Getting High Equipment Reliability

By

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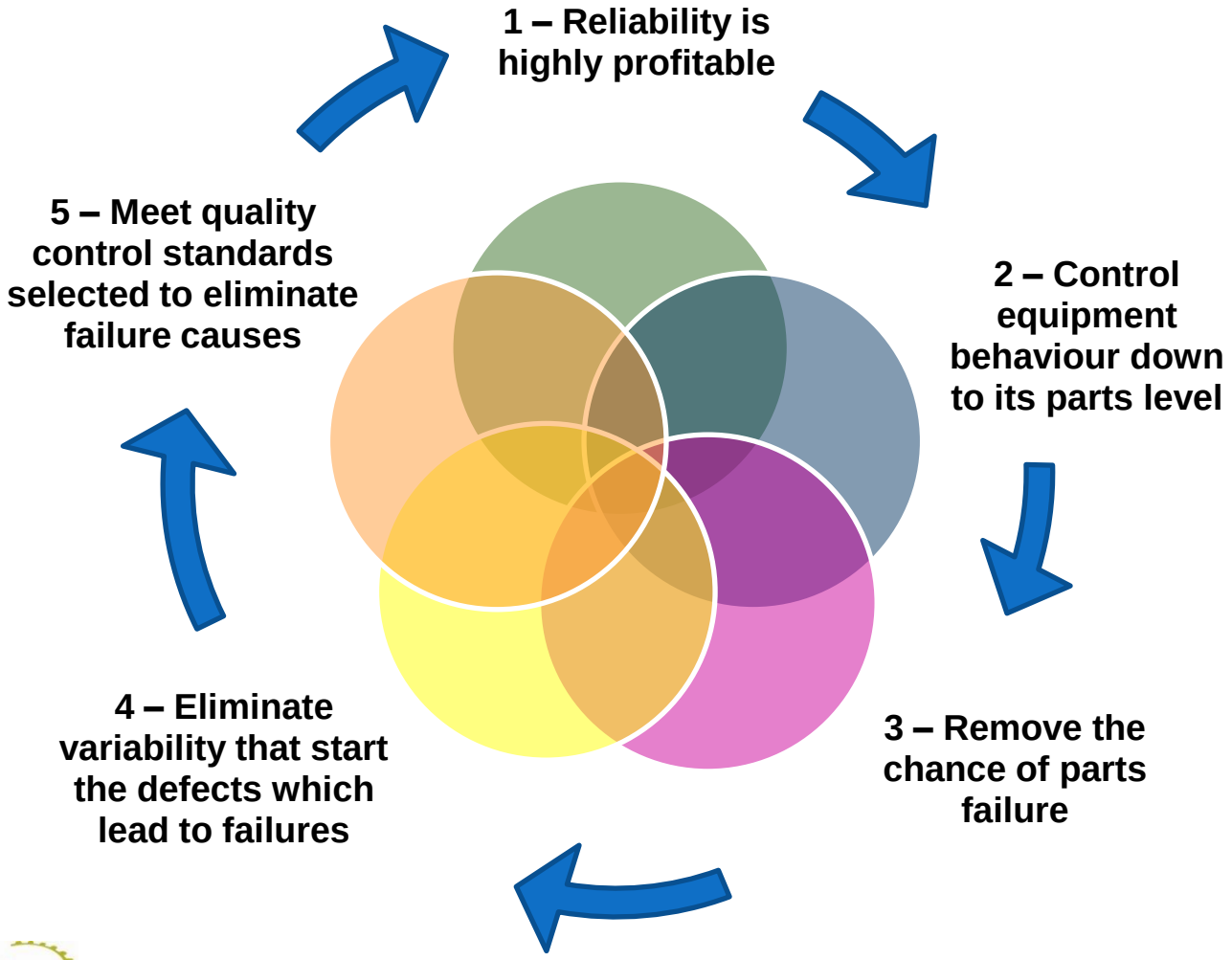
www.lifetime-reliability.com

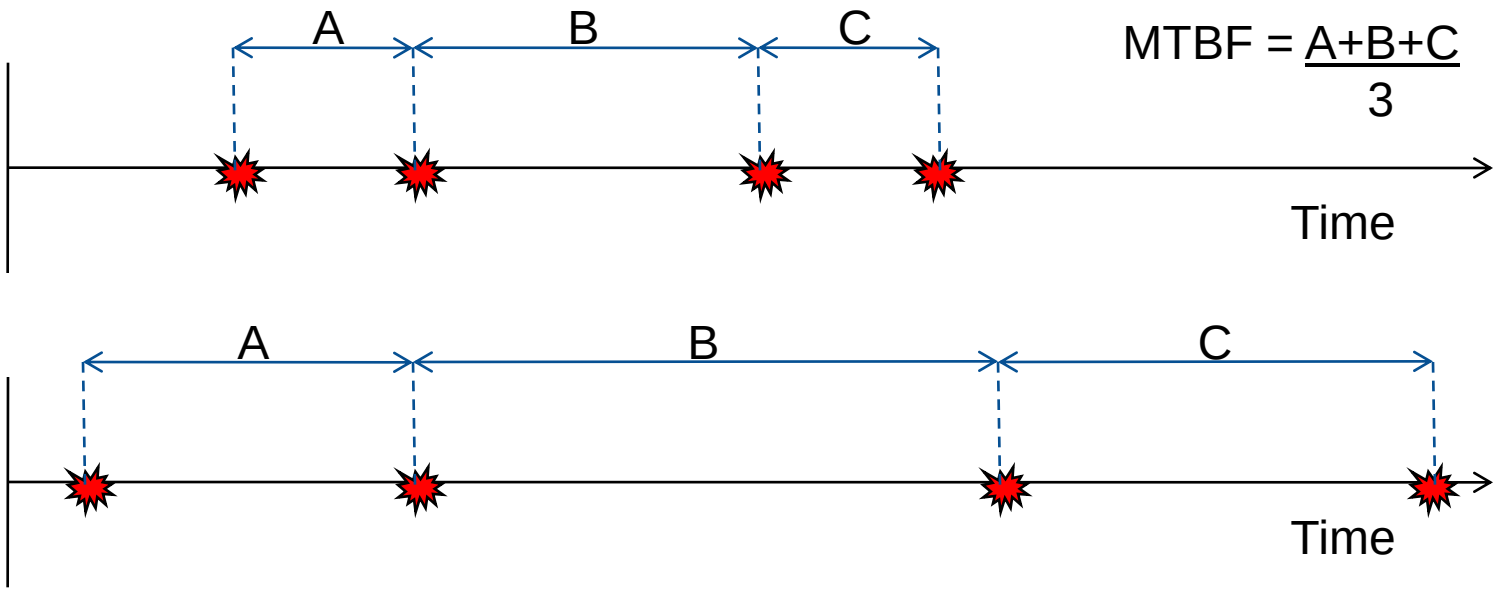
High Reliability is a choice you make



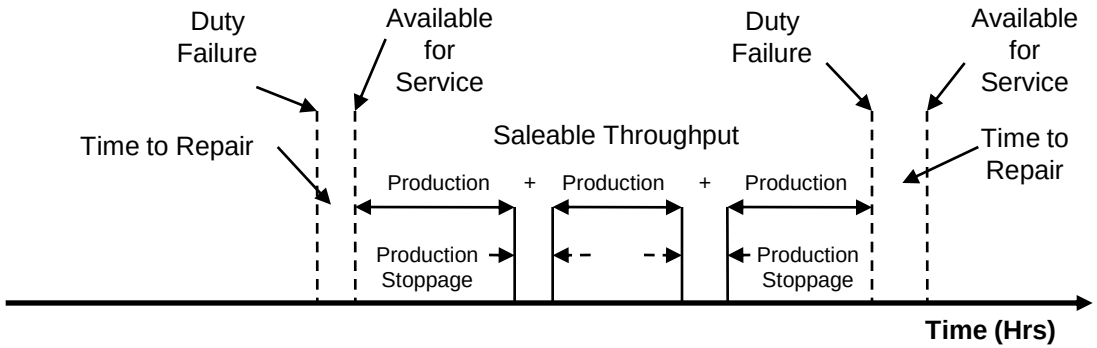
Value of reliability on operating time

"Time is Money" – *Benjamin Franklin*

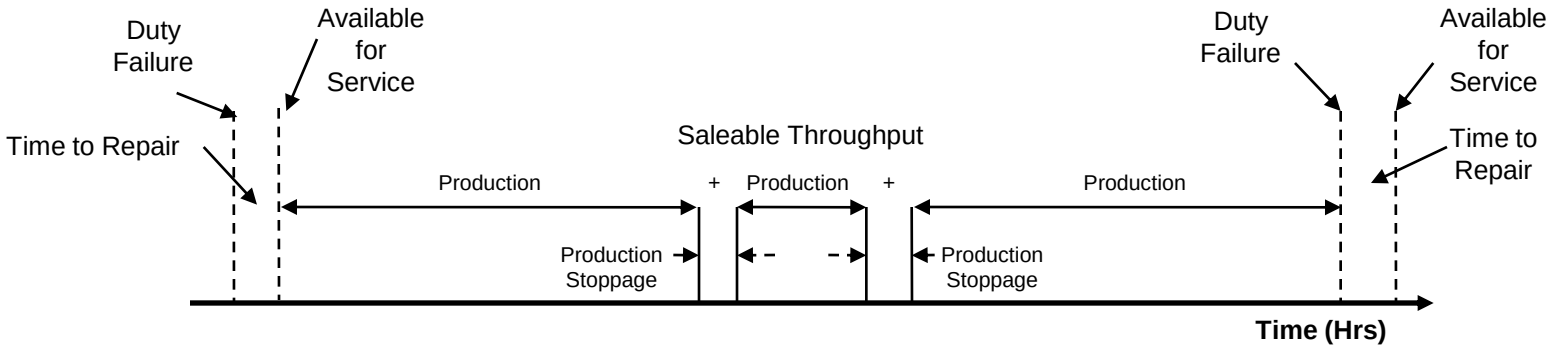
MTBF - average time between failures



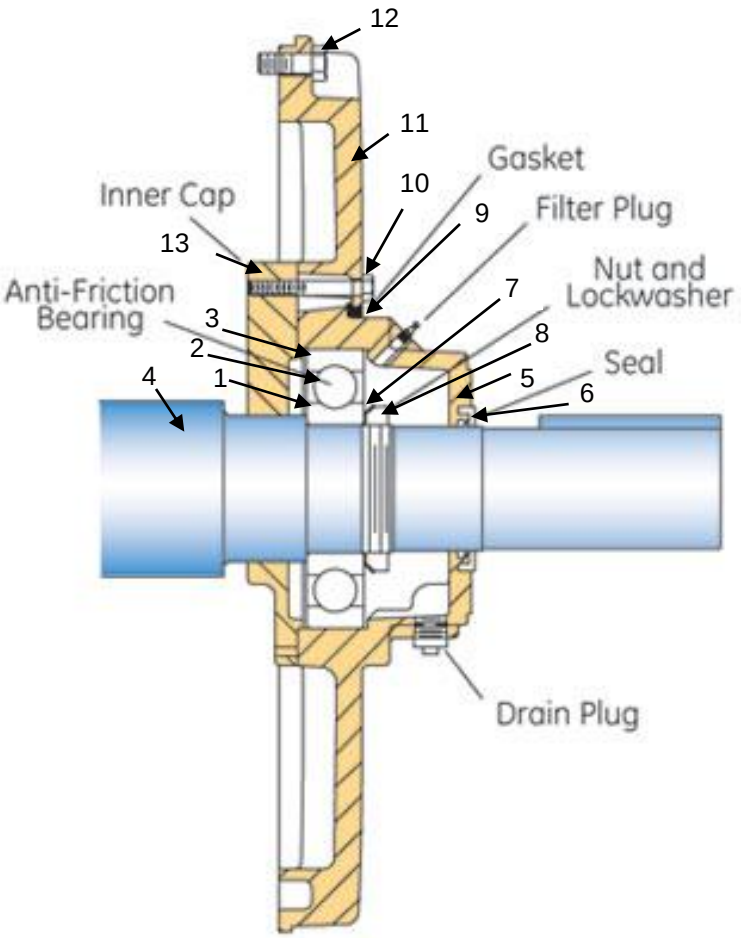
Value of reliability on Unit Cost of Production



Unit Cost of Production ($/T) = $\frac{\text{Operating Costs in the Period } (\$)}{\text{Total Saleable Throughput } (\text{Tonne})}$

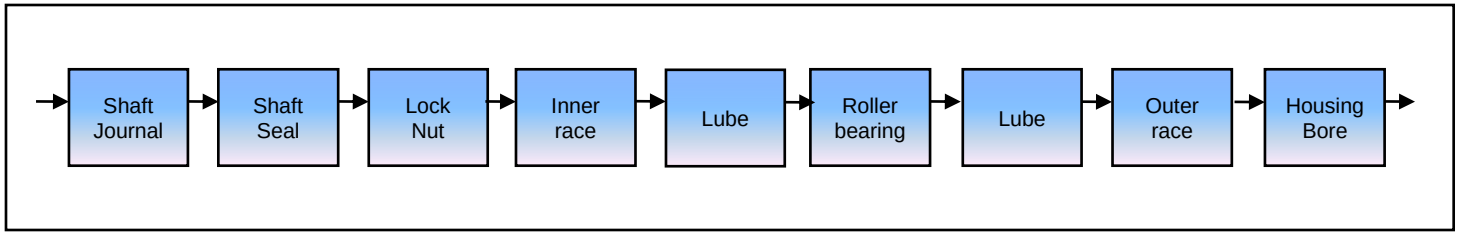


Your machines are components in series

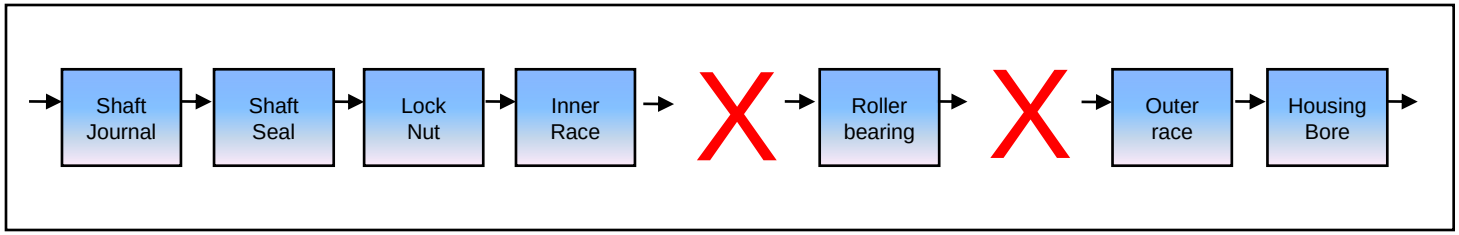


Electric motor drive end bearing

Series arrangements are at high risk



Motor parts shown as a series

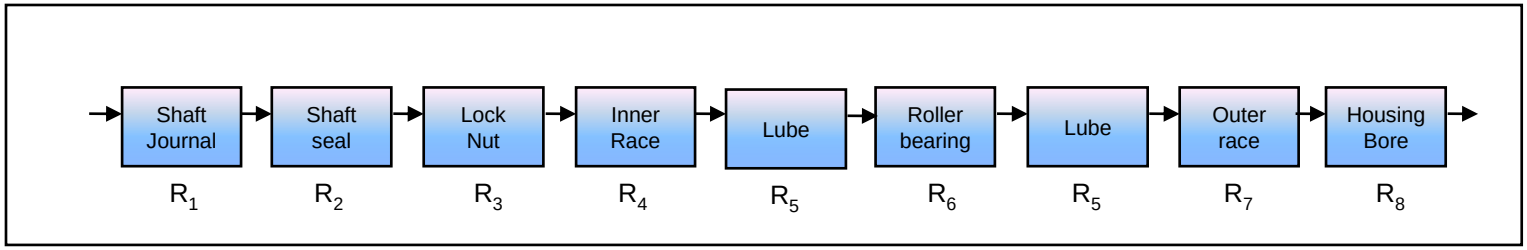


"Any one part fails; all fails"

Here is why clean lubricant is so important: It gets between the parts in your machines!

Calculating series reliability

Reliability is the **chance** that an item will last long enough to do its duty



$$R_{series} = R_1 \times R_2 \times R_3 \times \ldots R_n$$

$R_{series} = 0.99 \times 0.99 \times 0.99 \times 0.99 \times 0.99 \times 0.99 \times 0.99 \times 0.99 \times 0.99 = (0.99)^9 = 0.91$ (or 91%)

$R_{series} = 0.99 \times 0.99 \times 0.99 \times 0.99 \times 0.5 \times 0.99 \times 0.5 \times 0.99 \times 0.99 = 0.23$

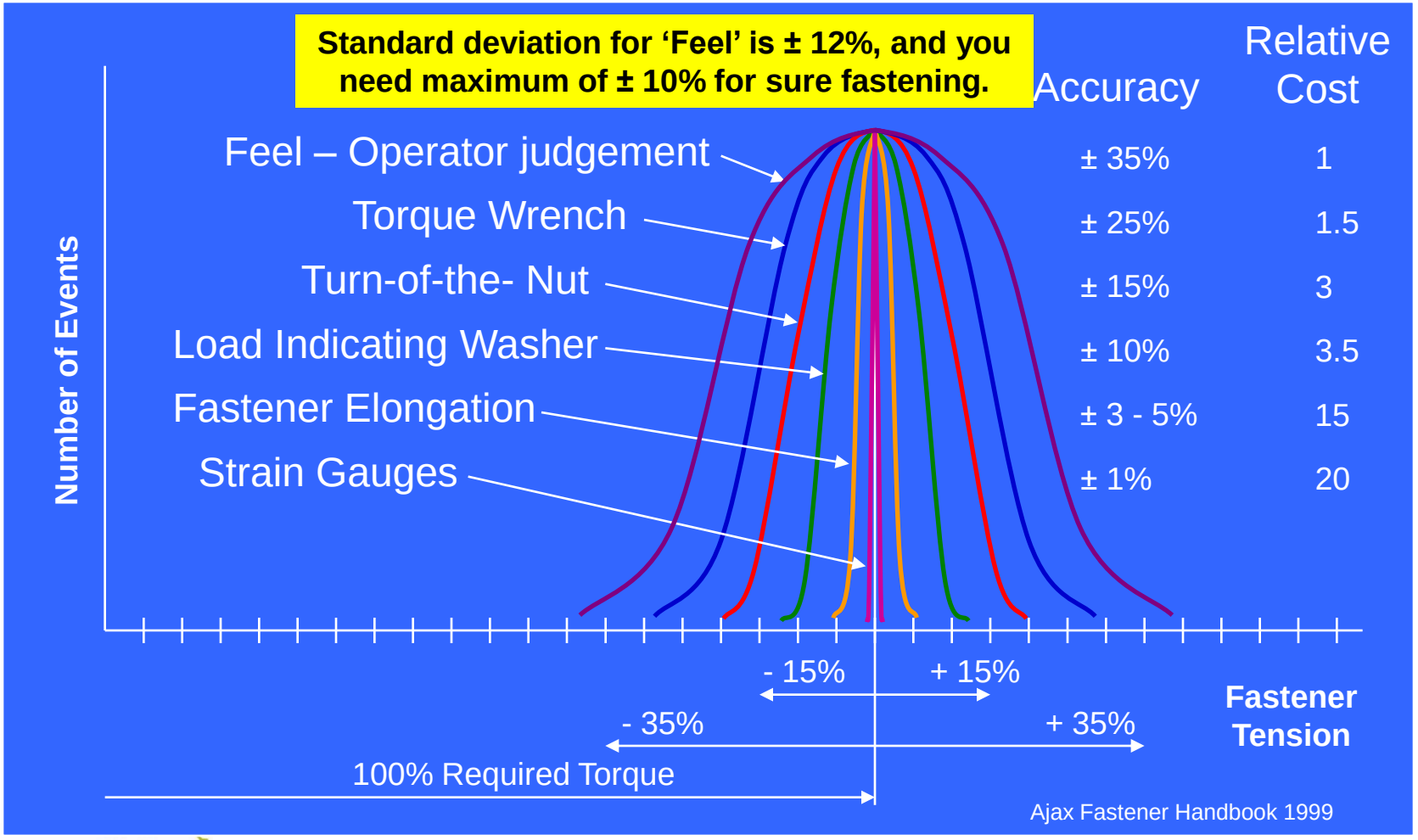
"Any poor, all poor"

$R_{series} = 0.99 \times 0.99 \times 0.99 \times 0.99 \times 0 \times 0.99 \times 0 \times 0.99 \times 0.99 = 0$

"Any fails, all fails"

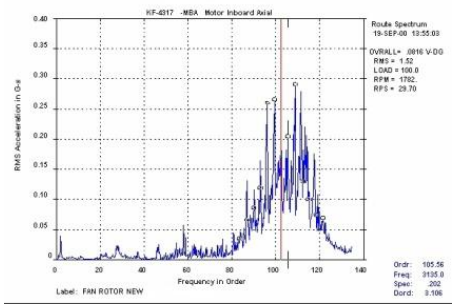
But where do your failures start?

Your problems start with chance variation…

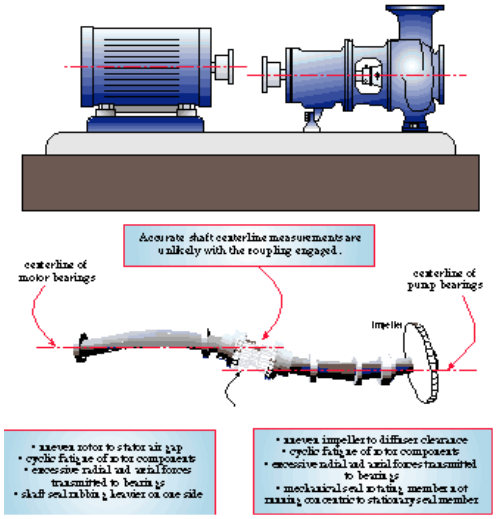


What chance variation does to machines

High Vibration:

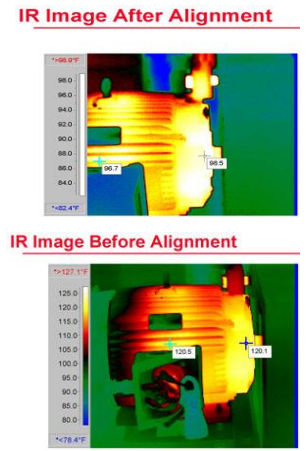


Deformation:



Extract from 'Shaft Alignment Handbook ',Piotrowski

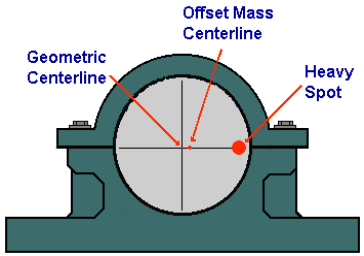
Misalignment:



Fastener Torque Error:

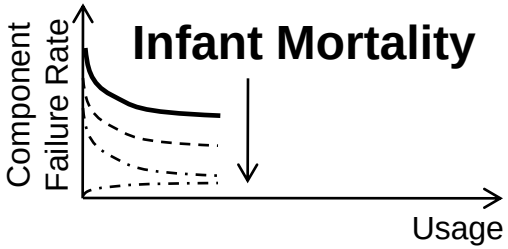
Unclean Lubricant:

Unbalance:

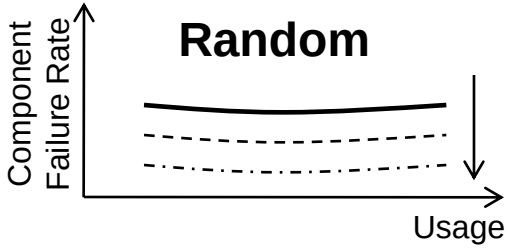


Lifetime Reliability • Solutions

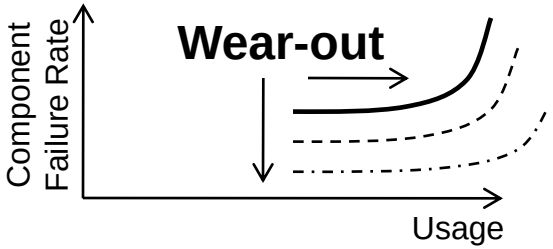
Cause and effect of your equipment failures



Cause: Incorrect Processes (controlled by management)



Cause: Induced Stress (controlled by people)



Cause: Accumulated Fatigue (controlled by people)

The 'failure curve' for a machine has a special name – ROCOF – Rate of Occurrence of Failure.

- Defective parts
- Poor assembly
- Manufacture error
- Poor start-up

- Operating overload
- Stress aging of some parts
- Local environment degradation
- Operator error
- Poor operating practices
- Poor maintenance practices
- Poor design choice

- Many aging/used parts
- Many parts degraded

Mean of Many Systems (machines)

With more parts, ROCOF becomes approximately constant

System Rate of Failing

A Single System (machine)

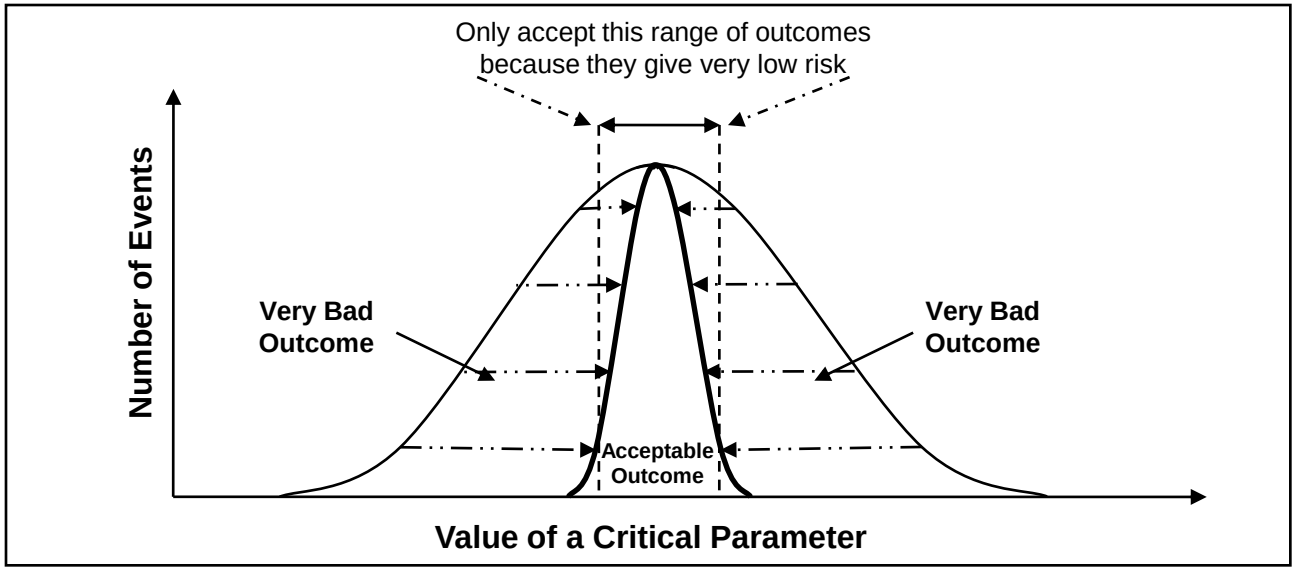
Time or Usage Age of System

Component Rates of Failing

Time or Usage Age of Parts

Lifetime Reliability • Solutions

The secret is to control variability to within the limits that bring benefits



Understanding what it means to be ‘in control and capable’

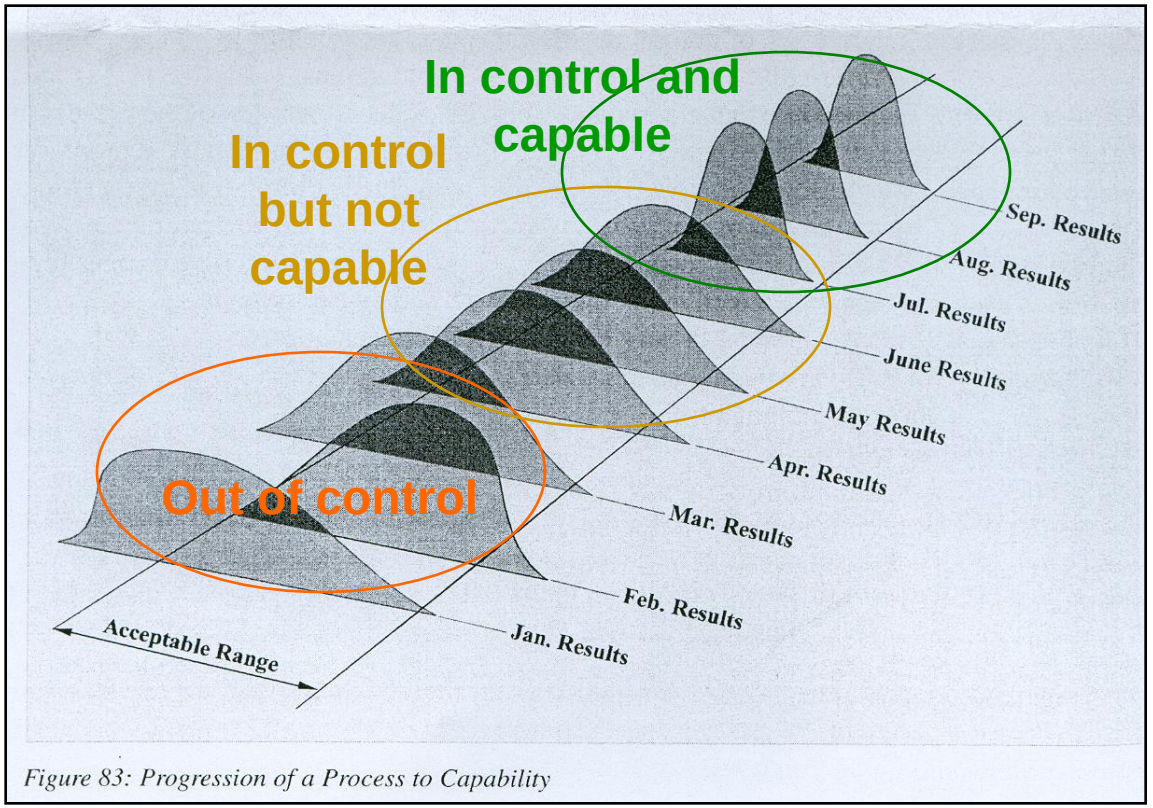
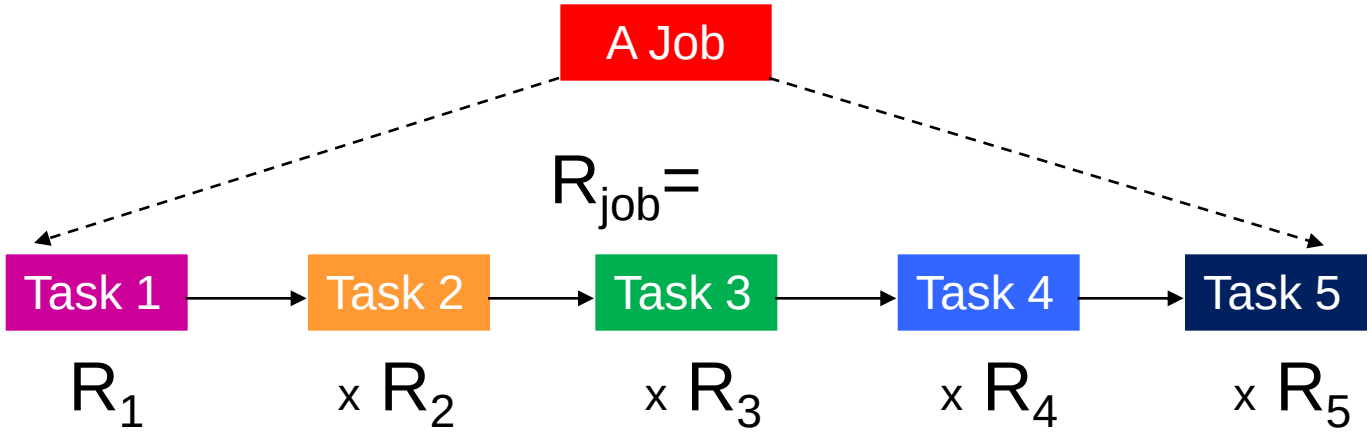
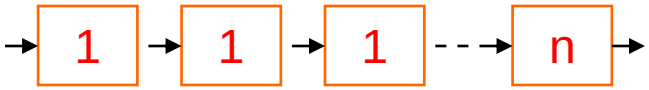


Figure 83: Progression of a Process to Capability

Work is a series process of tasks





$R_{series}= R_1 \times R_2 \times R_3 \ldots$

What is the chance that the whole job will done right?

Risks to work quality and machine reliability

Task Reliability is the chance that a task will be performed to its required quality.

A five task job.

$R_{job} = R_1 \times R_2 \times R_3 \times R_4 \times R_5$

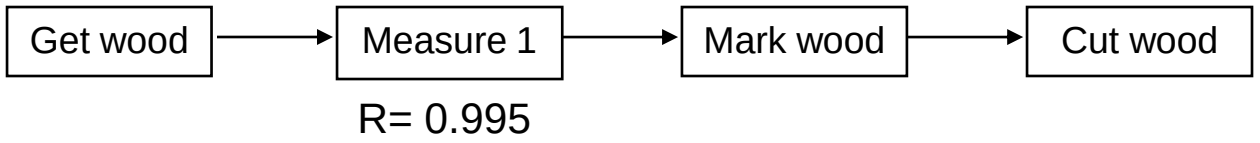
						10 tasks	20 tasks	50 tasks
0.9	0.9	0.9	0.9	0.9	**0.59**	**0.35**	**0.12**	**0.05**

Complicated non-routine tasks

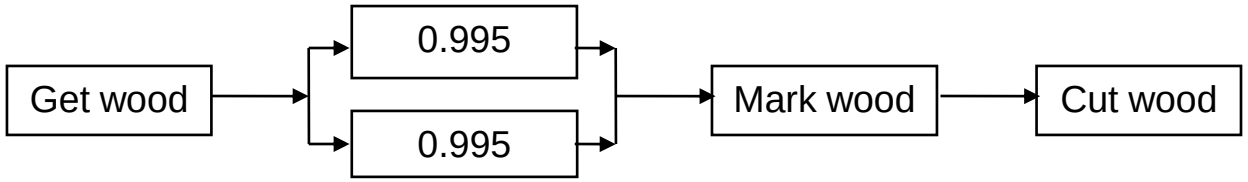
						10 tasks	20 tasks	50 tasks
0.95	0.95	0.95	0.95	0.95	**0.77**			
0.99	0.99	0.99	0.99	0.99	**0.95**	**0.90**	**0.82**	**0.61**

Controlling human error is the greatest challenge to reliability

Carpenter's creed: *'measure twice, cut once'*



1 error every 200 opportunities
~ 1 / wk

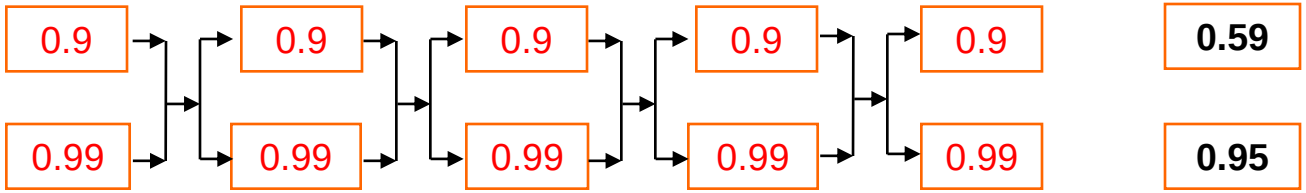


1 error every 5000 opportunities
~1 / 20 wk

The power of parallel proof-tests

Original task reliability

Proof-test reliability



0.59

0.95

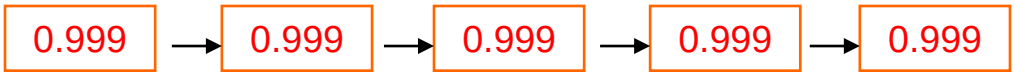
$$R_{system} = 1 - [(1 - R_1)x(1 - R_2)x(1 - R_3) \ldots.]$$

$$1 - [(1 - 0.9)x(1 - 0.99)]$$

$$1 - [0.1 \times 0.01]$$

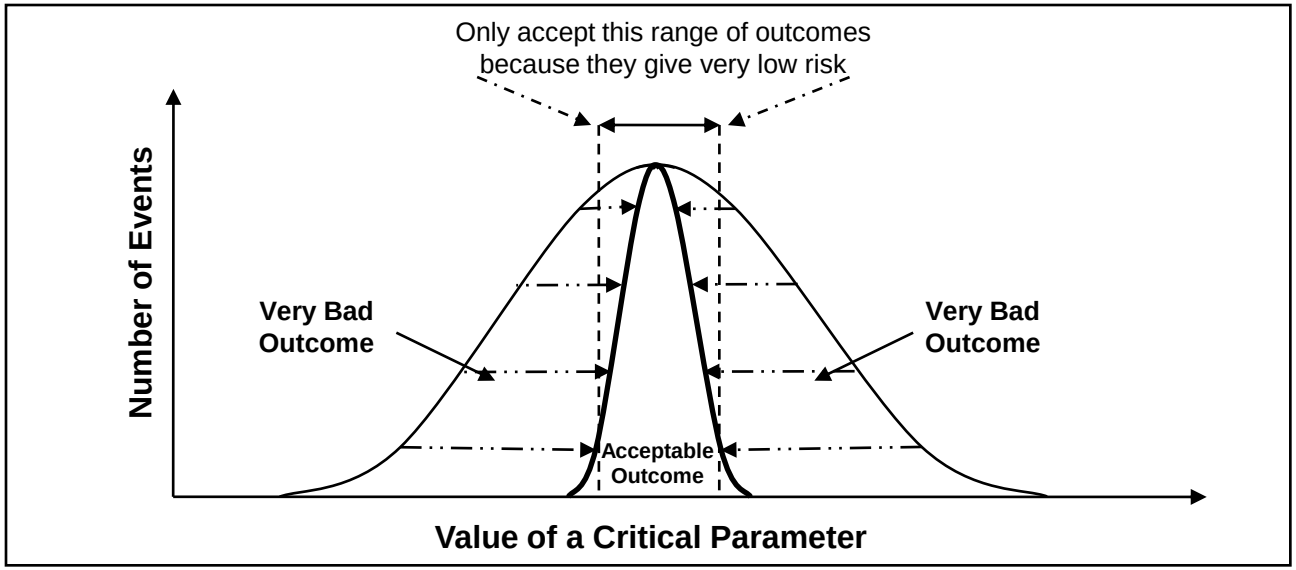
$$1 - [0.001] = 0.999$$

Equivalent series reliability



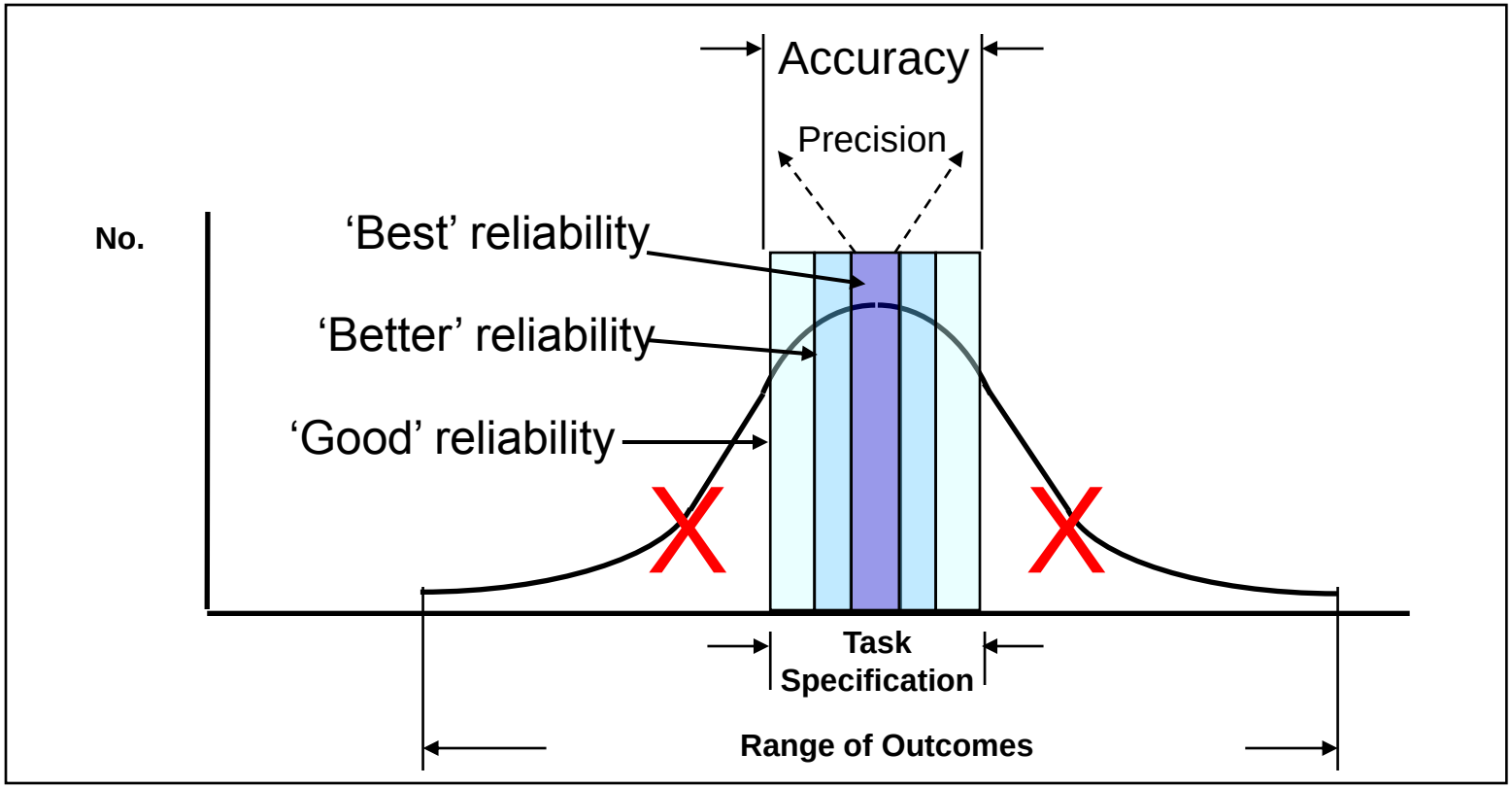
0.995

Remove the variability from your business processes – *unless you want to run your business by luck!*

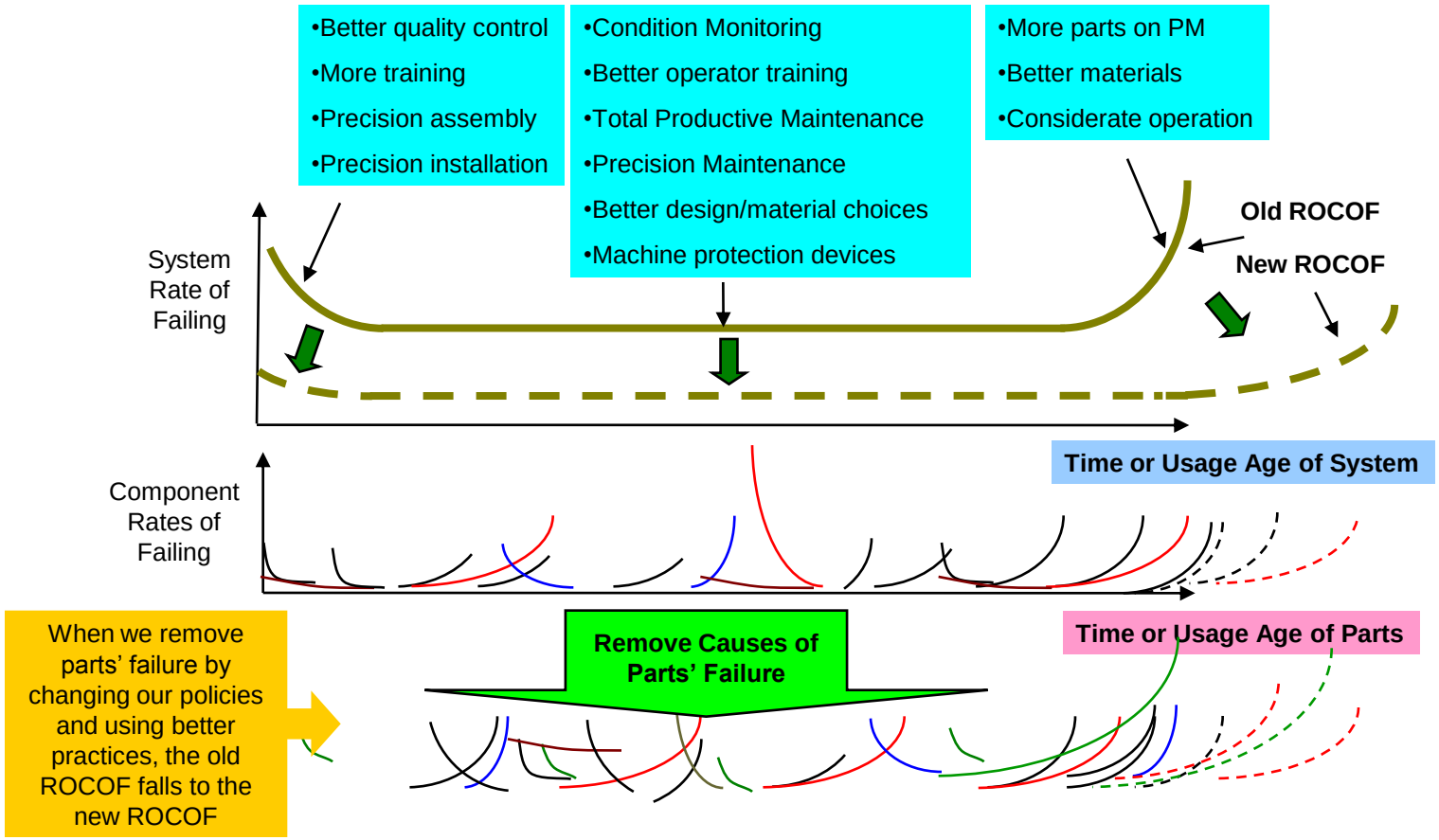


In the end... reliability is a quality control issue.

Set work task standards to deliver the quality that produces the reliability you want



Equipment reliability is malleable by choice of policy and quality of practice



How do we apply it to our machines?

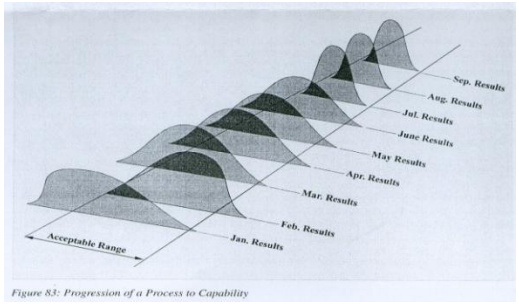
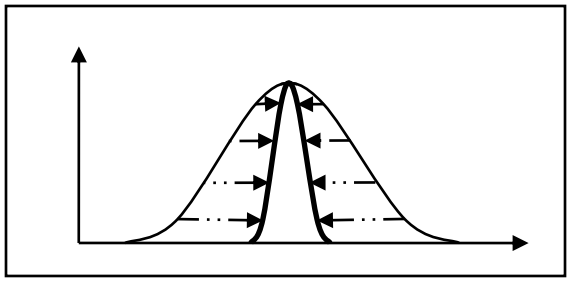
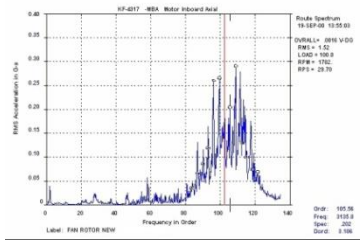
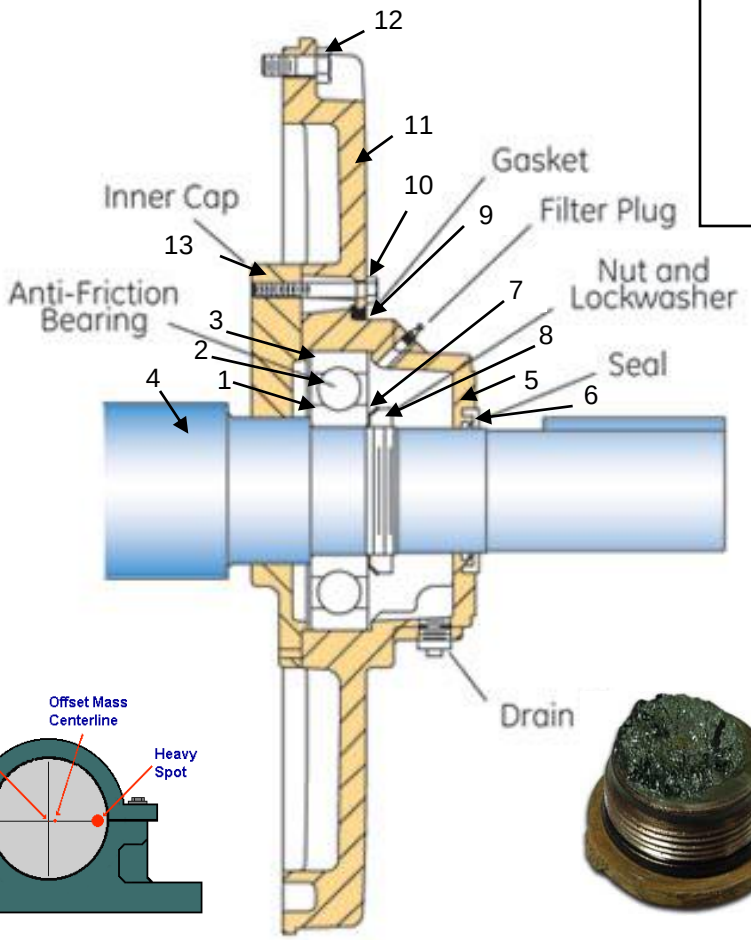


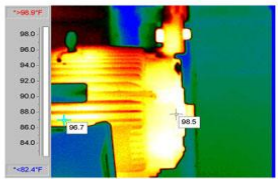
Figure 83: Progression of a Process to Capability





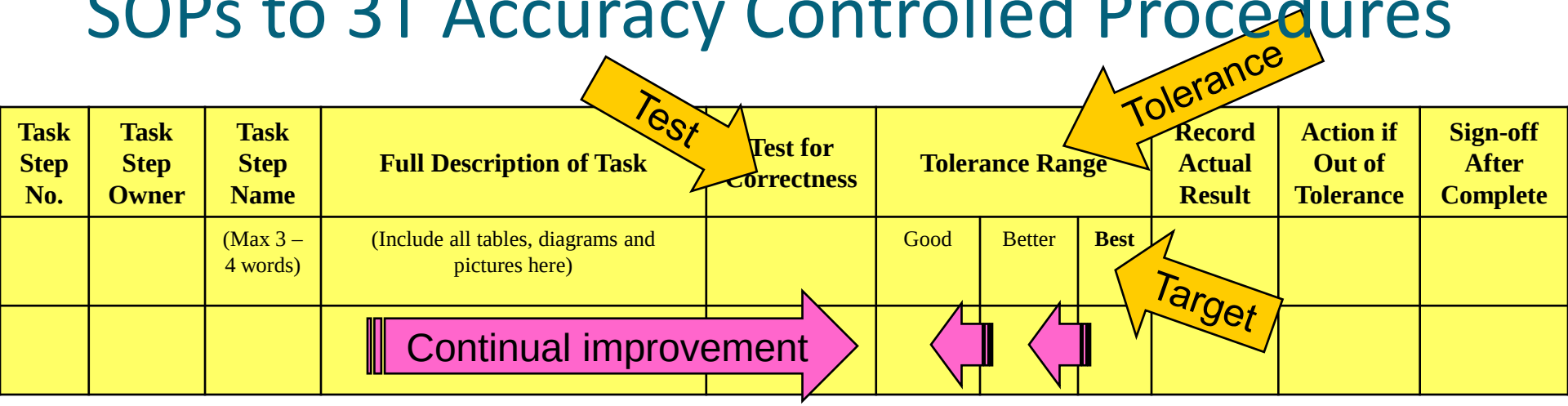


IR Image After Alignment



Electric motor drive end bearing

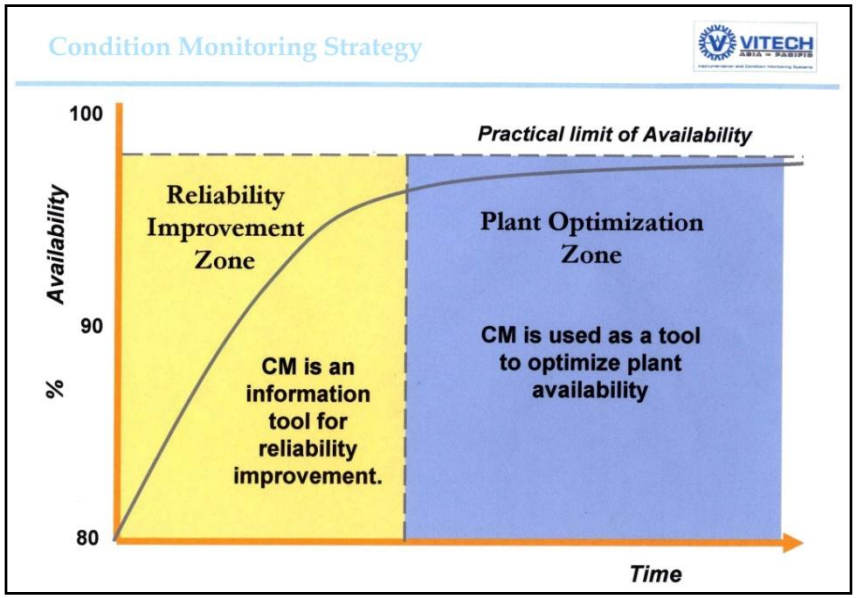
Control Your Processes by Converting your SOPs to 3T Accuracy Controlled Procedures

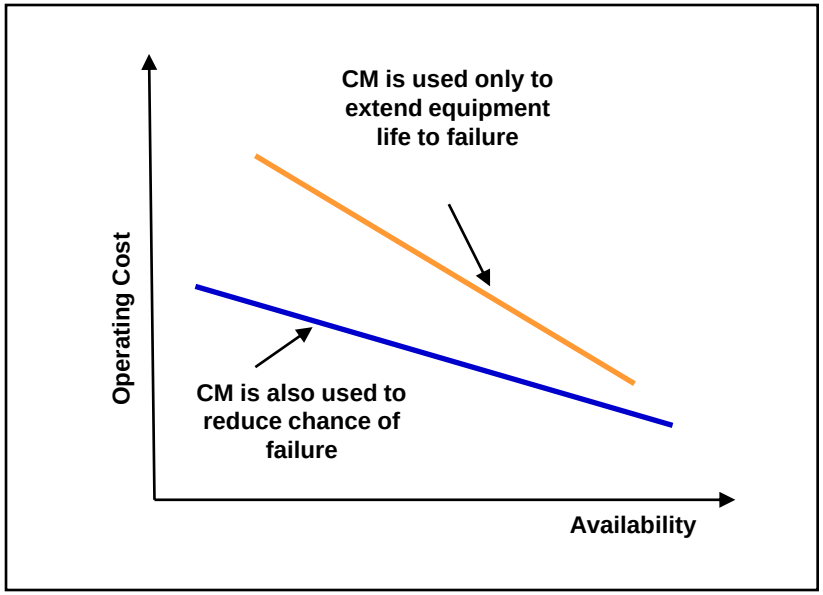


Task Step No.	Task Step Owner	Task Step Name	Full Description of Task	Test for Correctness	Tolerance Range			Record Actual Result	Action if Out of Tolerance	Sign-off After Complete
		(Max 3 – 4 words)	(Include all tables, diagrams and pictures here)		Good	Better	**Best**			

- Specify the 3Ts (Target, Tolerance, Test) for task precision and accuracy
- Describe in a measurable fashion what ‘good’, ‘better’ and ‘best’ are to challenge people to strive for excellence
- Advise what to do when out of tolerance – i.e. when not ‘it’s good enough’
- Get a signature when 3T done to tolerance so people are committed to precision
- Drive continual improvement by regularly introducing an even more precise ‘best’

Use condition monitoring as the proof test for task quality

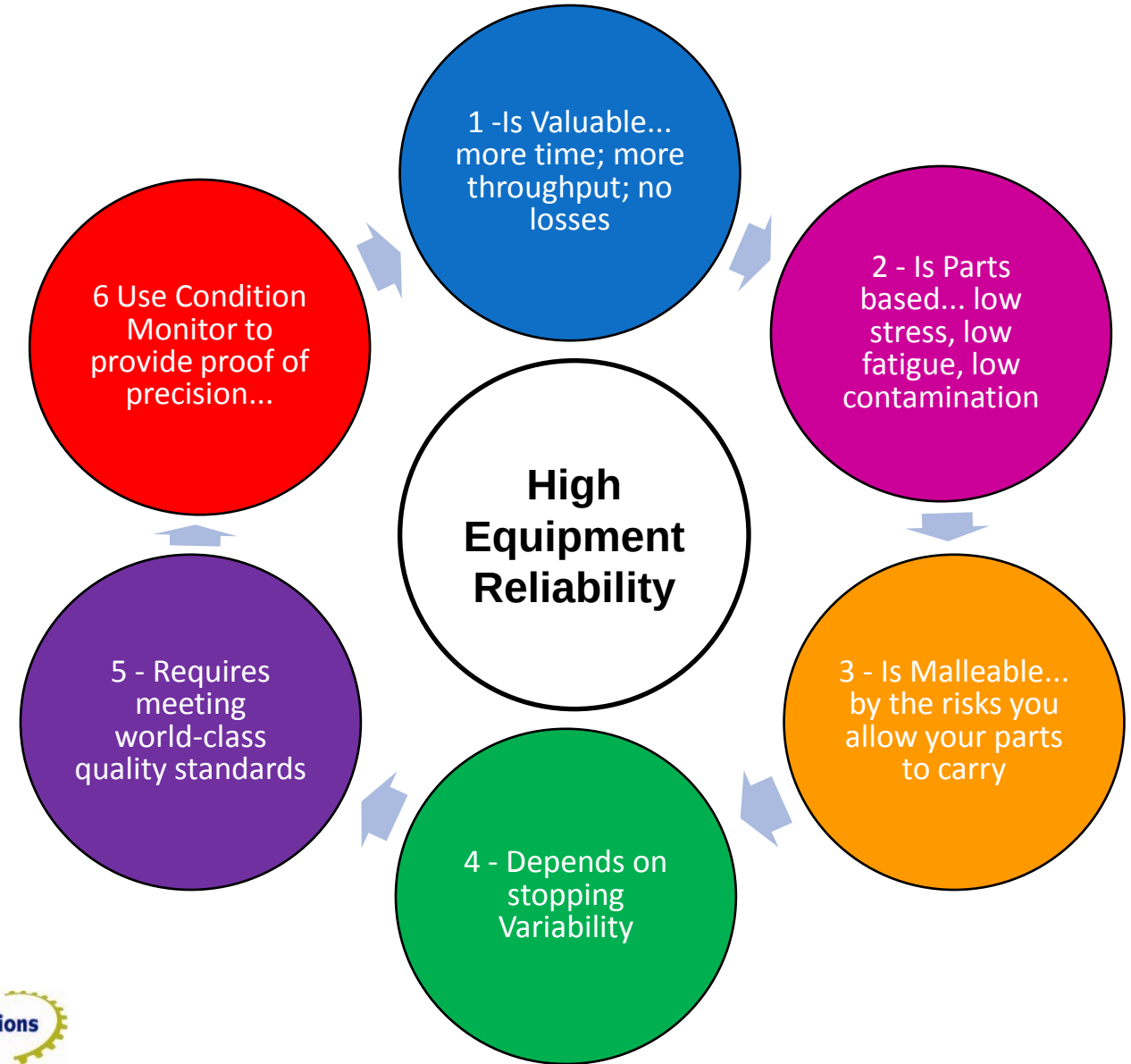




Life Extension Zone

Failure Elimination Zone

Getting high equipment reliability…



Lifetime Reliability • Solutions