

Enterprise and Asset Management Success with Plant Wellness Way EAM



**for CEOs, Executives, and
Senior Managers Pocketbook**

Second Edition





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CONTENTS

OPERATIONAL EXCELLENCE IS A RESULT	2
CREATING ASSET MANAGEMENT SUCCESS	3
HOW TO FIND NEW OPERATING FORTUNES	4
DESIGN PROCESSES FOR PLANT WELLNESS.....	6
DRIVE OPERATING RISK BELOW ALARP	10
WHY YOUR MACHINES & EQUIPMENT FAIL	12
LEARN HOW TO REMOVE RISK OF FAILURE.....	14
THE IMPACT OF SERIES ARRANGEMENTS	16
HUMAN FACTORS & HUMAN ERROR.....	18
DESIGN-IN MAXIMUM LIFE CYCLE PROFITS	20
THE INHERENT VARIATION IN PROCESSES.....	22
ACE 3T WORK QUALITY ASSURANCE	24
PROACTIVELY IMPROVE RELIABILITY	26
PROFIT BASED MAINTENANCE STRATEGY.....	28
BUILD IN-CONTROL & CAPABLE PROCESSES.....	30
MAKE YOUR DISTRIBUTION CURVES VISIBLE.....	32
SERIES RELIABILITY PROPERTIES No 1, 2, 3	34
PRECISION MAINTENANCE	38
CASCADED GOALS & MEASUREMENT	40
MAXIMUM EFFICIENCY & EFFECTIVENESS	41
BE LEADING A LEARNING ORGANISATION	43
MORE INFORMATION ON PLANT WELLNESS.....	45

OPERATIONAL EXCELLENCE IS A RESULT

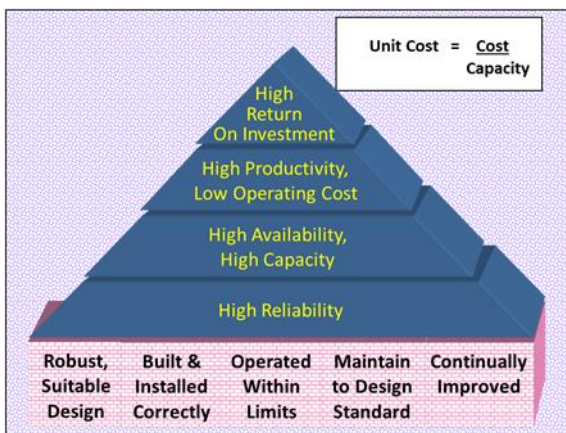
Operational Excellence requires a business system-of-reliability. Reliability is the chance of success, so a company built as a 'system-of-reliability' maximizes its operating profits and production success. The three requirements needed to create a system-of-reliability for Operational Excellence are:

1. **A defect eliminating work quality assurance system** where your processes are robust and anti-fragile to disruption, and insure right-first-time results. Only if processes are built to go right every time; are anti-fragile to error; and proactively prevent causes of problems, can you reach Operational Excellence.
2. **Business-wide process innovation** focused on optimizing for the highest productivity, least cost, and right quality output. Then you install the next generation of solutions for ever better productivity.
3. **Holistic, lifecycle physical asset management** for stable, reliable operation with outstanding availability, highest utilization and most sustainable throughput.

You do three phases to reach Operational Excellence the Plant Wellness Way: Design your system-of-reliability – Teach your system-of-reliability – Build your system-of-reliability. First, design a business that can be the best. Second, teach your leaders how to do the right things, rightly. Third, apply and do the right behaviours for success.

CREATING ASSET MANAGEMENT SUCCESS

When you practice good physical asset management you get rewarded twice—operating expenses reduce and throughput rises. You make more products with fewer resources in less time for less cost. It is a natural outcome of using the correct asset management processes and methods. Put sound reliability foundations in-place, use the right asset life cycle strategies and practices, and high ROI is certain.

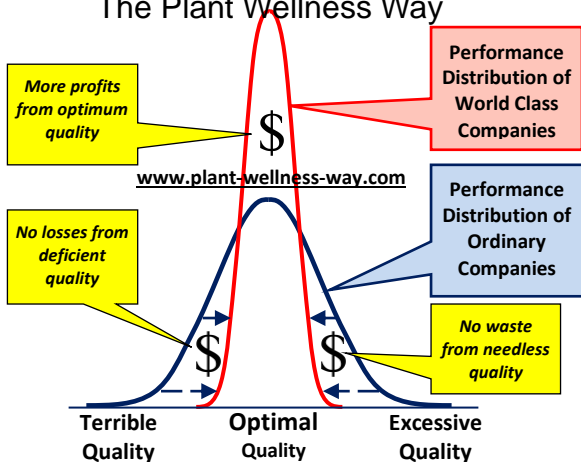


The **Plant and Equipment Wellness Way** is a business-wide solution to get world class life cycle asset management in your company. It guides you to identify and use the simplest, best reliability strategy, methods and practices for your business to ensure your operation uses world class asset management performance that produce operational excellence results.

HOW TO FIND NEW OPERATING FORTUNES

The Plant Wellness Way creates new operating profits. Your operational performance vastly improves by design so that world class results are standard. Its holistic mix of the right life cycle asset management processes, Lean improvements, work quality assurance, and reliability solutions bring to your company a fully organised and structured methodology for lasting world class Operational Excellence performance.

OPERATIONAL EXCELLENCE The Plant Wellness Way



The outside distribution curve in the image above represents the current range of operational performance from a company. The centre is optimal quality and cost. To the right is money spent on unnecessary excess quality—like using a pressure

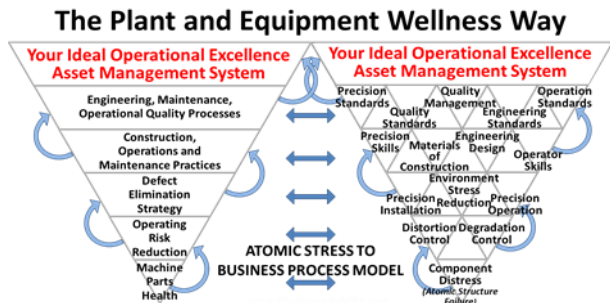
coded welder for welding structural steel, or using a Licensed Technician to do labouring, or printing in colour when black and white is fine. To the left is poor and bad quality—all the scrap, waste and rework you now suffer.

What the Plant Wellness Way (PWW) does for your Operation and Maintenance is drive the existing performance closer and closer to the optimal, so that more of your production is ideal. Your operational performance becomes the red distribution curve hugging the optimal result. Because your production is just-right, the moneys that were wasted and lost to problems and excess turn immediately into new operating profits. With the Plant Wellness Way you optimise your business design to generate new operating profits. PWW reduces and prevents business process wastes, losses, rework, mistakes, errors, excesses, etc. and gets you new fortunes by stopping unnecessary expenditures. As PWW drives you closer and closer to the optimal more and more operating profits are automatically produced. There are huge 'hidden' operational fortunes waiting for you to collect!

Using the Plant Wellness Way quickly increases operating profit, slashes maintenance costs, stops work quality problems and gets much more production from your operation. Its secret is in its ability to get the correct world class business, operational and reliability processes into your company so that your business is designed to be highly productive and continually deliver great operational profits every month.

DESIGN PROCESSES FOR PLANT WELLNESS

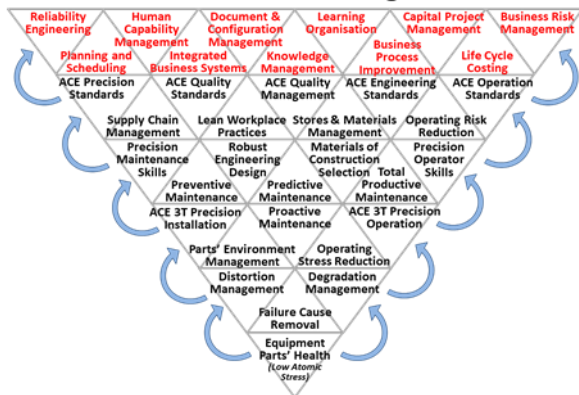
Plant and Equipment Wellness (PEW) is the first asset management methodology based on reliability first principles.



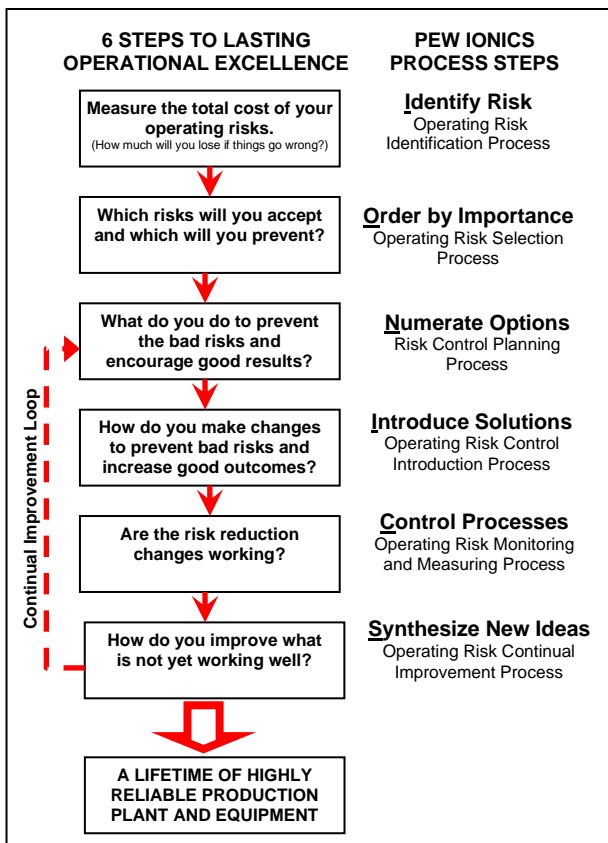
You follow the ‘Stress to Process’ Physics of Failure framework from bottom to top on a journey up the Plant Wellness Way to operational excellence. When you make your machine parts highly reliable you make your operation performance more certain and robust. The Boardroom decision to use PEW as a company’s asset management methodology improves its future by ensuring its processes and reliability practices are designed to create and bring lasting operational and maintenance success. PEW gets an operation to adopt the right lifecycle, business-wide asset management strategies that bring lasting reliability improvement. The PEW asset management methodology gets you world-class reliability and asset performance by using the six IONICS steps to optimally design your business processes. PEW identifies and removes operational risk to get maximum

equipment reliability, operating plant availability and asset utilisation so production unit cost are minimised safely.

Plant Wellness ‘Stress to Process’ Physics of Failure Scientific Asset Management Model



The PEW asset management methodology holistically addresses the complete life cycle of your operational assets. From business concept through to decommissioning PEW lets you design and build a sure and clear path to world-class operational, reliability and maintenance performance. As you travel up the ‘Stress to Process’ reliability model you build the right business processes, you design and create the optimal business system and you install the simplest life cycle solutions to deliver outstanding and lasting equipment reliability. PEW makes sure that you build only what your business and machinery need to get the reliability that takes your company to world class operational excellence results.



Plant Wellness produces asset life cycle operational risk reduction by concentrating on component defect elimination and operating plant failure prevention. Unlike other asset and

maintenance management methodologies that focus mostly on the maintenance group, this methodology requires companies to apply controls and protection across the organisation and throughout the asset life cycle that proactively prevent operating risks and creates plant and equipment health.

The 6-step wellness methodology is the foundation of PWW/PEW. Its use sets it apart from Lean Six Sigma, ISO 9001, Theory of Constraints and other process improvement methodologies because you design the best business solution first and stress test it with probability modelling so you are sure it works. **No other process improvement methodology proves its solutions work before you use them.** Because the scientific based techniques identify component level (parts level) operating risks and get you to develop appropriate strategy to address them, the PWW is universally applicable. It works in all industries, facilities, equipment and infrastructure. The necessary improvements in the business processes and best operating practices are identified and risk modelled, then the right solutions are written into your procedures and work instructions using ACE 3T tri-quality standards, finally your people are trained to use and implement them correctly at the operating sites. PEW takes an organisation to lasting world class operational excellence, because you identify the ideal asset management strategies, use the simplest processes and adopt the right reliability practices that forevermore reduce operational risk. You get high throughput with low operating costs by maximising plant availability, productivity and plant utilization.

DRIVE OPERATING RISK BELOW ALARP

Opportunity for disaster is all around us. Its financial impact is measured by its risk using the equation:

$$\text{Risk (\$/yr)} = \text{Consequence (\$)} \times \text{Frequency of Event (/yr)} \\ = \text{Consequence (\$)} \times \text{Likelihood (/yr)}$$

You reduce risk by minimising its consequence and/or its frequency. Frequency (also called Likelihood) has two parts:

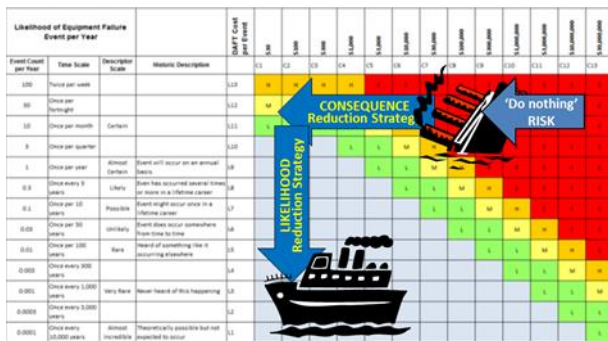
$$\text{Risk (\$/yr)} = \text{Consequence (\$)} \times [\text{No. of Opportunities to Fail (/yr)} \times \text{Chance of Failure at each Opportunity}]$$

‘No. of Opportunities to Fail’ is how many times a situation arises that *could* lead to failure. ‘Chance of Failure’ is the odds failure will happen at *each* opportunity. ‘Chance of Failure’ is 1 if it fails at every opportunity and 0 if it will never fail when the situation arises. Throw a pair of dice and every throw is an opportunity to get one on each. But the chance to roll a one on both dice in your next throw is 1 in 36 (6 x 6) that it will happen—0.0278 to 1 are poor odds to bet on.



The full risk equation provides the vital realisation that opportunity must arise first before there can be a failure. **It turns out that stopping opportunity to fail is the most successful strategy for world class enterprise asset management.** The next most fruitful strategy is to reduce the chance of failure, i.e. work on improving your odds of success.

You can see risk changing on a risk matrix. Starting at the ‘do nothing’, or ‘leave things as they are’ point, you estimate the impact of every consequence and likelihood mitigation put into place. Mitigations such as emergency plans, fire brigades and ambulances limit the consequences of an event. If we react quickly, correctly and early enough losses can be minimized.

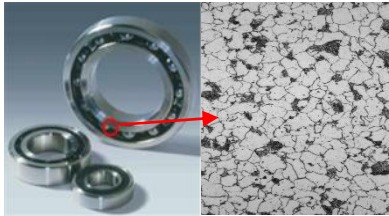


Likelihood mitigations prevent opportunity and/or chance of a situation arising. Opportunity reduction stops occurrences of an event—don't use a car and you cannot be in a car accident. Chance reduction reduces possibility of calamity—drive a car with brightly coloured flashing lights and you will have fewer accidents because more people will see you well in advance.

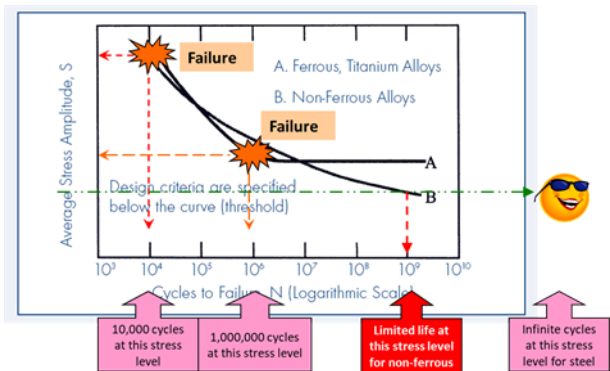
Once you drive your operating risk down to As Low As Reasonably Practicable (ALARP) you may be tempted to stop your risk reduction efforts. That point is justifiable in a court of law. Yet it is unlikely to be low enough to deliver the world class reliability needed for Operational Excellence.

WHY YOUR MACHINES & EQUIPMENT FAIL

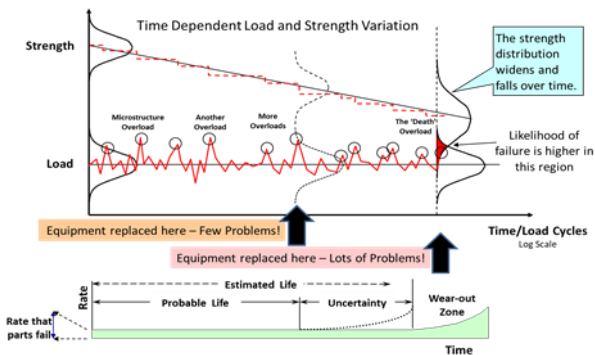
Machines fail because their parts break. Parts break because the materials of construction fail. Materials fail when their microstructure is



destroyed. Control the opportunity for microstructure failure in a machine's parts and you control its reliability.



Material fatigue curves tell us what to do to get a long service life for our machine parts. The curves in the fatigue diagram above show that 40% reduction in stress delivers 100 times more service life. They prove that if you lower the atomic stress in materials you will create massive reliability growth.



It is stress that destroys your machines by destroying their material microstructure. During operation the microstructure of a machine part receives stresses from working loads and changed environmental conditions (like temperature or lubricant chemistry changes). A massive overload destroys the microstructure and the part breaks. If a part suffers cyclic operating loads, as in the diagram above, its microstructure is gradually damaged over time and the part ‘ages’ from fatigue. If the part is not replaced it will someday have a breakdown.

Replacing aged parts before they fail is called Preventive Maintenance. Relacing parts after they break is Breakdown Maintenance. Breakdown Maintenance can cost you 20 – 30 times more than Preventive Maintenance. Reduce and control the stress levels in your machinery parts and you can make a lot of money by not spending it on breakdown maintenance, and instead delivering you more production uptime.

LEARN HOW TO REMOVE RISK OF FAILURE

Reliability is the chance of success. The reliability equation for your physical assets and operational equipment is:

$$\text{Equipment Reliability} = 1 - \text{Chance of Equipment Failure}$$

Which with a little manipulation you get:

$$\begin{aligned}\text{Chance of Equipment Failure} &= 1 - \text{Equipment Reliability} \\ &= \text{Unreliability}\end{aligned}$$

Including equipment failure in the full risk equation we get:

$$\text{Risk (\$/yr)} = \text{Consequence (\$)} \times [\text{No. of Opportunities to Fail (/yr)} \times \{1 - \text{Equipment Reliability at Opportunity}\}]$$

The full risk equation gives great insight on how to maximize equipment uptime. There is a direct inverse connection between equipment risk and equipment reliability. If equipment reliability is perfect and success is guaranteed (Reliability=1) the risk is zero. If there are no opportunities to fail there is no risk (Opportunity=0). If there is no consequence from an event risk is also zero. This gives you three strategies to protect your business and its operations.


1. Can you set up a situation so that if a failure event occurs it has no consequence?
2. Can you prevent opportunities to fail from arising?
3. Can reliability (chance of success) be improved?

Risk is reduced by minimising the consequence of an event and/or by reducing the likelihood of an event. Which focus you chose as your key operational risk management strategy is

a major factor in your future production success. The Table below subdivides common maintenance and reliability strategies into chance and consequence reduction strategies. Consequence reduction strategies act after a failure is initiated. You find the problem quickly, address it and minimize its effects for the least cost. Chance reduction strategies proactively use defect elimination and failure prevention to remove the opportunities for failure to start.

$$\text{Risk (\$/yr)} = \text{Consequence of Failure} \times \text{Frequency of Failure}$$

$$\text{Risk} = \text{Consequence of Failure} \times [\text{Opportunity to Fail} \times (1 - \text{Chance of Success})]$$

Consequence of Failure Reduction Strategies	Opportunity to Fail Reduction Strategies	Chance to Fail Reduction Strategies
<p>Strategies presume failure event occurs and act to minimise consequent losses</p> <ul style="list-style-type: none"> Preventive Maintenance Shutdown Maintenance Predictive Maintenance Non-Destructive Testing Vibration Analysis Oil Analysis Thermography Motor Current Analysis Total Productive Maintenance (TPM) Prognostic Analysis Criticality Analysis Emergency Management Computerized Maintenance Mgmt. System (CMMS) Key Performance Indicators (KPI) Risk Based Inspection (RBI) Operator Watch-keeping Value Contribution Mapping (Process step activity based costing) Logistics, stores and warehouses Defect and Failure True (DAFT) Cost Maintenance Engineering 	<p>Strategies prevent opportunities for a failure event arising</p> <ul style="list-style-type: none"> Engineering / Maintenance Standards Statistical Process Control Degradation Management Reliability Growth Cause Analysis (RGCA) Lubrication Management Hazard and Operability Study (HAZOP) Hazard Identification (HAZID) Failure Design-out Maintenance Failure Mode Effects Analysis (FMEA) Hazard and Operability Study (HAZOP) Root Cause Failure Analysis (RCFA) Precision Maintenance Training and Up-skilling Quality Management Systems Planning and Scheduling Continuous Improvement Supply Chain Management Accuracy Controlled SOPs (ACE 3T) Design, Operation, Cost Total 	<p>Strategies reduce probability of failure initiation if failure opportunity present</p> <ul style="list-style-type: none"> Training and Up-skilling Oversize / De-rate Equipment Hardier Materials of Construction Personal Protective Equipment (PPE) Segregation / Separation Controlled Atmosphere Environment e.g. +ve / -ve pressures, explosion proof atmosphere 
Done to reduce cost of failure	Done to reduce frequency of failure	

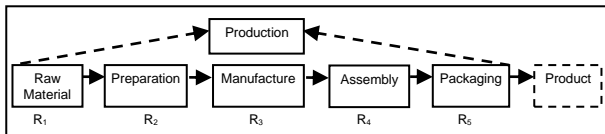
It is in your organization's best interest, and it will generate the most profit consistently for the least amount of work, to focus strongly on the use and practice of chance reduction strategies because they prevent risk events arising.

THE IMPACT OF SERIES ARRANGEMENTS

Every business process, every machine, every job is made of series arrangements. The arrangement forms a system and, like the links in a chain, every part is vital to the success of the whole. Miss one part anywhere and the entire system fails.



All series arrangements are unforgiving of mistakes. There is only one right way to assemble the bolt and nuts shown above, but over 40,000 ways for it to be done wrong (i.e. Factorial 8). Business processes, machines and jobs are far more involved and complicated.



A business is full of series arrangements. The production flow shown above uses a series of processes to make a product. Production performance depends on how well each process is done, which depends on how well each job in a process is done and on how well each machine works. The reliability of a series arrangement (i.e. the chance of system success) is found by multiplying together each step's reliability (i.e. the chance of a step's success). The equation used is:

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

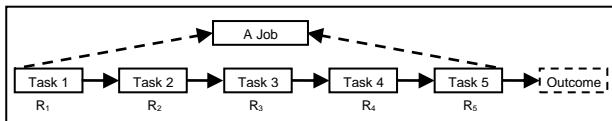
If any step in the flow of the production system above drops to zero, production also goes to zero. The calculation is:

$$1 \times 1 \times 0 \times 1 \times 1 = 0$$

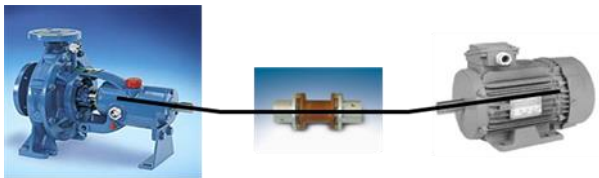
A step badly done and production outcome is just as bad.

$$1 \times 1 \times 0.25 \times 1 \times 1 = 0.25$$

The job below is a series of tasks. Every task must be right for the job to be correct. Make an error in any task and the job has to be redone if the error is found, or you will have to recall the item and replace it if the customer finds the error first.

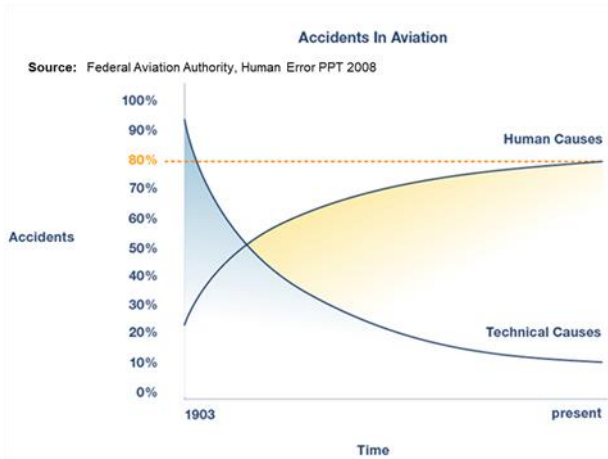


A machine is a series of assemblies working together. Each assembly is a series of parts. Every part must be right in every assembly for the machine to work properly. If the coupling should fail on the pump-set shown below, the impeller mounted in the pump cannot turn and the pump-set has failed. Once any vital part fails your machines fail and business stops.



In series arrangements (and they are everywhere): one fails, all fails – one poor, all poor!

HUMAN FACTORS & HUMAN ERROR



Our machines are fine. Our engineering is fine. Our materials of construction are fine. The problems of poor equipment reliability, poor maintenance and poor production performance are, by far, due to human factors and human causes.

“... the major challenge to reliability theory was recognized when the theoretical probabilities of failure were compared with actual rates of failure [and the] actual rates exceeded the theoretical values by a factor of 10 or 100 or even more. They identified the main reason for the discrepancy to be that the theory of reliability employed did not consider the effect of human error... Human error in anticipating failure continues to be the single most important factor in keeping the reliability of

engineering designs from achieving the theoretically high levels made possible by modern methods of analysis and materials... nine out of ten recent failures [in dams] occurred not because of inadequacies in the state of the art, but because of oversights that could and should have been avoided... the problems are essentially non-quantitative and the solutions are essentially non-numerical.¹”

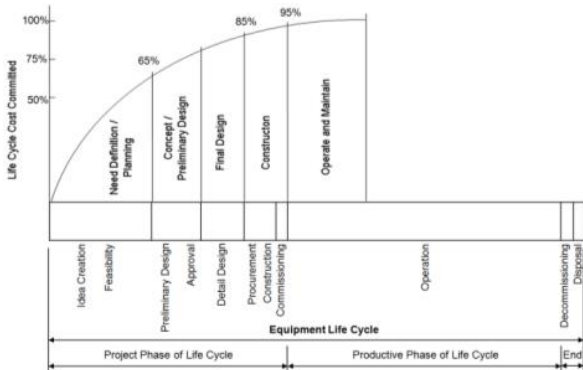
Human beings are imperfect. We always have been and always will be. It is because we are flesh and bone. We age, fatigue and suffer pain and stress. Our knowledge is always incomplete. Our brains are designed to adopt habits that streamline our decision making process, so we unknowingly miss important details. Our minds make assumptions without evidence confirming the truth. All this makes human error inevitable. Human error cannot be stopped. But that does not mean it must result in failure. Human error can be reduced through proper use of business processes and work control methods that factor ‘the human element’ into their design. You will never stop all mistakes, but you can stop all failures.

Stop the impact of human error throughout the life cycle and you make big improvements in plant reliability and operational results. Build error detection and error prevention into everything done in your company. Apply the 4Ts—**T**arget, **T**olerance, **T**est (the ACE 3Ts) all the **T**ime.

¹ Petroski, Henry, ‘Design Paradigms: Case Histories of Error and Judgment in Engineering’, Cambridge Press, New York, 1994. Remarks on Pages 7 and 8 on role of humans in failures.

DESIGN-IN MAXIMUM LIFE CYCLE PROFITS

An operation's life cycle is a series process: feasibility, design, procurement, installation, commissioning, operation and disposal. A mistake or misunderstanding made anywhere in the life cycle will always find its way into the operating costs.

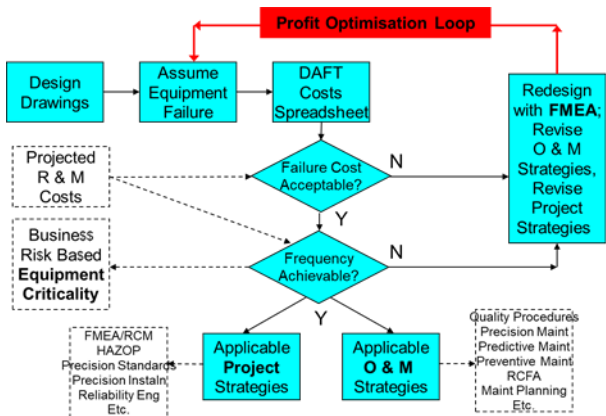


95% of operating costs come from the choices made during feasibility and design². Once plant and equipment are selected their operating costs come with them. Low operating costs and high profits are built into a plant during its project phase.

Many latent problems are introduced during feasibility and design that later cause operational failure. Investigations into safety incidents confirm that mistakes and errors, which later cause safety accidents, are made at every stage of a facility's

² Blanchard, B.S., 'Design and Management to Life Cycle Cost', MA Press, 1978

life cycle³. It is why maintainers regularly curse project designers for their hidden ‘traps’. High costs and troubles during operation are nearly all due to project phase choices.



It is vital in the early life cycle phases to stop mistakes and errors, else all subsequent phases suffer waste and loss. Because your operating plant reliability is almost totally dependent on choices made before start-up, your business needs a way make the right choices during the design phase to guarantee least cost operation. Your project designers need an operational risk reduction process, like the DOCTOR⁴ above, to investigate and model the problems that their design will cause the operation so they maximise your operating profits.

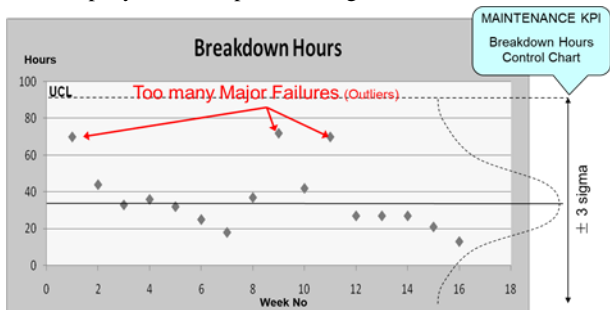
³ Foord, A. G., Gulland, . G., ‘Can Technology Eliminate Human Error?’, Trans IChemE, Part B, Process Safety and Environmental Protection, 2006 84(B3): 171-173

⁴ DOCTOR = Design and Operating Costs Totally Optimised Risk

THE INHERENT VARIATION IN PROCESSES

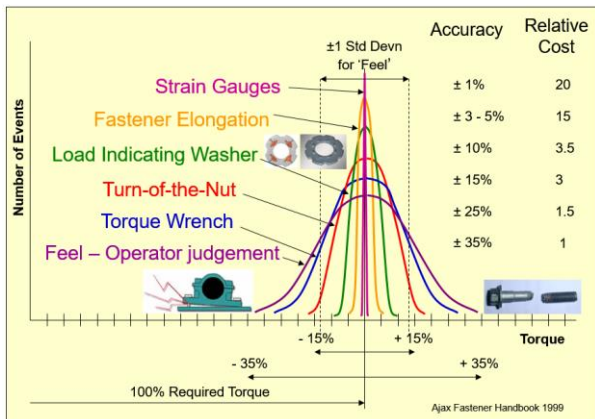
The late quality guru, W. Edwards Deming, advised, “Your system is perfectly design to give you the results that you get!” His quote truthfully explains why companies have the results that they do—they are the natural outcomes of their way of doing business. The effect and power of business process choice is astounding. Your current equipment performance is the designed outcome that your reliability system delivers.

Deming said that if you can fit a normal distribution curve to a set of business data it indicates a stable business process⁵. The run chart below is a time series of Breakdown Hours in an operation. Since all data points are within the three sigma statistical boundaries, the breakdowns are a statistically stable outcome for this company. Breakdowns are a ‘product’ that this company makes as part of doing its business.



⁵ Deming, W. Edwards, Out of the Crisis, MIT Press, 2000

In this business breakdown manufacture is a natural result of the way the company works. To stop breakdowns it must change to processes that prevent breakdowns happening.



The normal distribution curves above are for six ways to tighten bolts and fasteners. The method that produces greatest variation, $\pm 35\%$, is 'Feel - Operator Judgement', where muscular tension gauges fastener stretch. Since wide variation is inherent in using muscles the fastening process makes you have both loose and broken fasteners. Companies that let their people use judgement to tighten fasteners have approved the use of a process with high inherent variation. As well as properly tightened fasteners, they also will get many under-tightened fasteners and over-tightened fasteners. To reduce fastening problems they must change to a less variable process.

The process you use produces the results that you get.

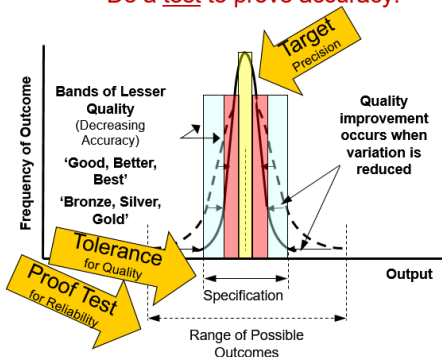
ACE 3T WORK QUALITY ASSURANCE

Hardly anyone ‘gets’ what quality is really about. Quality is a value you reach. It is a measure of accomplishment. It is the delivery of a performance characteristic. Once the required quality is achieved the necessary performance is delivered.

It is impossible to have quality until acceptance standards are set. To gauge quality a characteristic needs a target and an allowed range of performance. You can describe and measure quality by its 3Ts—Target, Tolerance, Proof Test.

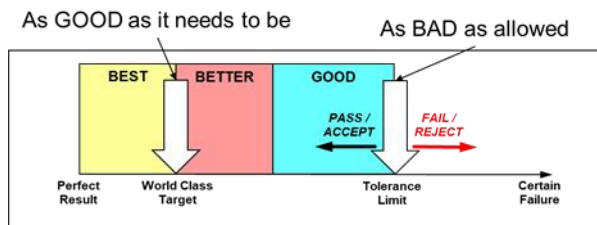
Build Mistake Proofing into SOPs

- Set a target for each task.
- Specify the acceptable tolerance.
- Do a test to prove accuracy.



Once an Accuracy Controlled Enterprise (ACE) 3T standard is specified you then measure if the processes used to achieve it are capable of meeting the standard. The 3Ts make top quality

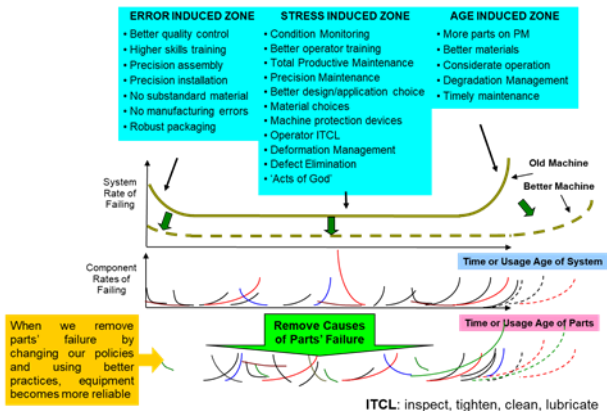
clear and measurable and gives you knowledge and information on how close you are to its achievement. The 3Ts go far beyond normal quality control methods, such as Inspection and Test Plans. ITPs set worst allowed quality limits—they tell us when quality is too poor. Their use naturally and regularly creates scrap. Instead ACE 3Ts provide tri-quality limits with its ‘good, better, best’ zones.



In our minds the 3Ts act like a target. A tri-quality limit creates a ‘bulls-eye’ to tell us how good we need to be to get world class results—not just how bad we can be and get away with it. The 3Ts rate our performance against the accuracy necessary for world class quality. They separate average from great and let us get the satisfaction of being amongst the best.

PROACTIVELY IMPROVE RELIABILITY

Equipment reliability is malleable by choice of policy and quality of practice. You create the reliability you get. Because a machine is a series arrangement of parts it will stop when one of its working parts fail. Prevent parts from failing and you create a highly reliable machine. You craft highly reliable plant and equipment that works trouble free for decades by removing the causes of equipment failure.



We know why parts fail. We understand the science of failure and can engineer our machines for long, trouble-free service life. Reliability can be created by doing what is listed in the slide. Just like a failure has its causes, so too are there causes of outstanding reliability.

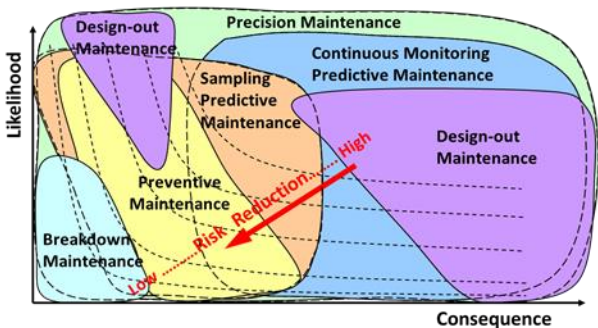
You cause equipment reliability growth by using the same strategy as the world-class leaders in industrial safety use for workplace safety improvement. They proactively improve safety by identifying safety risks and installing appropriate protection and improvements against harm **before incidents happen**. They remove opportunity for defects to arise that later become accidents and safety incidents. They make proactive risk prevention a habit in their company.

Reliability grows by preventing equipment defects and risk, and by proactively promoting machinery health and wellness. In PWW, Reliability Growth Cause Analysis (RGCA) is used to identify and positively prevent failures of equipment parts from errors and defects created during the life cycle by engineering, manufacturing, installation, operations, maintenance, and procurement. RGCA lets you recognise what can cause operational risk in all stages of parts' life-cycle. You then make necessary improvements to policy, processes and practices to prevent every cause from starting.

Plant Wellness requires you to identify ways that will cause reliability and not simply prevent failure. The aim is to never allow a work process step or machine part to fail. It requires you to list all the ways that reliability can be maximised, and that becomes your strategy for reliability growth. The level of operational risk allowed decides which reliability growth improvements to do. Then you drive their rapid introduction by using the right reliability policies, practices and processes.

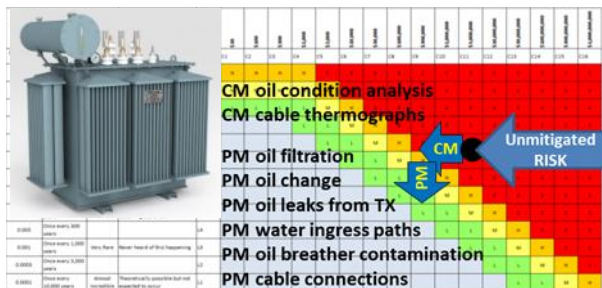
PROFIT BASED MAINTENANCE STRATEGY

Maintenance is equality about economics and about plant and equipment health. Whether or not to do maintenance is an economic decision—there must be profit from doing it. Maintenance must reduce operational risk by preventing plant and equipment failure. If a maintenance activity does not protect your equipment from loss of performance, thereby making more money for your company than letting it fail, you should not do that maintenance. Do maintenance because it makes more operating profit than by adopting other risk reduction strategies. Do maintenance when it is profitable.



Maintenance strategy types are few. You match them to operating risks to drive total business risk lower. When you cannot apply a strategy you apply another or a combination of them. The single strategy that is always effective is Precision Maintenance because it removes stress from parts.

You need to prove that maintenance is profitable before you do it. The effect of each maintenance activity performed must be seen to reduce risk on a risk matrix. It must either save cost and/or create reliability. Cost savings are seen as consequence reduction and risk moves to the left. Reliability improvement is chance reduction and risk moves down the matrix.

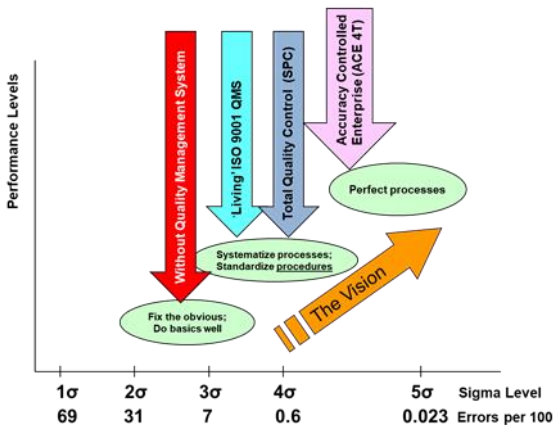


The transformer in the slide gets protection only if the maintenance done is useful for reducing the risk of its failure. Starting at the unmitigated risk point you plot and trace the financial benefits that each work order brings the company. Condition Monitoring (CM) work is a consequence reduction strategy. Proactive Maintenance (PM) work is a chance reduction strategy. The financial benefit of each scheduled maintenance work order must be identifiable on a risk matrix.

If you are not making good money from your maintenance efforts, then you need to change your maintenance policies and activities to those that are profitable.

BUILD IN-CONTROL & CAPABLE PROCESSES

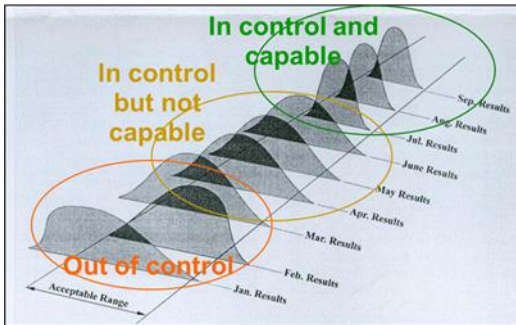
CEOs and Executives' role is to create business processes that are capable of reliably delivering the required outcomes. Business, operational and reliability process performance improves when you standardise procedures and make them systematic so that there is one way only to do a thing and it is done that way every time. Do this and you will reduce variation and move your processes to higher sigma levels (error rate) because fewer mistakes and waste occur.



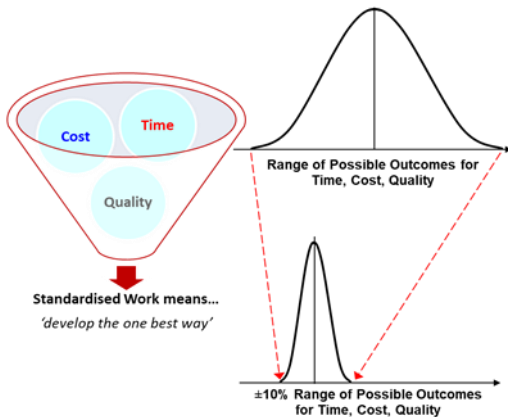
Sources: David Burns, SIRF Roundtables Ltd, Melbourne, Australia
George. Mike et al, 'What is Lean Six Sigma', McGraw-Hill, 2004

Achieving that requires a quality management system (QMS). PWW uses the Accuracy Controlled Enterprise (ACE 4T) method as its QMS to build a business of in-control and capable processes where future performance is a known outcome. This strategic aim of ACE 4T is achieved with the

right standardised and systematized reliability, quality and continual improvement processes imbedded in the business and equipment life cycle so fewer and fewer variations arise.

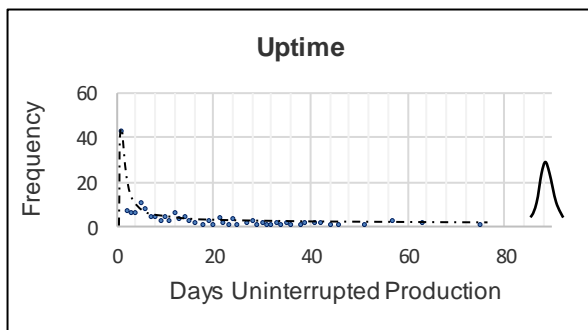
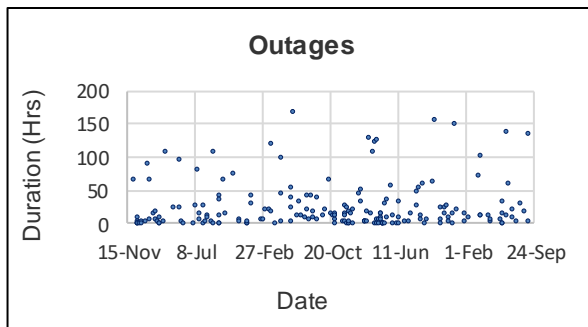


Once processes are stable, cost, time and quality are certain.



MAKE YOUR DISTRIBUTION CURVES VISIBLE

The top figure is a run chart of outages for an industrial plant. The bottom figure is its distribution of Uptime (Availability).



The top figure contains information that has meaning. Look at the density of the dots. There are times of frequent trouble and times of less. Note the stratification of dots—many below 50 hours outage duration and far fewer above.

The bottom figure is the same data turned into a distribution curve of Uptime Duration frequency. The shape tells a lot. The ‘spike’ contains dozens of less than 2-days long Uptime. The spike means short production runs caused by short stoppages are terribly common. There are many uptime periods of 2 to 10 days length. Too few uptime periods longer than 20 days. Once, 75 days without stoppage. The area under the dotted curve is the probability of plant uptime. You can estimate by eye the area between 0 to 20 days is larger than the area from 20 to 80 days by about four times. The odds are 4 to 1 the next plant outage is less than 20 days away rather than more. And it looks about three times more likely an outage will happen in less than 10 days rather than longer. It would be valuable to analyse operating history and learn what types of events cause so many stoppages.

This company wants three months of trouble-free operation between 2-day long planned outages. It wants performance to be like the solid distribution curve centred on 90 days—always 3-month long stoppage-free production runs. Its managers and people work hard and smart. But history shows that what they do never stops short Uptimes—frequent production disruptions by short stoppages is the norm. It will always be so since the business processes and practices cannot ensure 90-day production runs; they cannot even guarantee 10-days. To move the distribution curve from its historic norm and centre it over 90-days would be this company’s greatest success story.

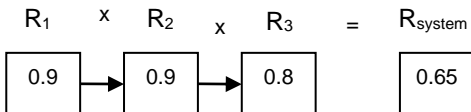
Once you can see your distribution curves you cannot hide the truth. People can say what they want to explain away the performance, but the curves never lie. If management cannot move the curves using what they know, they need to find new answers. You can use the Plant Wellness Way to move your distribution curves and get outstanding business performance.

SERIES RELIABILITY PROPERTIES No 1, 2, 3

A series arrangement has the three reliability properties described below. Series Reliability Property No 3 is where the big money is.

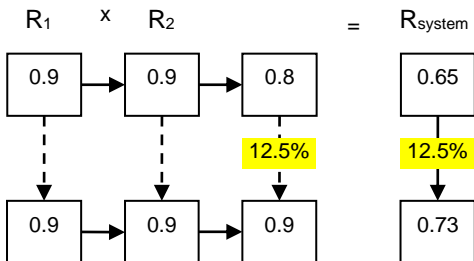
- 1. The reliability of a series system is no more reliable than its least reliable component.**
- 2. Add 'k' items into a series system of items, and the chance of failure of all items must fall an equal proportion to maintain the original system reliability.**
- 3. An equal rise in reliability of all items in a series causes a vastly larger rise in system reliability.**

Series Reliability Property 1 means that system reliability can never be higher than the least reliable item in the series. This is modelled in the diagram below (called a reliability block diagram) where the three-item system reliability is 0.65; dragged down by the 0.8 of Item No 3.

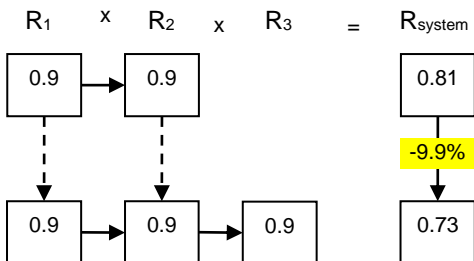


To improve reliability System Reliability Property 1 says to lift the reliability of the least reliable item first, as it alone is keeping the whole system from being more reliable. As shown in the following reliability block diagram, improving the

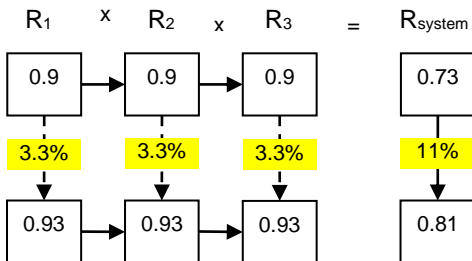
reliability of one item in a series improves system reliability an equal amount.



Series Reliability Property 2 means that if you want highly reliable systems you must not add more steps into the series and further complicate the process. In the diagram below one more step is added to a two-step series. The longer series reliability falls because there is now more that can go wrong.

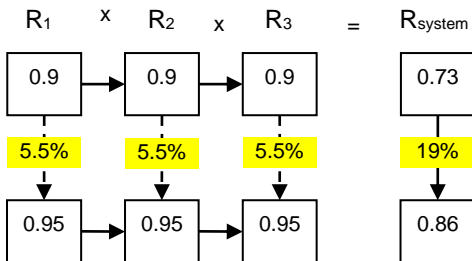


To return the longer system to the same reliability as the shorter system the reliability of each item must rise equally.



Series Reliability Property 2 tells us to simplify, simplify, simplify! Removing steps from a series lifts system reliability because that there are fewer things that will go wrong.

Series Reliability Property 3 says reliability improvements that universally lift the reliability of every item in a series will improve system reliability by a greater proportion.



The reliability block diagram above shows that by taking a series with individual step reliability of 0.9 (90% chance of success in each step) up to individual step reliability of 0.95

produces a 5.5% individual step reliability improvement while the correspondingly system reliability improves 19%—more than triple the step improvement. It seems that with Series Reliability Property 3 you only need to put in one part effort to get back 3 parts reward.

Series Reliability Property 3 tells us that business-wide reliability improvements deliver the greatest payback.

Series Reliability Property 3 allows the CEO and the Board to create high reliability organisations. If they chose the right reliability policy and practices they will flow throughout the business and permeate all its operations to make the plant and equipment highly reliable and the company wealthy.

An example of a system-wide improvement that Boards can make is the decision to adopt Precision Maintenance as a company standard. Another is to decide to use Lean practices throughout the business. By introducing Precision Maintenance standards and Lean practices across the operation every machine and plant item will, in time, run at much lower stress and suffer fewer human error induced failures. Once you significantly reduce stress in machine parts and prevent error you greatly increase operational plant reliability.

Series Reliability Property 3 allows Boards to create reliability in their operations. As has been said, “Equipment reliability is malleable by choice of policy and quality of practice.” The CEO and Board can create the reliability that they want.

PRECISION MAINTENANCE

Outstanding machinery reliability lives within ten microns of perfection, five micron is better, two micron is best. Exceptional reliability requires a very tight and narrow zone of high precision quality. This level of quality minimises component stresses. Once you remove stress from machine parts by putting them in the ‘precision quality zone’ you get a massive step-change improvement in machine reliability. The difference can easily be 10 times fewer failures with commensurate savings in operating and maintenance costs.



It is not sufficient to be 'acceptable' or 'tolerably' close to the precision zone—for lasting high reliability every working part must be in the precision quality zone for its entire working life.

A normal maintenance technician or university trained engineer is not able to produce such a high level of precision. Once you set precision standards you must retrain your people to reach the skill levels needed to hit the targets that bring outstandingly reliable equipment performance.

It is necessary to know what factors affect a machine's parts reliability and the value of 'precision quality' needed for each part to be in its 'precision quality zone'. Setting those values is the foundation of the PWV physical asset management strategy. You then develop the life cycle and business wide processes needed to surely deliver outstanding reliability to your plant and machinery forevermore.

REQUIREMENT	TARGET	TOLERANCE
1. Chemically correct, Contaminant-Free Lubricant	Right Viscosity; 0ppm water; ISO129	<14/11; <100ppm water
2. Accurate Fits and Tolerance at Operating Temperature	Form IT5, Temperature to design	<IT7
3. Shafts, Bearings, Couplings Running True to Centre	IT5	<IT7
4. Distortion-Free Equipment for its Entire Lifetime	IT5	<IT7
5. Forces and Loads into Rigid Mounts and Supports	No Looseness; Safely absorb/dampen forces	
6. Accurate Shaft Alignment at Operating Temperature	Coupling/Feet offset <10µm/20µm	<20µm/40µm
7. High Quality Balanced Rotating Parts	<G1	<G2.5
8. Total Machine Vibration Low	<1.5mm/s rms	<2.5mm/s
9. Correct Torques and Tensions in all Components	±5% of correct tension	<±10%
10. Correct Tools in Precise Condition to do quality work	As new condition and calibrated	
11. Only In-specification Parts	OEM approved material and design specs	
12. Precision Skills and Techniques	Competence to deliver precision standards	
13. Failure Cause Removal during Maintenance	Creative Disassembly; Precision Assembly	
14. Proof Test for Precision Assembly Quality	Every task proven correct	Milestone Checks
15. A quality assurance system to make all above happen	ACE 3T Quality System	ITP (Inspection & Test Plan)

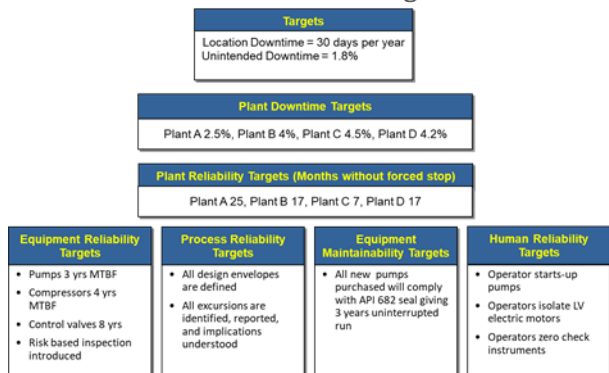
NOTE: These parameters are indicative of 2, 4 & 6 pole speed machinery. They may not apply to your machines. Confirm minimum requirements with the manufacturer.

The table above gives you an idea of the requirements and standards your machines need to get all their parts into the 'precision quality zone' for maximum reliability. These quality standards are demanding values—but when you achieve them you get world class reliability.

CASCADED GOALS & MEASUREMENT

To make reliability improvement come alive in your operation you need to guide your people to make right choices and to follow through with right actions. Show them what they need to attain and do to contribute to the company's reliability improvement goals. Make clear to all what reliability success looks like and why it is valuable to them and the business. Set reliability goals and you make reliability real for people to achieve. Reliability goals make uptime vitally important to your people every minute of their career in your company.

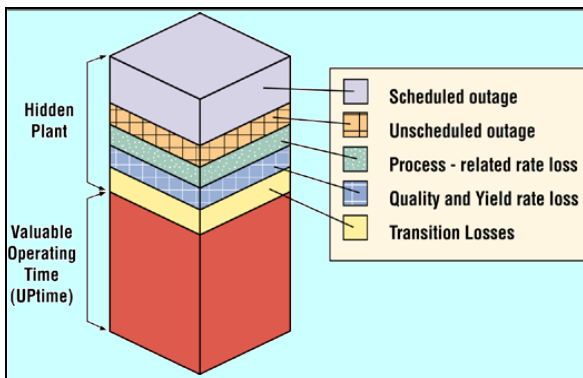
Cascading objectives that tie directly back to the overall business goals.



From your business objectives cascade the necessary results down to departmental outcomes and then to the individual performance required of your machines and of the people selecting, operating and maintaining them.

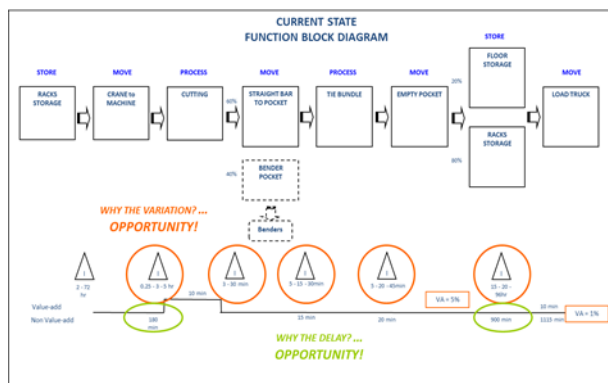
MAXIMUM EFFICIENCY & EFFECTIVENESS

The Plant Wellness Way adopts the least changes needed to get most efficiency and maximum reliability improvement and imbeds them in ACE procedures. The focus is to get lower production costs by eliminating operating risks and creating outstanding plant and equipment reliability. Minimising cost, effort and waste becomes the forte of your business processes. PWW is designed to maximise plant uptime and throughput. PWW incorporates the most effective tools and methods necessary to optimally achieve high operating plant reliability.



The Lean and Six Sigma methods most often used include Total Productive Maintenance (TPM), also called Autonomous Maintenance, to empower workers to care for their equipment; 5S workplace management for efficient maintenance and production workflows; Single Minute Exchange of Dies (SMED) for maximum time savings in work activities; Error

Proofing to prevent defect creation; Process Control Charts to target compliance to specification; Kaizen continuous improvement for rapid workplace development and work practice progress; Root Cause Analysis (RCA) for defect elimination and failure prevention; Value Stream Mapping (VSM) combined with Risk Analysis of work and business processes to identify where reliability losses can occur in the operation and during the equipment life cycle.

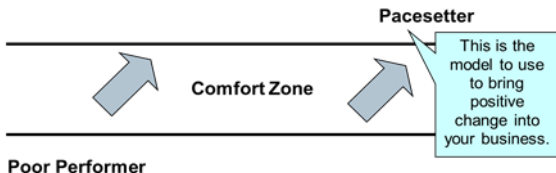


Lean and PWW philosophies are fully compatible. As process mapping is the first step in building Lean processes for smooth flow, reduced lead time, highest quality, and lowest cost. Process mapping for Risk Identification is the first step of the 6-Step PWW Methodology. The efficiency and effectiveness benefits gained by process optimisation means business process design is an integral part of PWW EAM.

BE LEADING A LEARNING ORGANISATION

To move from a repair-focused organization, where failure is seen as inevitable, where maintenance is a servant to breakdown and reliability is the responsibility of an ‘elite’, and become a reliability-focused organization with a culture of failure elimination that permeates management and staff at all levels, requires a mindset change. It is driven by a passionate senior management group over a long time⁶.

The Pacesetter's Business Model



Leading companies adopt a pacesetter model of continuous improvement—they challenge themselves to get better. They:

- Identify the prime business aims
- Identify what to be good at to achieve these aims
- Instigate the changes
- Have performance measurement targets
- Have a continual improvement mechanism

Soon they outdistance their competition and the competition never catches up.

⁶ Wardhaugh, Jim. Extract from 'Maintenance – the best practices' presentation, Singapore IQPC Reliability and Maintenance Congress, 2004

A learning organisation mainly applies two styles of leadership to successfully introduce the changes that need to be made—Situational Leadership and Servant Leadership.

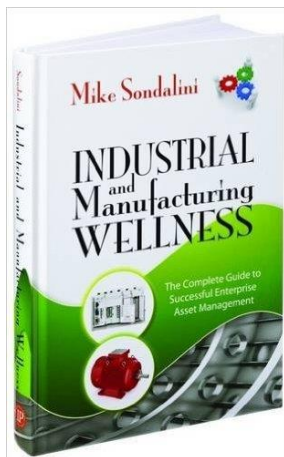
The Situational Leader lets the right people take the lead and make the decisions in every situation. The Captain of an ocean-going vessel does not run down and replace the boiler attendant when the boiler pressure falls. He knows that his boiler attendant is better at the job than he will ever be and lets those properly trained in running and using boilers take the lead in a crisis. Situational Leadership means getting your people to step-up and become leaders at those times when they are the right people to lead the effort.

Servant Leadership is giving support, resources and useful feedback to the people in the front line who are tasked with making good things happen. It is clearing the path of the barriers that they face within and without of the organisation. It is being a team player working beside the others in the team and making the team's performance more important than your own personal performance and glory.

It is only by changing your own and your peoples' behaviours to those actions that produce reliability that you can ensure you will create a high reliability organisation forevermore.

MORE INFORMATION ON PLANT WELLNESS

The PWW enterprise asset management methodology is fully explained in the book, Industrial and Manufacturing Wellness.



It contains all PWW EAM strategies, practices, and techniques. You can request additional training that fully covers all aspects of the Plant Wellness Way and its workplace implementation. The course covers all PWW process design methods, tools, skills and practices to execute the failure prevention and defect elimination requirements of world class reliability.

All the best to you and your organization,

Mike Sondalini

www.plant-wellness-way.com

***Puts World Class Equipment Reliability into Your Operation,
with a Plant Wellness Way EAM System-of-Reliability***

“In all things success depends on
previous preparation, and without such
preparation there is sure to be failure.”

Confucius (Analects)

“Victory favours the prepared.”

(Latin Proverb)

