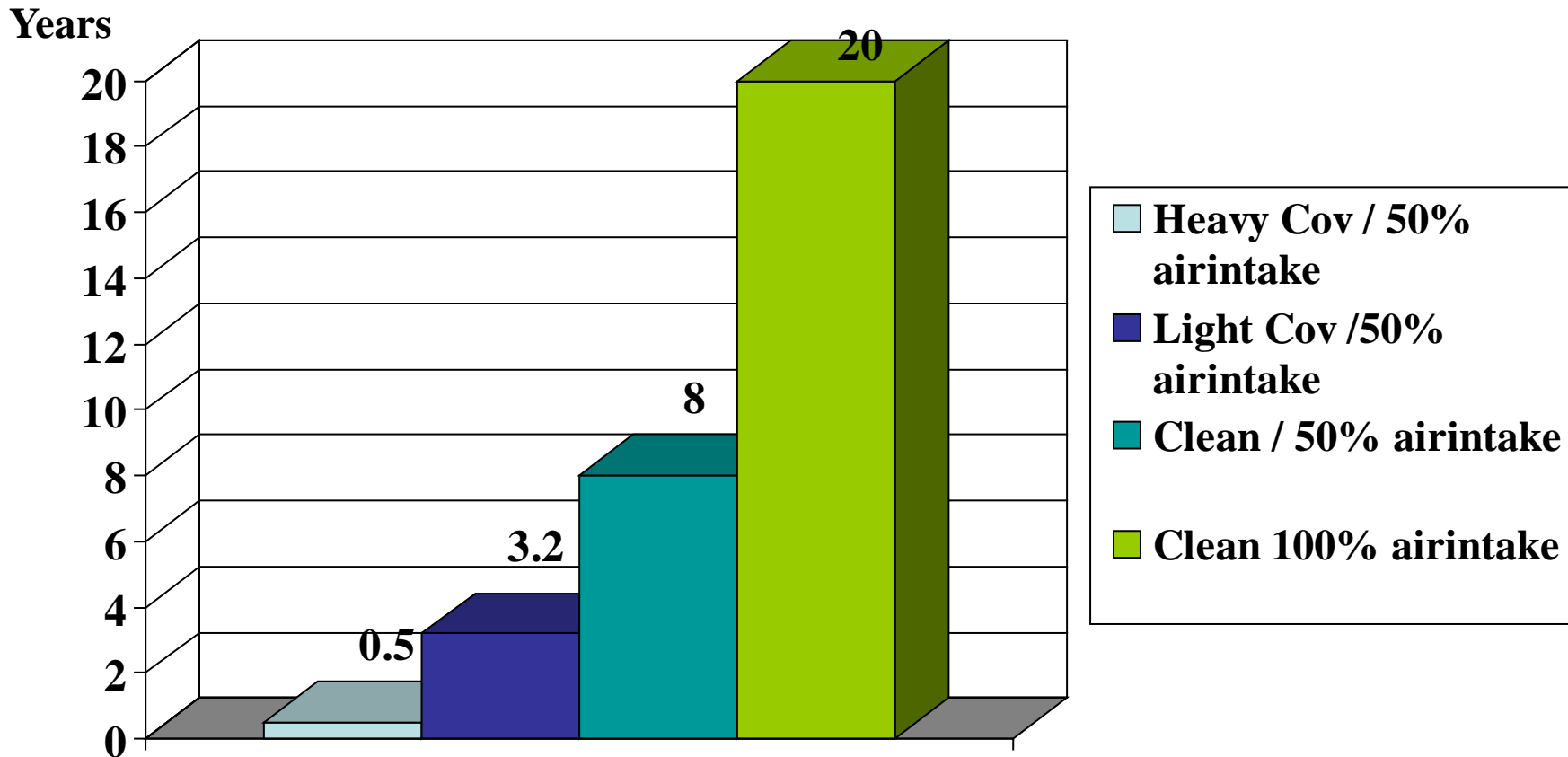
*Essential Care - Prevent*

*Results Oriented  
Reliability and Maintenance  
Consulting and Training*





## Motor Life in Relation to Cleanliness



20 HP, 1800 rpm, frame class F (155°F)



## *Dirty Motor*



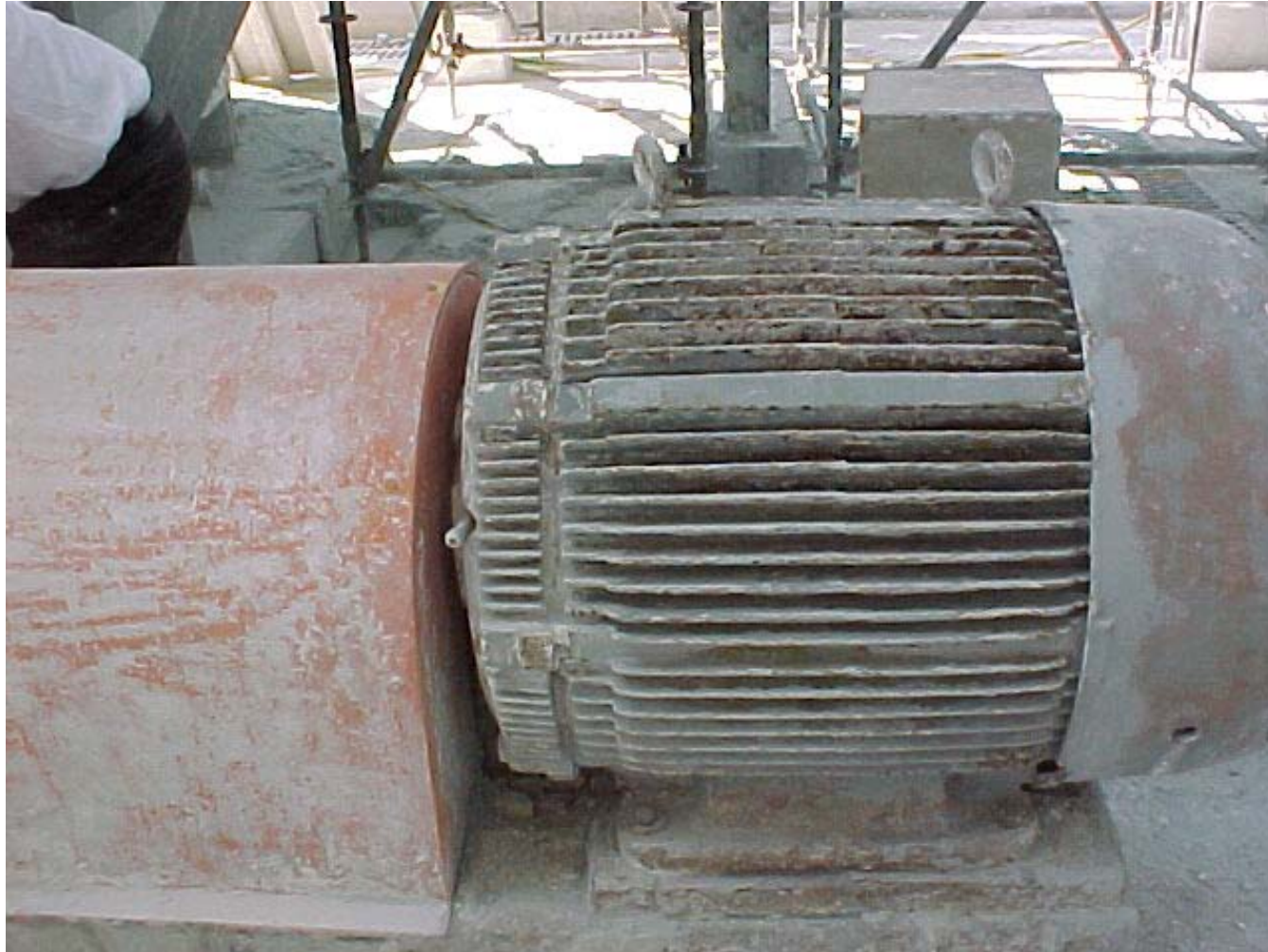
185 °F

### **Rule of Thumb:**

An 18 °F  
Increase In  
Temperature  
Reduces Motor  
Life by 50%



*Cleaner Motor*



135 °F

*Make a Visible Change Early in the Project*





*Make a Visible Change Early in the Project*

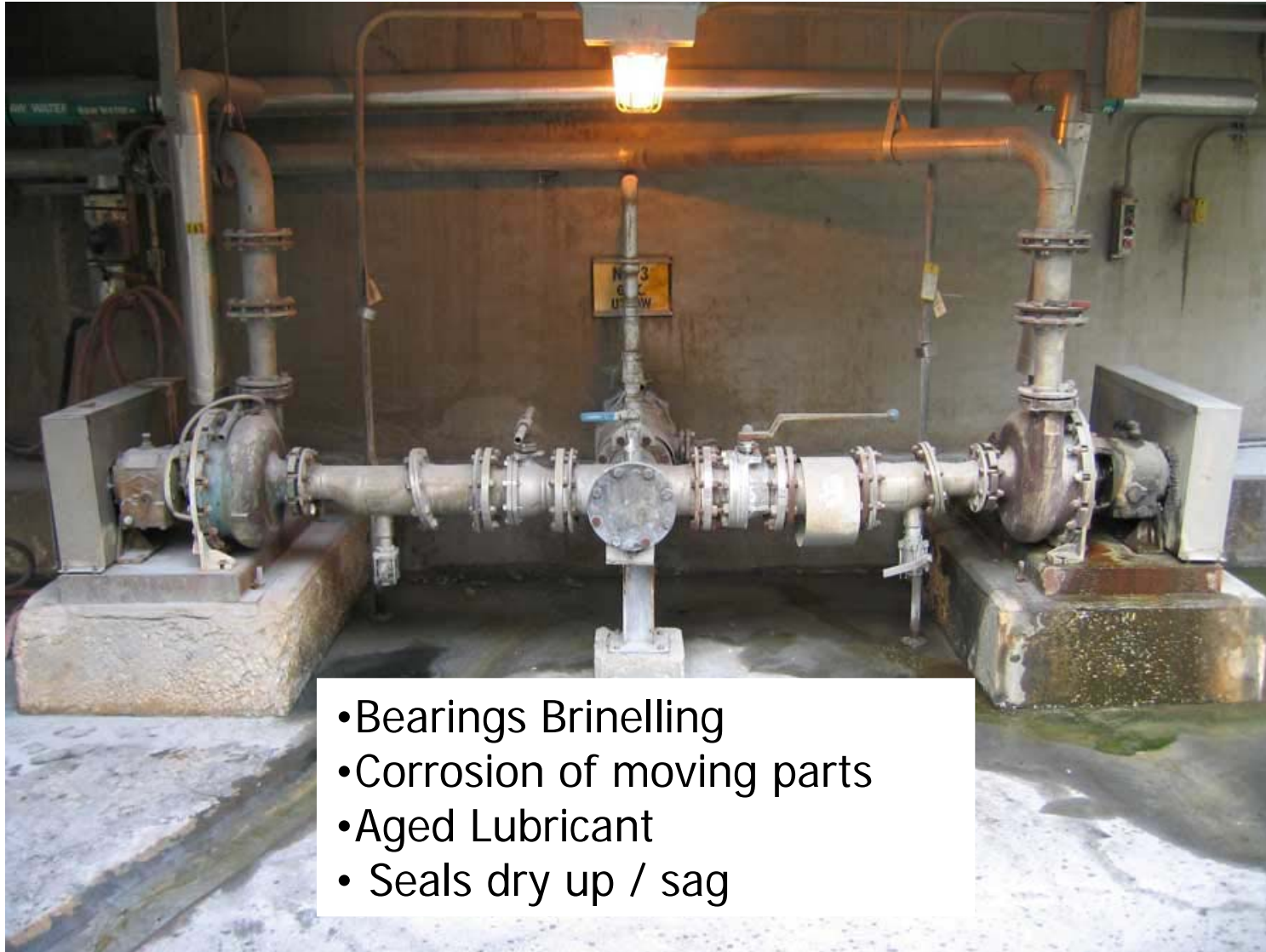


## *Operate Equipment with Reliability in Mind*



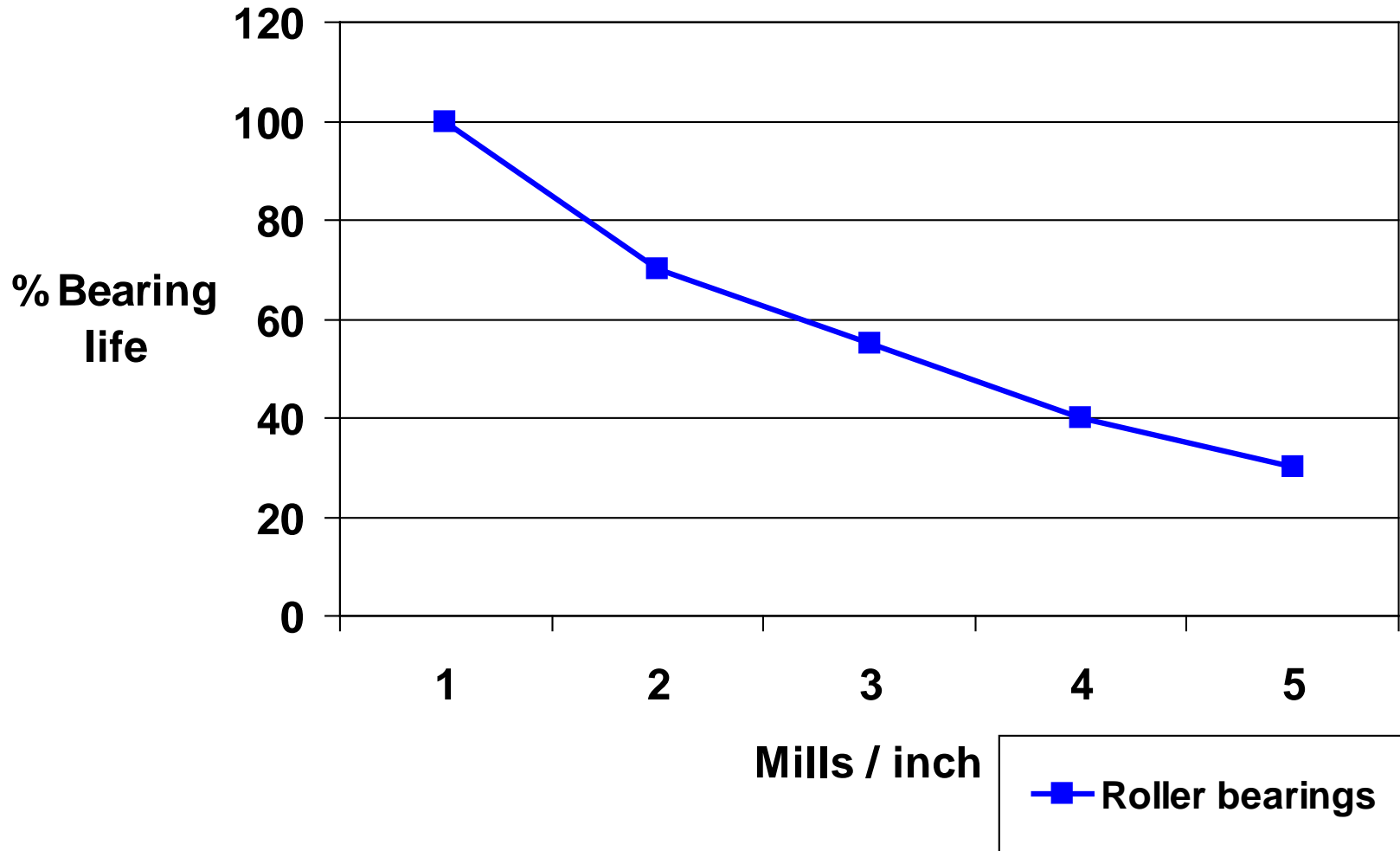
The current load is 4-7 times the full operating load at starting the motor. Operators should therefore not try to start Motors several times quickly together. It will burn the motor

## *Operating Procedures - Parallel Systems*



- Bearings Brinelling
- Corrosion of moving parts
- Aged Lubricant
- Seals dry up / sag

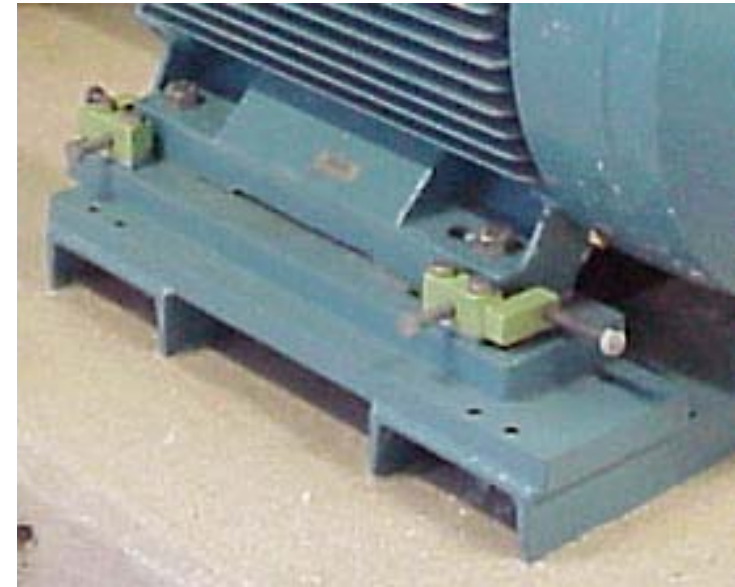
## *Bearing Life Reduction – An Example*



## *Signs of Poor Alignment*



**Poorly aligned**



**Probably Well Aligned**

### **Other Signs:**

- **Hot bearings**
- **Hot Couplings**
- **Vibrating Equipment**



## Measurement of Particle Size

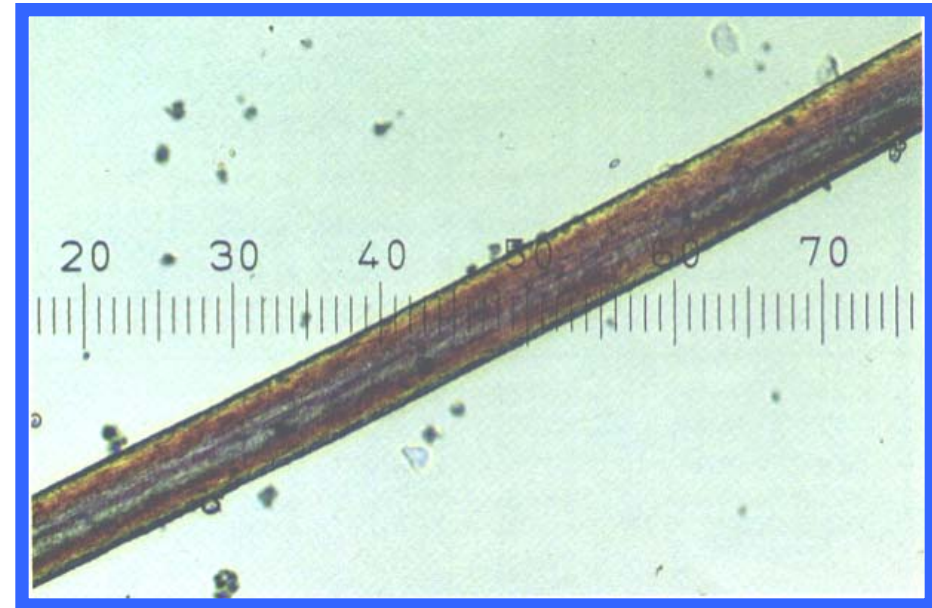
### The Micrometer “ $\mu\text{m}$ ”

“Micron” = Micrometer = 0.000001m

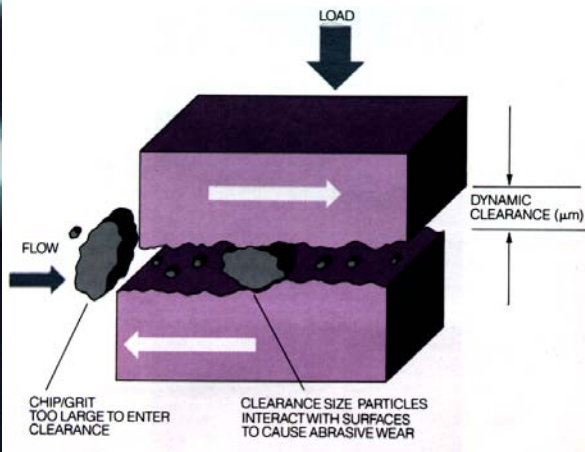
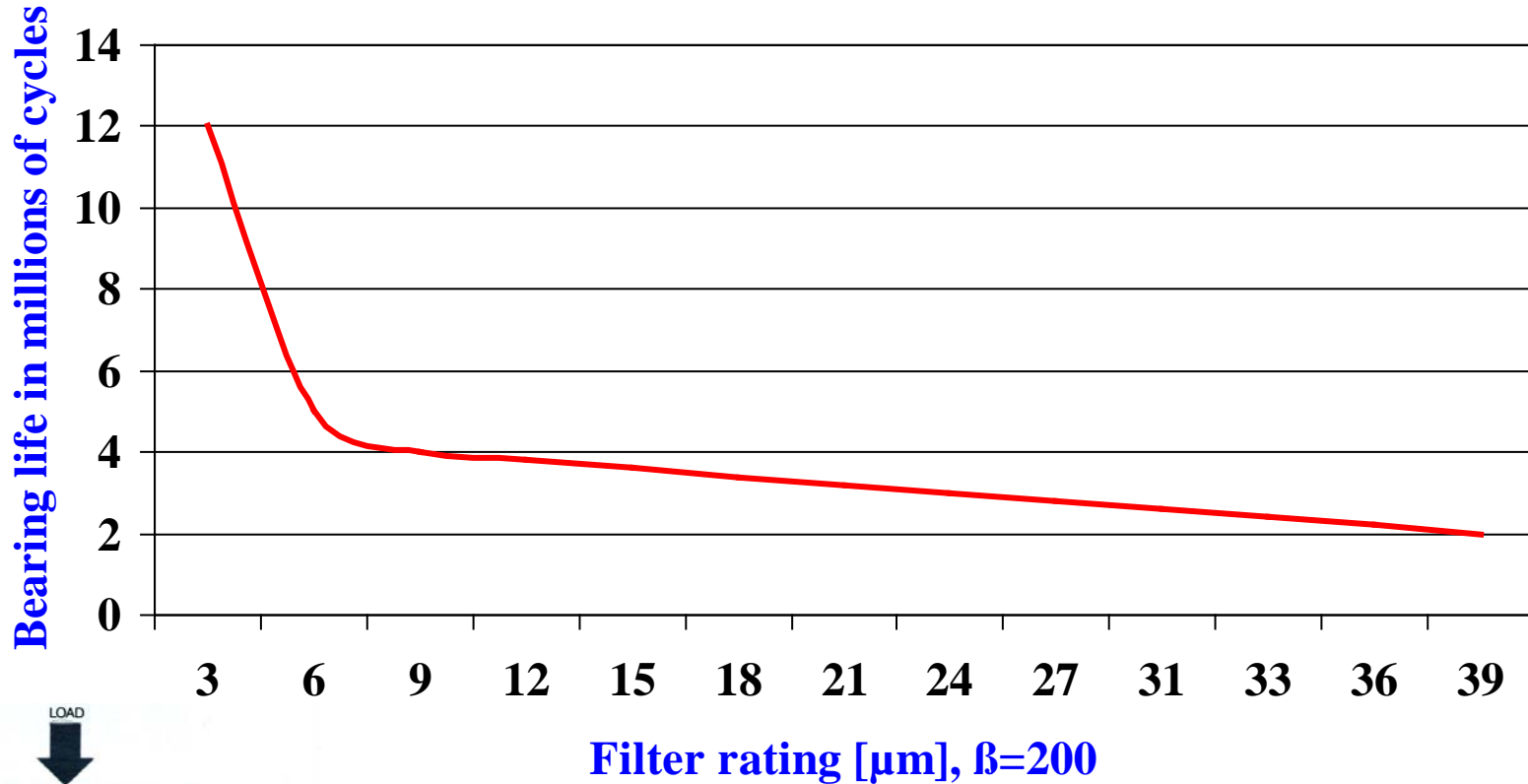
1 Micron = 0.000 039 inch

Human Hair 75  $\mu\text{m}$  particles 10  $\mu\text{m}$

Grain of salt	100 $\mu\text{m}$
Thickness of paper	75 $\mu\text{m}$
Human hair	70 $\mu\text{m}$
Naked eye can see	40 $\mu\text{m}$
White blood cells	25 $\mu\text{m}$
Red blood cells	8 $\mu\text{m}$
Bacteria (cocci)	2 $\mu\text{m}$



# Bearing Life & Filtration



Reference: Dr. P.B Macpherson, U.K







*Maintainability*





## *Design for Reliability*



## *Design for Maintainability*



# *Design For Maintainability*





# *Motor Shelf*





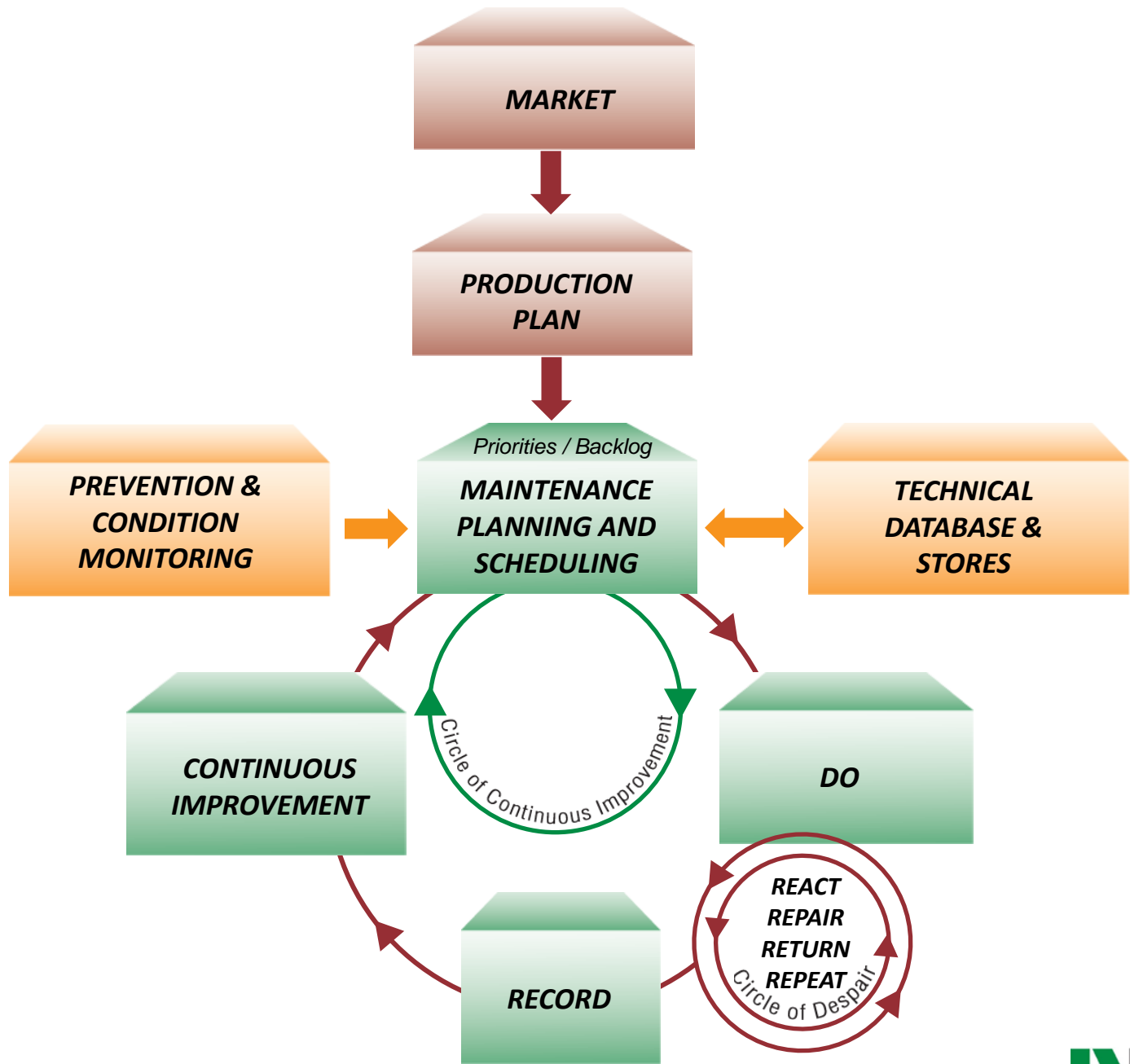
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The background is a collage of images. At the top left is a close-up of a man's face. Below it is a photo of two men in hard hats. A large green arrow points from the left towards the center. In the center is a photo of a control room with multiple monitors. At the bottom is a large industrial facility with complex piping and structures. On the right side, there is a large blue area containing the title text, and a partial view of a man in a yellow hard hat at the bottom right.

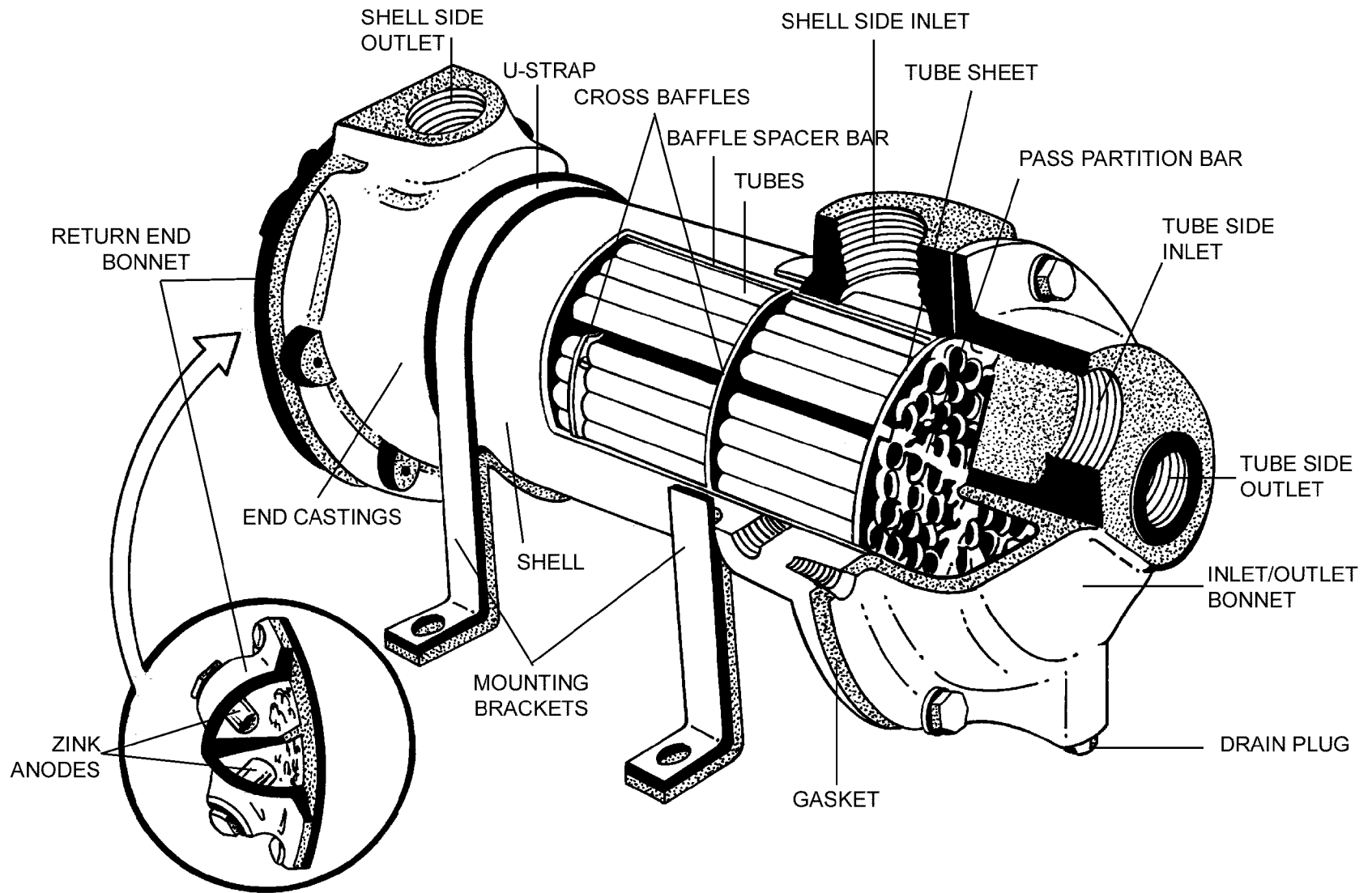
## *Condition Monitoring – Finding Failures*

*Results Oriented  
Reliability and Maintenance  
Consulting and Training*





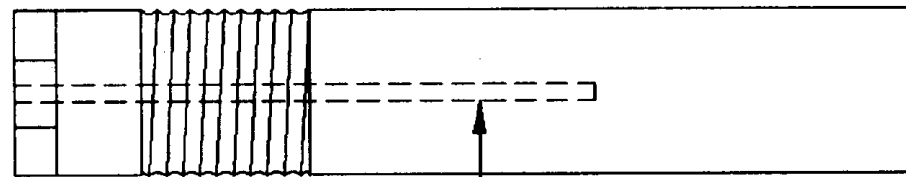
# How would you inspect the Zinc anodes?



# Solution?

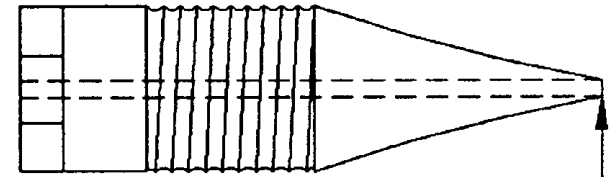


NEW ANODE



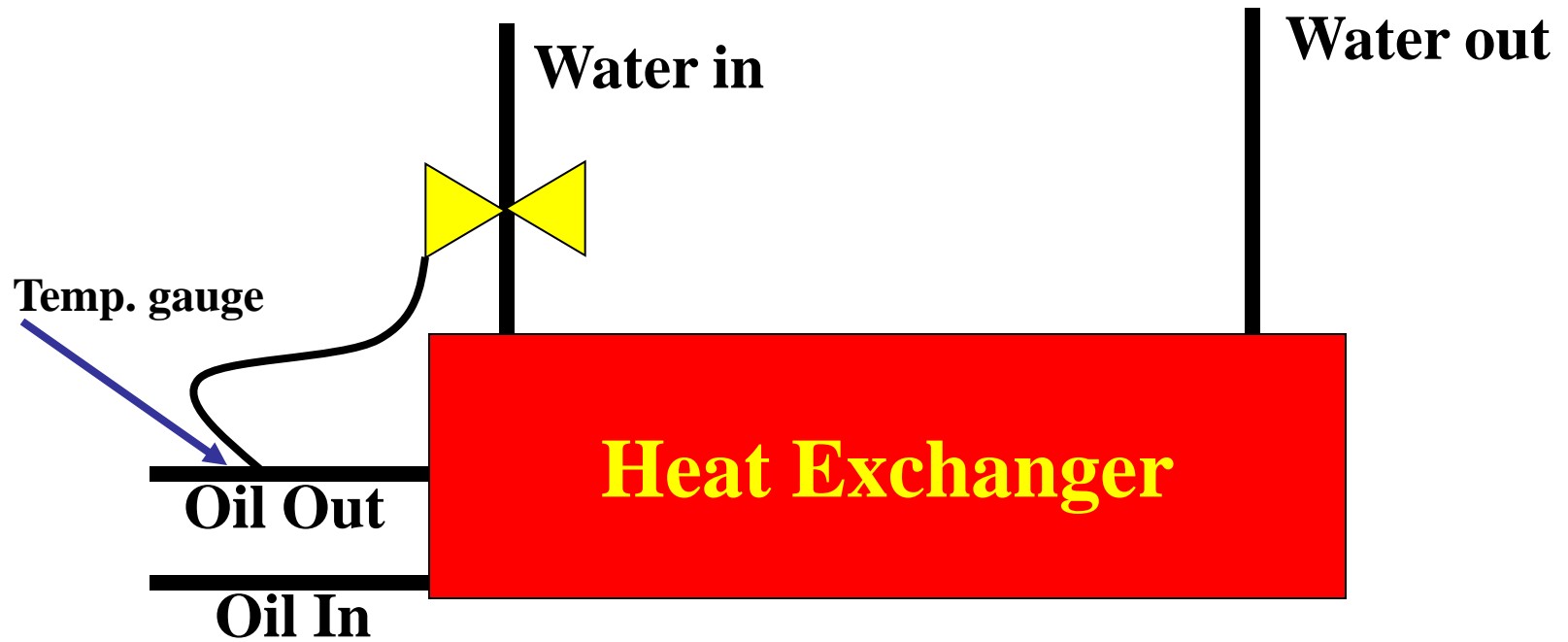
DRILLED HOLE

OLD ANODE



SLIGHT LEAKAGE

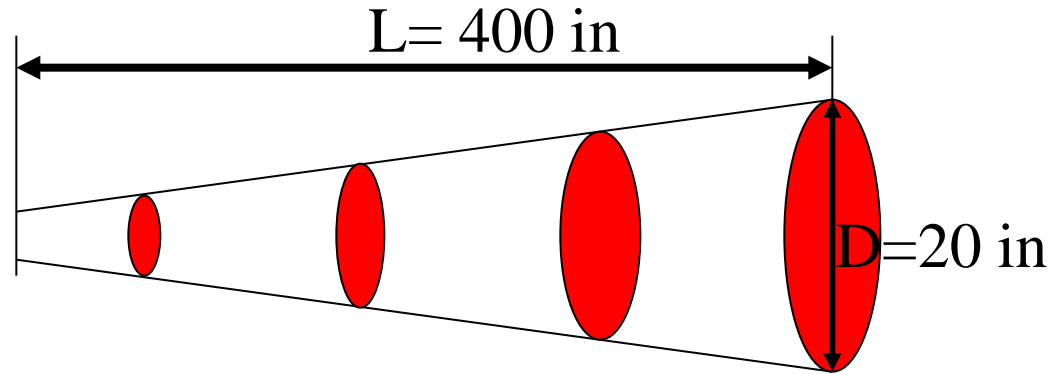
*Exercise 8-B*



## *Heat Exchanger Valve*



# Infrared Temperature "Guns"



$$\text{RATIO} = L/D = 400/20 = 20:1$$

**Expensive**  
**Cheap**

**Ratio 200:1**  
**Ratio 3:1**





# Possible Inspection Tools

## Inspection Mirrors



## IR Gun



## Flashlight



## Vibration Pen



## Stroboscope



## Industrial Stethoscope





# Flashlight



285 Lumens, size of a Marker

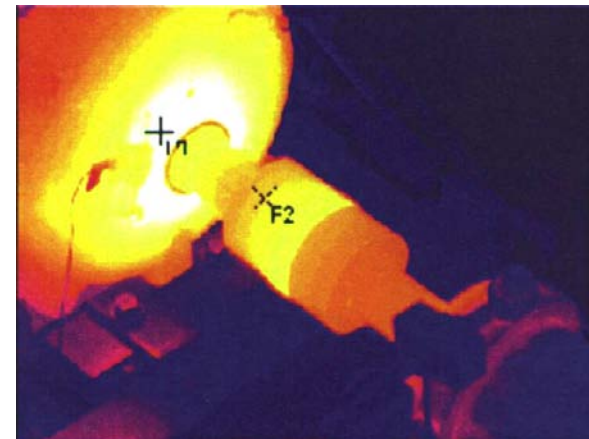
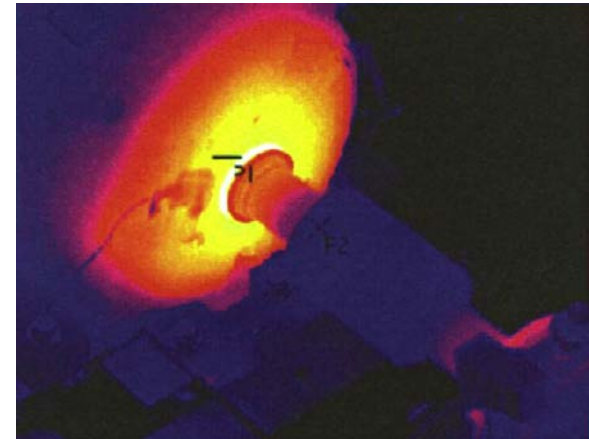


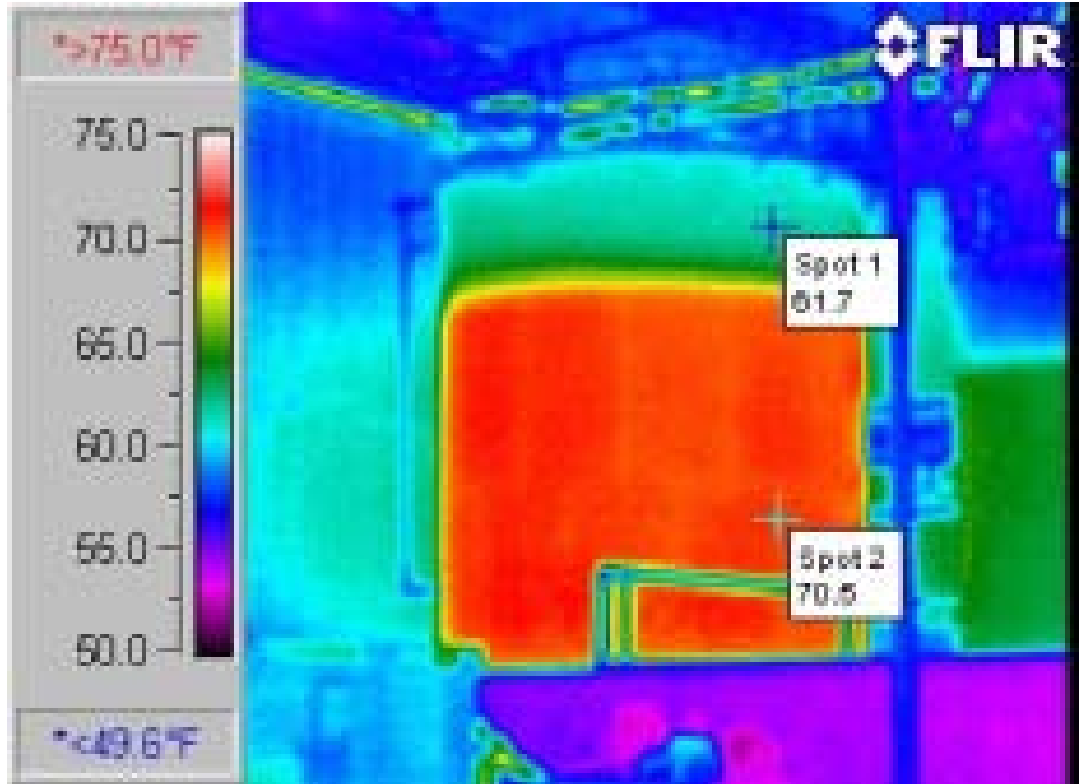
218 Lumens / 4D Batteries about a foot long

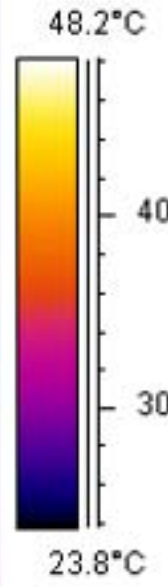
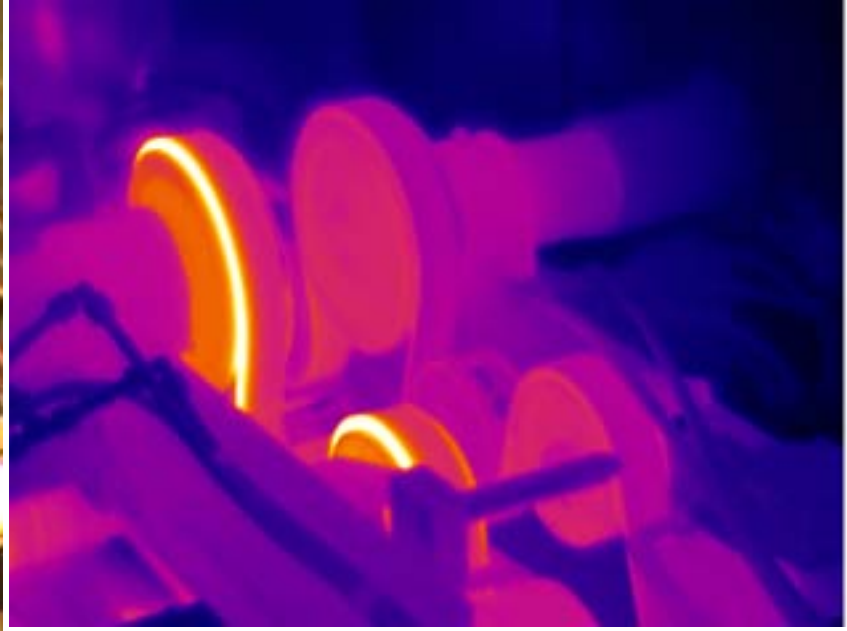
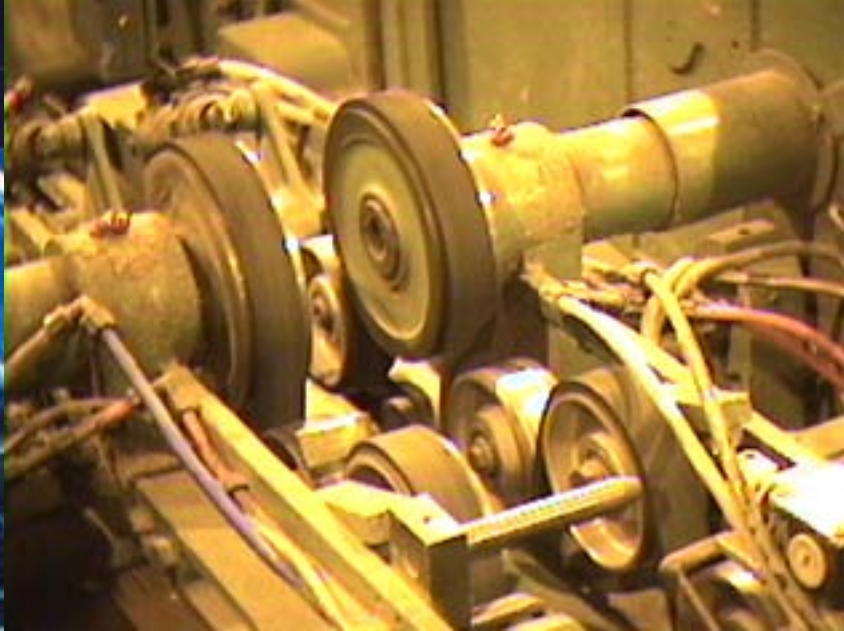
# *Temperature Crayons*



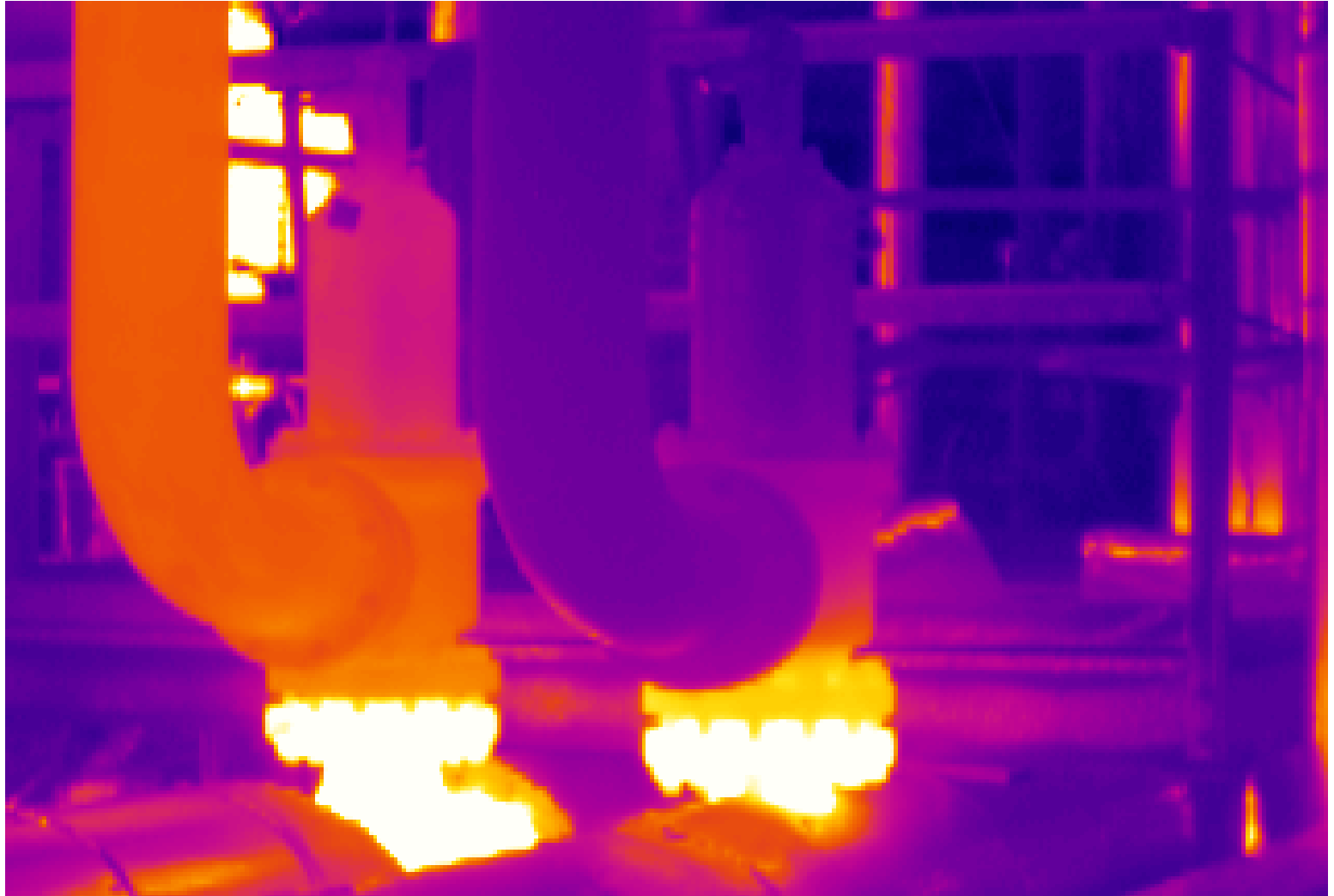
# Infrared Camera



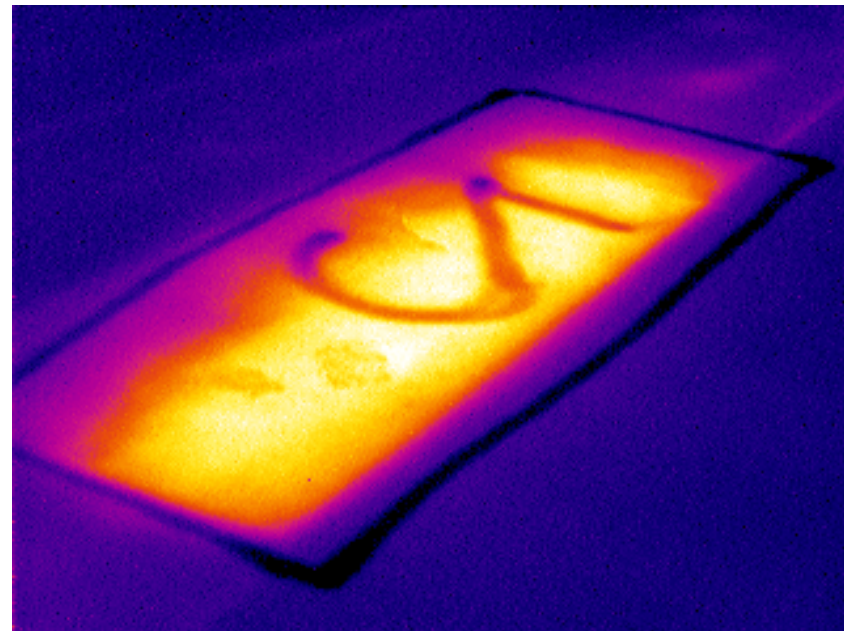
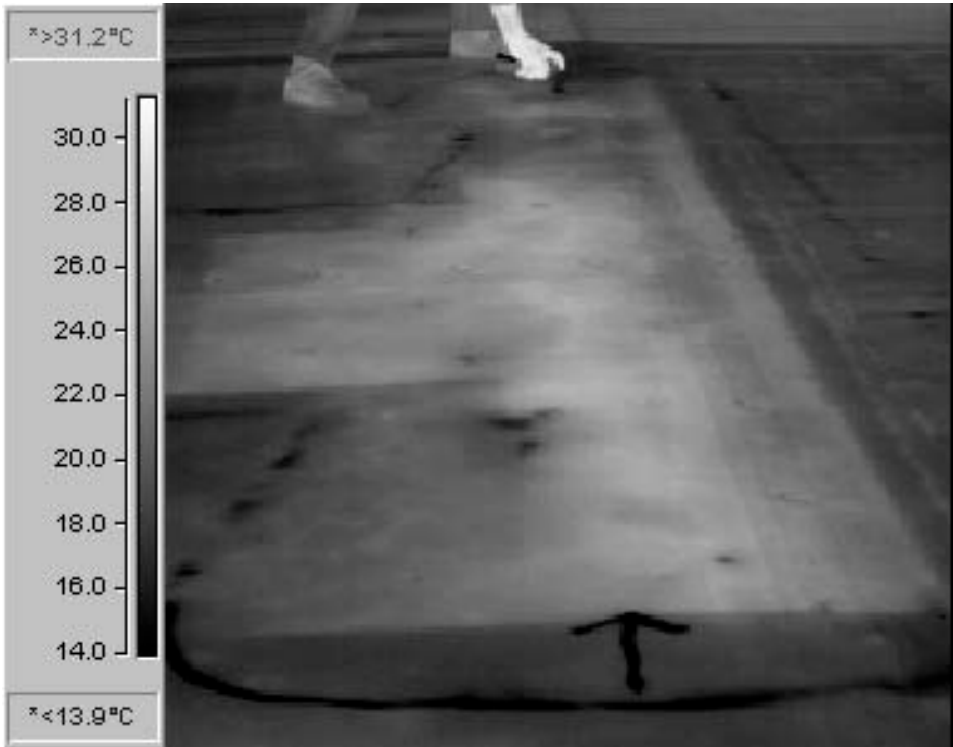




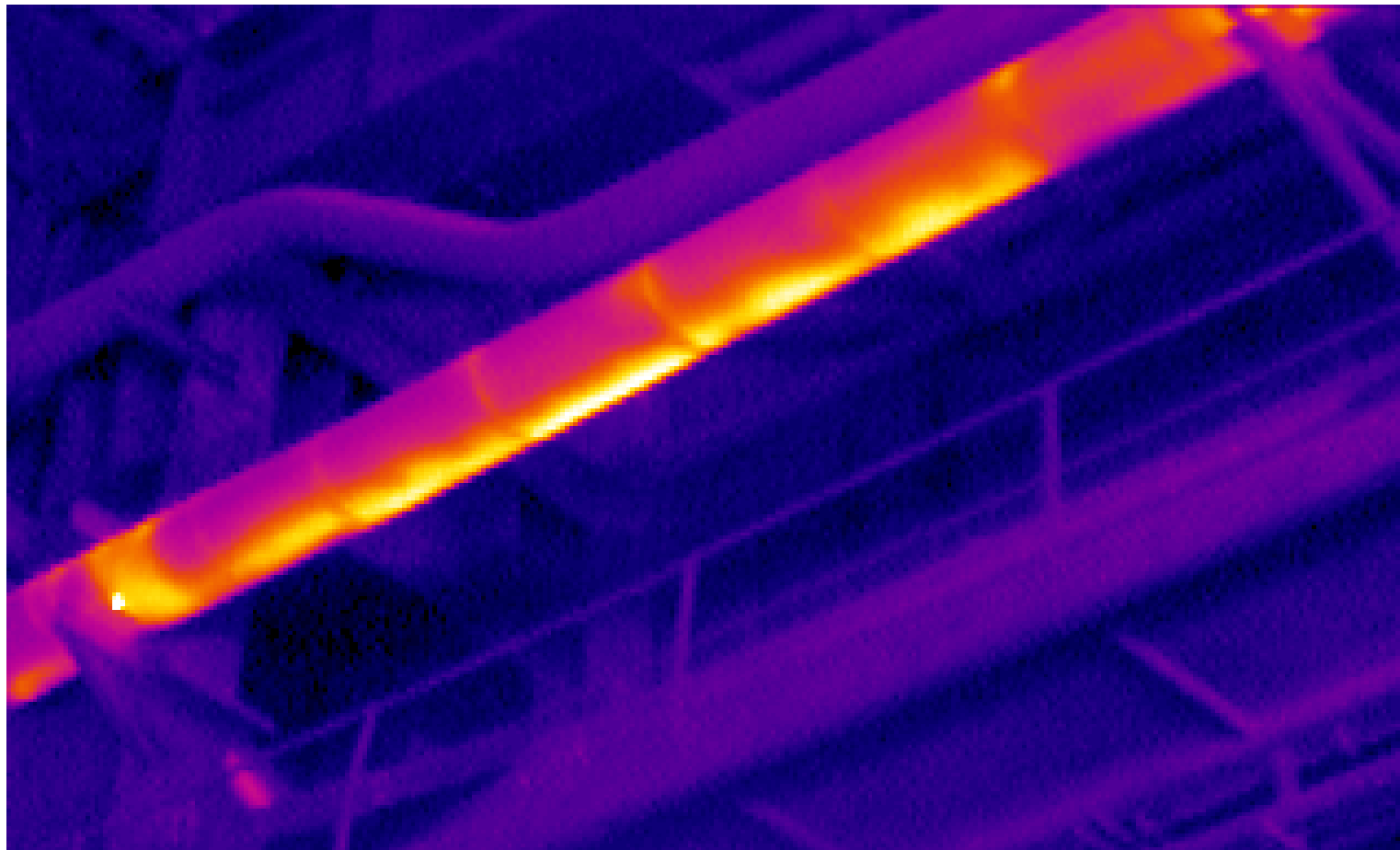
## *Leaking Steam System – Relief Valve*







*Wet Insulation – Saturated with Water Due to Leak*





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The background is a collage of images: a man's face in the top left, two men in hard hats in the top right, a large green arrow pointing right in the center, a close-up of a control panel with many buttons in the middle left, a large industrial facility with pipes and scaffolding in the bottom right, and a man in a yellow hard hat in the bottom right corner.

## *The Basics of Reliability and Document tasks*

*Results Oriented  
Reliability and Maintenance  
Consulting and Training*

# Paper Inspection Route Example



Equip.No: Route No: Doc No:	Equipment Name	Int. Pos. Vol.	Comments STX.No Activity M.Type	UoM	Description
899-316-3111-801 530	CAUSTIC - KILN EAST GLC RAKE LIFTING DEVICE	7 1			
899-316-3210-011 540 CMS100R	CAUSTIC - KILN WEST GREEN LIQUOR CLARIFIER MOTOR 1745 RPM	7 1 0			Air Intake. Temperature _____ Noise and Vibration _____ Bolts. Base. Foundation. Electrical. Detailed Cleaning. Junction Box. Comments: _____ TEMP ° F WINDINGS _____ VIB IN/S INBOARD BEARING _____
899-316-3210-021 550	CAUSTIC - KILN WEST GREEN LIQUOR CLARIFIER	7 1			
899-316-3210-022 560 CMS117R	CAUSTIC - KILN WEST GREEN LIQUOR CLARIFIER REDUCTION GEAR	7 1 0			Noise. Vibration. Temperature. Lubrication Level. Leakage. Detailed Cleaning. Visual Breather. Visual Seals. TEMP ° F BEARING HOUSINGS _____ VIB IN/S BEARING HOUSINGS _____
899-316-3210-027 570 CMS121R	CAUSTIC - KILN WEST GREEN LIQUOR CLARIFIER RAKE	7 1 0			Seal Water. Packing. Belts. Bolts. Foundation. Bearings. Overload.
899-316-3211-011 580 CMS100R	CAUSTIC - KILN WEST GLC RAKE LIFTING DEVICE MOTOR 1745 RPM	7 1 0			Air Intake. Temperature _____ Noise and Vibration _____ Bolts. Base. Foundation. Electrical. Detailed Cleaning. Junction Box. Comments: _____
899-316-3211-022 590 CMS117R	CAUSTIC - KILN WEST GLC RAKE LIFTING DEVICE REDUCTION GEAR	7 1 0			Noise. Vibration. Temperature. Lubrication Level. Leakage. Detailed Cleaning. Visual Breather. Visual Seals.
899-316-3211-801 600	CAUSTIC - KILN WEST GLC RAKE LIFTING DEVICE	7 1			
899-318-1071-011 610 CMS100R	TRS COLLECTION AND INCINERA TRS HEADERS FOUL CONDENSA MOTOR 3450 RPM	7 1 0			Air Intake. Temperature _____ Noise and Vibration _____ Bolts. Base. Foundation. Electrical. Detailed Cleaning. Junction Box. Comments: _____
899-318-1071-021 620 CMS175R	TRS COLLECTION AND INCINERA TRS HEADERS FOUL CONDENSA FOUL CONDENSATE PUMP	7 1 0			Temperature. Bolts. Seal. Noise. Vibration. Oil Level. Oil Condition. Leaks and Piping. Pressure Gauge. Detailed Cleaning. Breather. Cavitation.



# CMS (100 Available)



Pump – Double-Suction Single Stage Centrifugal  
CMS175R – On-The-Run Inspection  
Condition Monitoring Standards



## Basic Principle

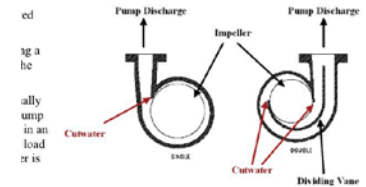
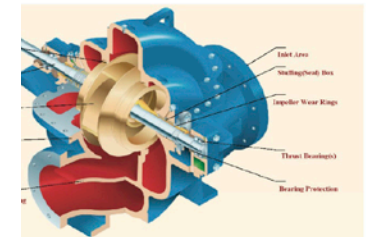


Figure 1 – Cutwater and dividing vane locations of normal (left) and hydraulically balanced (right) centrifugal pumps.



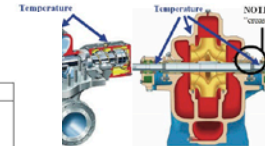
Internal arrangement of a typical double suction centrifugal pump, if Flowserve.

## FETY FIRST!

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CMS175R Page 1 of 11

KEY	WHAT	WHY
	High temperatures may be due to high product temperatures or problems such as cavitation, the internal rubbing of parts, incorrect packing adjustment, over-greasing, overload, misalignment, existence of foreign material within the pump or failing bearings.	Any substantial change in temperature usually indicates some fault, e.g.: <ul style="list-style-type: none"> <li>Excessive lubrication</li> <li>Insufficient lubrication</li> <li>Bearing damage</li> <li>Overload</li> <li>Induced Vibration</li> <li>Shaft misalignment</li> <li>Shaft bent</li> <li>Impeller imbalanced</li> </ul>



Temperature reading locations on double suction pumps of Flowserve (left) and Goulds Pumps (right).

Temperature at the locations indicated above. If the pump is running, the temperature will rise.

Temperature on bearings refer to CMS167R.

Outboard bearing functioning normally. Measured temperature 134.5°F (57.0°C)



Highlighted temperature reading spots.

Temperature observations on a double-suction pump at a large board bearing was found to have failed and was exchanged below, thanks to inspection.

Temperature measurements, with an infrared temperature gun, trying various locations. The readings will be most accurate if they are taken above the bearing, or in the crease next to the bearing eye is on the casing.

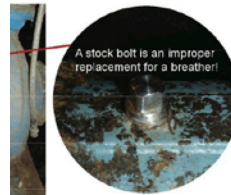
Temperature measurements, consideration must be taken of the fact that temperatures are generally 10-20°F (5-10°C) higher than measured on the outer surface of the casing, above the bearing.

Temperature depends on casing design, product temperature, bearing amongst others.

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CMS175R Page 6 of 11

KEY	WHAT	WHY
	...Continued NOTE: Typical pump breathers only filter out dirt to a certain size, typically 10 microns, which is inadequate for keeping out particles harmful to the bearing. It is a good idea to install a silica gel breather, which is able to filter out much finer particles, down to 3 microns, as well as drying the air entering the pump. Refer to CMS115R for more information on silica gel breathers.	The most harmful contaminants in mechanical components and bearings are between 3 and 5 µm in size. Standard metallic breathers are nowhere near able to filter air to the appropriate level of cleanliness.



A stock bolt is an improper replacement for a breather.

Allowing methods:

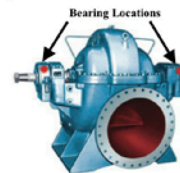


Figure 16 – Bearing locations on a typical Goulds double suction pump. Courtesy of Goulds Pumps.

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CMS175R Page 9 of 11

KEY	WHAT	WHY
Leaks and Piping	Check for visible leaks at pump mating surfaces, connections and fittings. Also check condition of hangers supporting the pump piping. Pipes and pipe hangers are covered in CMS172R. If you are experiencing an unusual amount of flange gasket failures, it may be caused by misaligned piping, lack of "cold spring", high heat, low PH level of liquid in the pipe, incorrect selection or installation of the gasket.	Air leaks on inlet can cause cavitation in the pump. Discharge leaks will cause efficiency losses and spills. Leaking of liquids can be a safety hazard. Missing or damaged hangers may cause pipe strain and cause severe wear and misalignment of pump assembly. To check if inlet connections have a leak, pour water over suspected leak points and listen if cavitation sound goes away.
Breather	A breather is an air filter, located on pump bearing housings, and has the purpose of relieving pressure inside the casing and filtering the air entering oil compartments. The breather should not be clogged, and be kept clear of debris. On older equipment, the breather may have been replaced with incompatible parts of the wrong type or size. It is therefore important that you visually inspect the condition of the breather.	A clogged air filter may cause very high temperatures inside the oil compartment due to increased pressure as the closed container heats up. This can result in blown bearing seals.



Figure 13 – Leaks have consequences no matter where in the system they occur. Water leak (top) at a pump-pipe fitting, at black-liquor pipe above double suction pump assembly (lower-left), under a pulp slurry pump (lower-right)



Figure 14 – Breather location on a typical Goulds double suction pump. Image courtesy of Goulds Pumps.





## Handheld Example

Eq. no. 813-5423-MT

Name No. 5 Hood Exhaust Fan - Motor AC

Reference CMS100R Rt. Seq. 1020

Check air intake. Detailed Cleaning. Water/Humidity. Record temperatures. Noise and Vibration. Motor Base. Electrical. Grease.

WORK OR. [ ]

MEASURE [ ]

CLOCK 12:46:59 pm

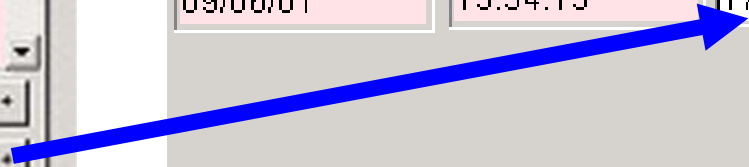
OK

**Description**  
Temperature front bearing of motor

**Type** Temp. **UoM** Fahrenheit

**Latest Reading**  
09/06/01 15:33:35 158

**New Reading**  
09/06/01 15:34:15 175





## *Common Mistakes – (A Few Examples)*

- Make a route for only one component or equipment type, for example “pumps routes” or “valve routes”
  - Because inspector will have to walk around the plant 30-50 times to reach all equipment
- No use of standard job plans for inspections
  - Makes maintenance of inspection lists very cumbersome if a new inspection tool or new technique is established
- Separate routes for different inspection intervals
  - Often a daily, a weekly, a monthly, a semi annually route for each trade make scheduling cumbersome and maintenance of routes very maintenance intensive.
- Set up of too many measuring points that are collected but not analyzed
- We don't fix what we find



# Work Order PM

Mandatory PPE: Safety Footwear, Eye Protection, Gloves, & Hearing Protection



Recommended PPE:

### Purpose

Use this document to check for cavitations damage on the TMP/RMP Low Pressure White Water Pump. Service Number: 740244

The estimated total time to check for cavitations damage is 0.5hrs using 1 filter.

This procedure must be used in conjunction with procedure # XXXXXXX? for changing the volute casing for the removal and reinstating procedure.

The suction head to this pump is too low causing a large amount of cavitation and impeller damage. The suction head should be 8m high but it is only 3-4m and it is not economic to increase the height of the chest so the impeller is sacrificial.

This check is undertaken on a 2 yearly basis.



### Hazards

Refer to procedure # XXXXXX for hazards, changing volute casing.

### Pre-Checks

(Things to check before starting this process)

- Check Operations schedule
- Confirm availability of materials and tools
- Confirm maintenance crew available
- Visually inspect slings and chain blocks for damage before use

### Time Line

Step	Procedure Overview	Time
1	For Pump Removal, Re-assembly and Reinstall	See procedure #XXXXX
2	Check impellor for cavitation damage and replace if required	1/2 hour

### Labour Required

Quantity & Description	Hours
1 Fitters	1/2

### Materials Required

- Quantity & Description
- (x1) Impellor 444mm diameter P/N 23448 (don't remove from stock, check that available incase it is required)
  - (x1) Impellor o-ring P/N 23637 (don't remove from stock, check that available incase it is required)

### Isolations

Electrical Drive:  
Refer procedure # XXXXXX for isolations, changing volute casing.

### Environmental

Refer procedure # XXXXXX for environmental considerations, changing volute casing.

### High Temperature Work

Working environment not extreme. Drinking plenty of water will reduce the effects.

### Permits


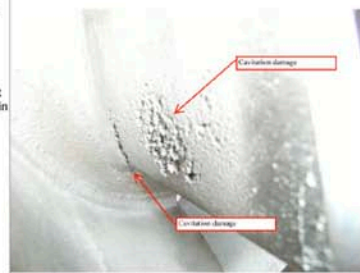
Refer procedure # XXXXXX for environmental considerations, changing volute casing.

### References:

#### Document Name & Description

- AC Pump PS Plus™ Model 100/150 (F23A2, F23B2 and F23C2) Process/Slurry Centrifugal pump. Installation & Operations Manual (internal) and TMP pumps file.

**STOP** Read Hazards

Activity	Inspection Task
Remove pump	1. <b>For Pump Removal, Re-assemble and Reinstall – see procedure # XXXXXX</b> Includes setting impeller clearance
	2. <b>Check pump impellor for cavitation damage</b> <div style="display: flex; justify-content: space-between;"> <div style="width: 60%;"> <p>2.1. When the pump head and impeller have been removed from the volute.</p> <p>2.2. Check the back side of the six blades (See Fig 1) for cavitation damage.</p> <p>2.3. If evident the cavitation damage will be present on the back side (mechanical seal side) of the six blades and will be close to the eye of the impeller. See example Fig 2.</p> <p>2.4. If the structural integrity of the impeller is compromised by the damage and parts of the impeller could break away while in operation then replace the impeller.</p> <p>2.5. The acceptable level of wear or damage is a discretionary call if you are unsure get a second opinion from a mechanical engineer.</p> <p>2.6. Figure 2 shows previous cavitation damage, at this level of damage the impeller was replaced on 25/05/2008.</p> <p>2.7. Make sure - if the pump is returned to service with some damage evident that you are confident it will run for the next two years. It is likely to sustain further damage and must still hold together.</p> </div> <div style="width: 35%;">  <p>Fig 1: Area for inspection</p>  <p>Fig 2: Example of cavitation damage</p> </div> </div>

Prepared: G Handcock	Authorised: J Hoogstraten	Date: 12-06-2008
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Uncontrolled copy printed on 23/03/10 @ 14:41 – out of date in 3 days! Check the version before use		

## *What is the Final Documentation Product of OEC and PM*

### Usually

- Inspection Routes for on-the-run PM/OEC
  - Usually less than 5 minutes per equipment number
- Work orders for off line PM/OEC
  - Often longer jobs 30 min – 16 hrs

## *Reliability Basics*

- **Maintenance Methods Available**
- **Life of Components**
- **Failure Developing Period (FDP)**

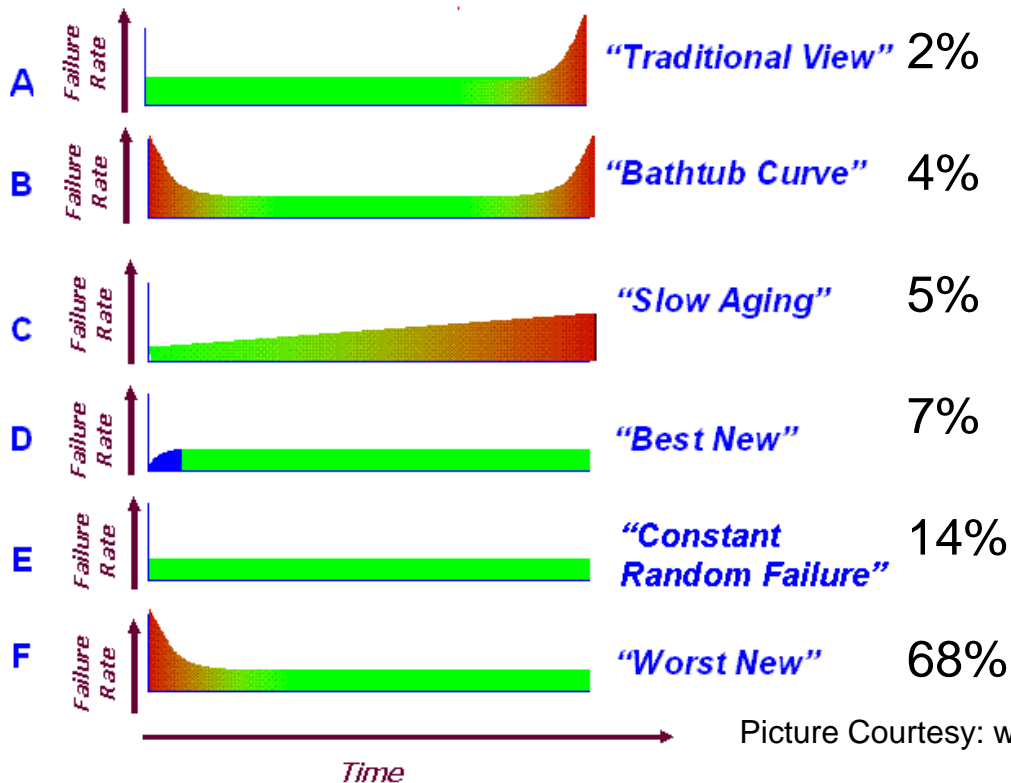
## *Maintenance Methods – Existing Equipment*

- **OTB – Operate To Break-Down**
  - Often Too Expensive
- **FTM - Fixed Time Maintenance**
  - Don't Know Life Most of the Time
- **CBM – Condition Based Maintenance**
  - 70-85% Will Therefore Need CBM



## Random or not?

- It is unnecessary to know which of the traditional six life expectancy. You need to estimate if the failure IS Random or NOT. All failures are somewhat random and 5 – 11% somewhat predictable (C & possibly A & B).



Picture Courtesy: [www.weibull.com](http://www.weibull.com)

## *Component Life*

**Bearing life under the same operating conditions,  
can vary from 1 to 25 years**



**UNPREDICTABLE**

$L_{10}$

$L_{90}$

## *Component Life*

**Car tires life under the same operating conditions,  
may vary from 35,000 to 45,000 miles  
(6000-6500 mil)**



**PREDICTABLE**

35 K

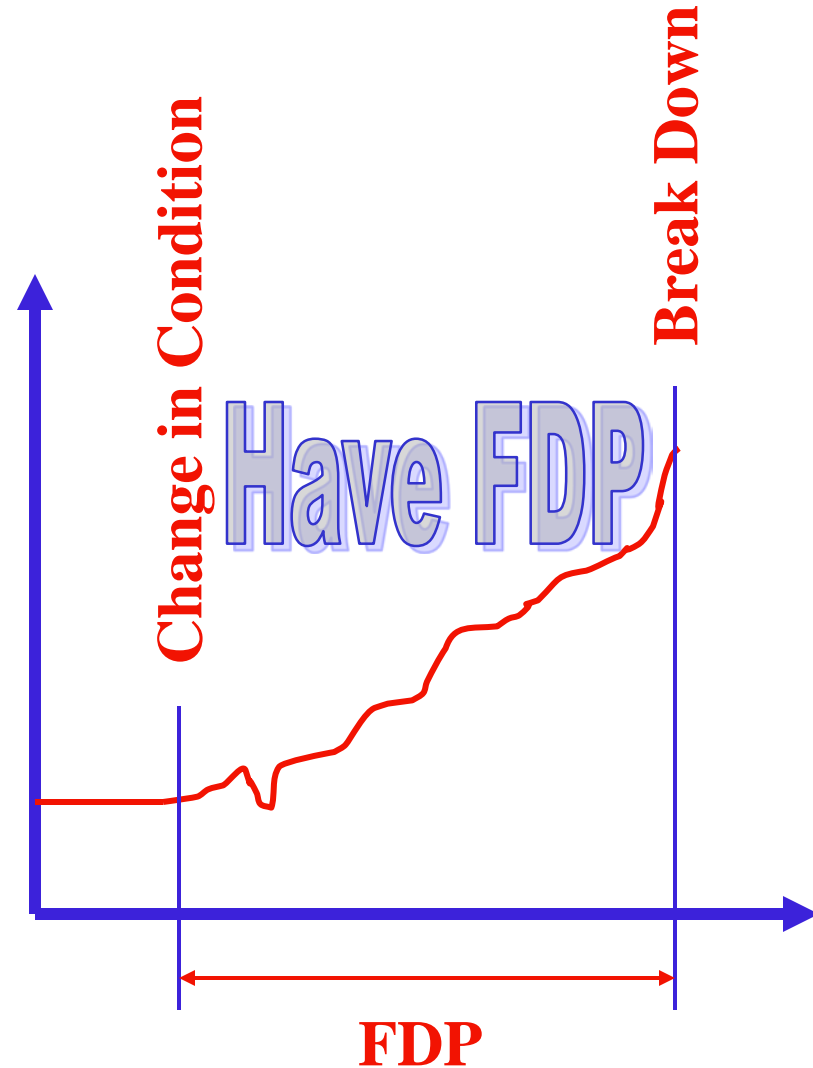
45 K

[Back](#)



# Failure Developing Period

**A belt will show signs of deterioration before breaking down**



# Failure/ Break Down

When the failure has developed to the point that the equipment is unable to operate  
**BREAK DOWN**



**FAILURE**



The failure is detected and reported

**SOURCE** Event that initiate Failure developing  
When the equipment condition reaches an unacceptable level

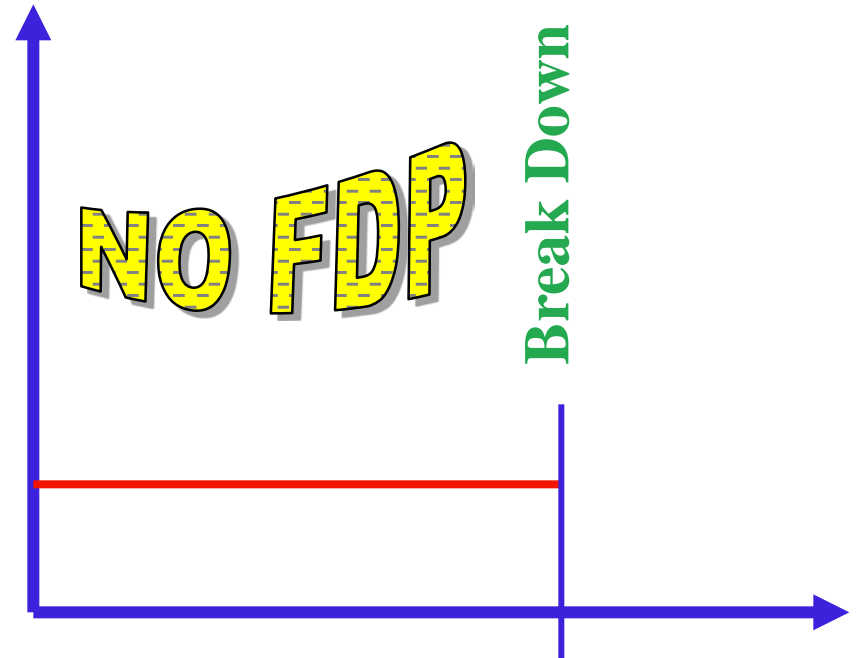
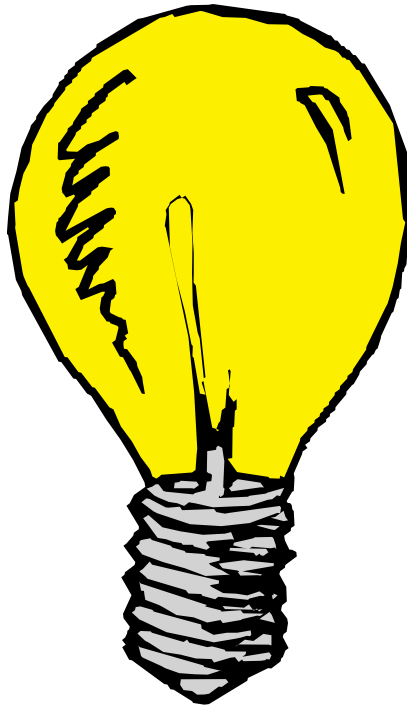


Source: källa till felet  
Break down: Haveri



# *Failure Developing Period*

**A light bulb will break  
instantaneously without any  
signs of deterioration**



## *Selecting Maintenance Method*

- 1. Prevent failures**
- 2. Most cost effective maintenance method**
- 3. Implement the most cost effective method**

## *Preventing Problems*

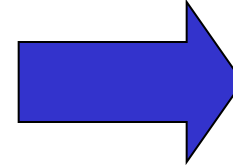
- **Detailed Cleaning**
- **Lubrication**
- **Alignment**
- **Adjustment**
- **Operating Procedures**
- **Filtration**
- **Balancing**
- **Installation Procedures**

## *Maintenance Methods – Existing Equipment*

- **OTB – Operate To Break-Down**
  - Often Too Expensive
- **FTM - Fixed Time Maintenance**
  - Don't Know Life Most of the Time
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## Selecting Maintenance Method

What is the Function?



What will happen if the function Break down?

1. Environmental damage or personal injury
2. High cost (lost production or damages)
3. Preserve value (Life)

**ANSWER BY:**

**99%**

- Obvious
- P & ID
- Ask operator



*For Existing Equipment*

## ESSENTIAL CARE (EC)

lubrication

alignment

balancing

detailed cleaning

operating procedures

filtration

## CBM

Inspection lists on component level

1. Running objective
2. Running subjective
3. Shutdown objective
4. Shutdown subjective

## *Decide What, Who, and When*

- Decide what inspections/ PM to Do
- Decide who Should do the tasks
- How often should the task be done?

## *Alternative to RCM (Reliability Centered Maintenance)*



*How does this component work?*



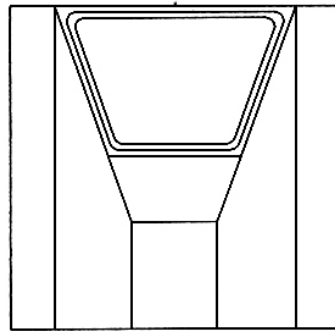
*How can this component fail?*



*How can I predict the failure?*



How does it work?

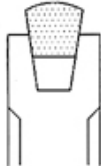
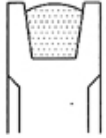
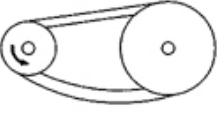

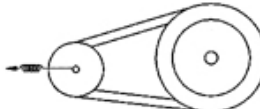

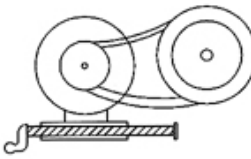
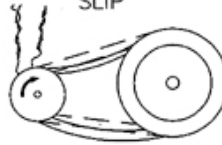
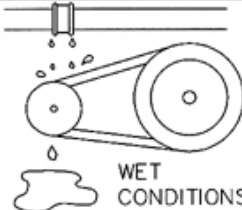

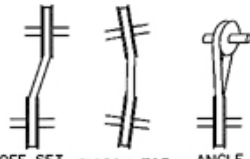
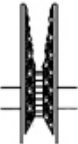


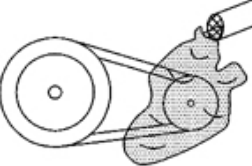


How does it fail?

**E!**

Check:

- Slippage/ oil, water
- Belt tightness
- Alignment of Belt
- Sheave Wear
- Noise

 TOO MUCH RIDE OUT	 BELT BOTTOMING	 OVERLOAD (H.P.)
 MISMATCHED	 TOO TIGHT	 SHEAVE GROOVE NOT UNIFORM
 NOT ENOUGH TAKE UP	 SLIP TOO LOOSE	 WET CONDITIONS
 SHEAVES TOO SMALL	 OFF SET PIGEON TOE ANGLE MISALIGNED SHEAVES	 WORN SHEAVE GROOVE
 BENT BROKEN SHEAVES	 SHEAVE WOBBLE ECCENTRICITY	 DUST & DIRT ABRASIVE

## *Motor Inspection*

### On-The-Run

- Cleanliness (fins, plugged airflows, etc)
- Fan with strobe
- Temperatures with (IR Temperature - Max? 170F (75C)
- Vibration (feel or with Pen – Alarm 0.25 in/sec 6.35 mm/sec?)
- Hold down bolts
- Base
- Condition of Junction Box and wires
- Noise
- Load (Current Reading)

### Shutdown

Winding test



CMS 100 R



*Exercise 5-B*



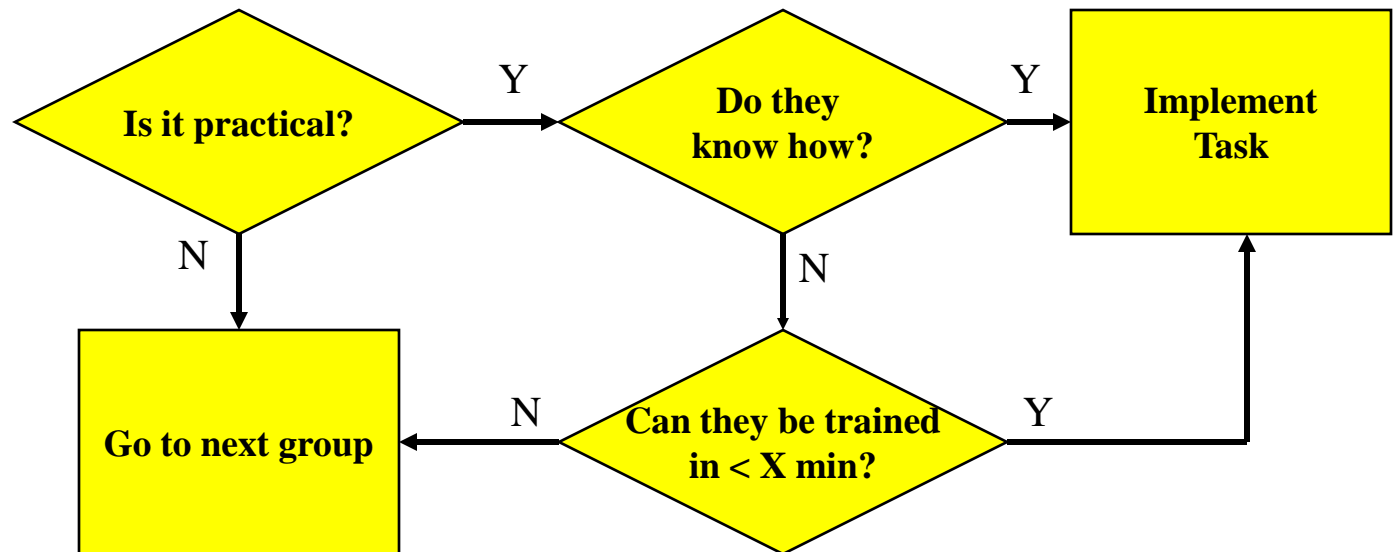
## *Exercise 5-B*

- Temperatures
- Bolts and Fasteners
- Noise and Vibration & cavitation
- Oil - Level and Condition
- Leaks
- Pressures
- Cleaning
- Breather
- Piping to and from Pump
  
- [CMS 127R](#)

*Who*

## **GROUPS**

- 1. Operator**
- 2. Area Maintenance**
- 3. In house maintenance expert**
- 4. Outside expert**

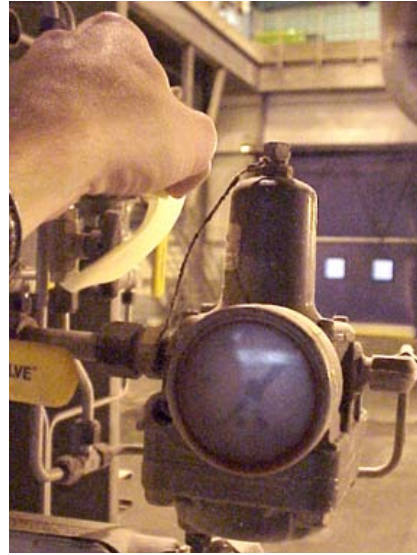




# Typical Operator Inspections



**Motor Temperature**



**Weep Hole Regulator**



**Belt and Coupling Condition  
with Stroboscope**



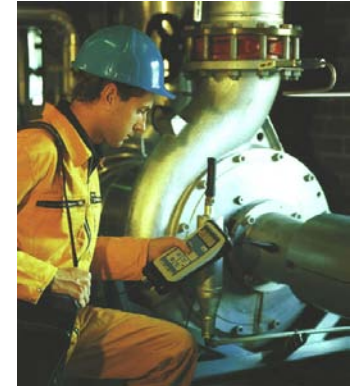
# Typical Maintenance Inspections



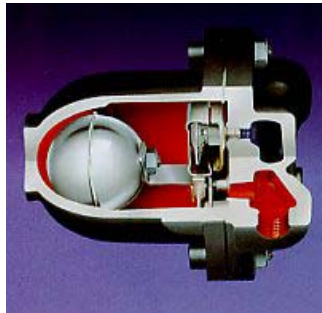
**Places Impractical for Operators to Get To**



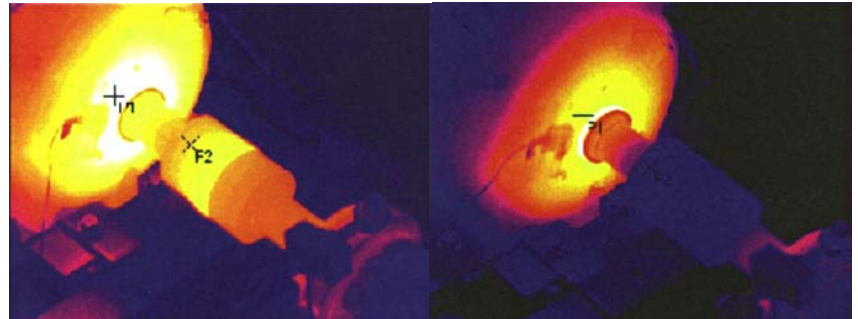
**Complex Systems**



**Vibration Analysis**



**Components that Require Experience**



**Infrared Camera**



COMPONENT	ON-THE-RUN INSPECTION	Frequency	SHUTDOWN INSPECTION/ FTM	Frequency
 <p><b>Coupling Gear</b></p> <p><b>Ref: CMS106R</b></p>	<p><b>Operators:</b> Look for grease outside coupling _____. If grease is present the seals may be blown. Check for unusual noise _____. Check housing and bolts for loosens with stroboscope _____. Check temp. with IR-gun _____, misaligned coupling gets hot. If coupling can't be seen, modify guard at earliest convenience</p> <p><b>Mech. Maint.:</b> Look for grease outside coupling _____. If grease is present the seals may be blown. Check for unusual noise _____. Check housing and bolts for loosens with stroboscope _____. Check temp. with IR-gun _____, misaligned coupling gets hot. If coupling can't be seen, modify guard at earliest convenience</p>	<p>Weekly</p> <p>Monthly</p>	<p><b>Lubricator:</b> Take apart, inspect, clean all parts, change seals, re lubricate, check alignment.</p>	<p style="text-align: center; font-size: 2em;">X</p> <p>2 years</p>
 <p><b>Motor AC</b></p> <p><b>Ref: CMS100R</b></p>	<p><b>Operations:</b> Clean if needed, check temperature (alarm 175°F), listen for unusual noise. Damaged electric junction box and condition of cables _____. Check bolts/ foundation/ base for cracks, corrosion and looseness _____. Make sure the motor isn't exposed to unnecessary water or moisture _____. Check vibration: Check vibration (middle of bearings in horizontal plane) coupling side ____in/s, back side ____in/s. Check fan condition with strobe light</p> <p><b>Mech. Maint.:</b> Detailed cleaning of cooling fins and air intake if needed _____. Scan motor and record highest temperature ____F. Check for unusual noise ____, damaged electric junction box and condition of cables _____. Check bolts/ foundation/ base for cracks, corrosion and looseness _____. Make sure the motor isn't exposed to unnecessary water or moisture _____. Check vibration: Check vibration (middle of bearings in horizontal plane) coupling side ____in/s, back side ____in/s. Check fan condition with strobe light.</p> <p>Vibration analysis</p> <p>Lubrication (if applicable). Frequency depends on rpm and grease.</p>	<p>Weekly</p> <p>Weekly-monthly</p> <p>2-3 Weeks</p> <p>3 months</p>	<p><b>E/I Maint.</b> For critical motors, it's suggested to run a winding test. A winding test can be done with a number of different tools, use the mill standard tool.</p> <p>If there is a maintenance opportunity, do detailed cleaning of unit, remove junction box cover and inspect connections. Follow required safety procedures.</p>	<p>Yearly</p>
 <p><b>Pump Centrifugal Packing</b></p> <p><b>Ref: CMS127R</b></p>	<p><b>Operations:</b> Needs cleaning _____. Check for vibration, noise _____. Check for signs if cavitation _____. Check piping to / from pump for leaks _____. Check packing tubing for damage _____. Check packing for excessive leakage _____. Packing gland gap _____. Check for right amount of seal water (30-60 drops/min).</p> <p><b>Mech Maint.</b> Record temp. bearings IB____. OB____. Check oil level and condition ____, clean oil glass _____. Check for vibration, noise _____. Listen for cavitation _____. Record discharge pressure if gauge is installed _____. Check foundation / base /bolts for corrosion, cracks and looseness _____. Check piping to / from pump _____. Check tubing for loose fittings, corrosion, damage _____. Check packing for excessive leakage _____. Packing gland gap _____. Check for right amount of seal water (30-60 drops/min) _____. Tighten packing if needed.</p>	<p>Twice weekly</p>	<p><b>Lubricator:</b> Oil change yearly for mineral oil, every 3 years for synthetic oil.</p>	<p>1-3 years</p>

# *Hydraulic Cylinder*





## Consequence of Break Down Analysis

MAINTENANCE PROCEDURE	FAILURE RATE	DIR. MAINT. COST REPAIR TIME + MATERIAL = COST	COST / YEAR	DOWNTIME COST / YEAR	DAMAGES	MAINTENANCE COST/YEAR	
OTB	0.2	16h * \$40 = Parts 3,000	\$640 3,000	\$728	$0.2 * \$4,000 * 10 = \$8,000$	1,000*0.2 =\$200	$728+8,000+200$ =\$8,928
FTM	1	10h *\$40 = Parts 3,000	\$400 3,000	3,400	0	0	\$3,400
CBM	0.2	10h *\$40 = Parts 3,000	\$400 3,000	680	0	0	\$680

## *Summary of Documentation Setup*



*Results Oriented Maintenance*

**Most Organizations  
KNOW  
What to do**

**Best Organizations  
Do it.**



*Lost opportunity – actual example*

**Example 1- Kiln bricks**

Operate To Breakdown - OTB

\$500,000

If responded to Inspection

\$60,000



# Accounting

Why do we spend so much on Preventive Maintenance when we never have any breakdowns!?

