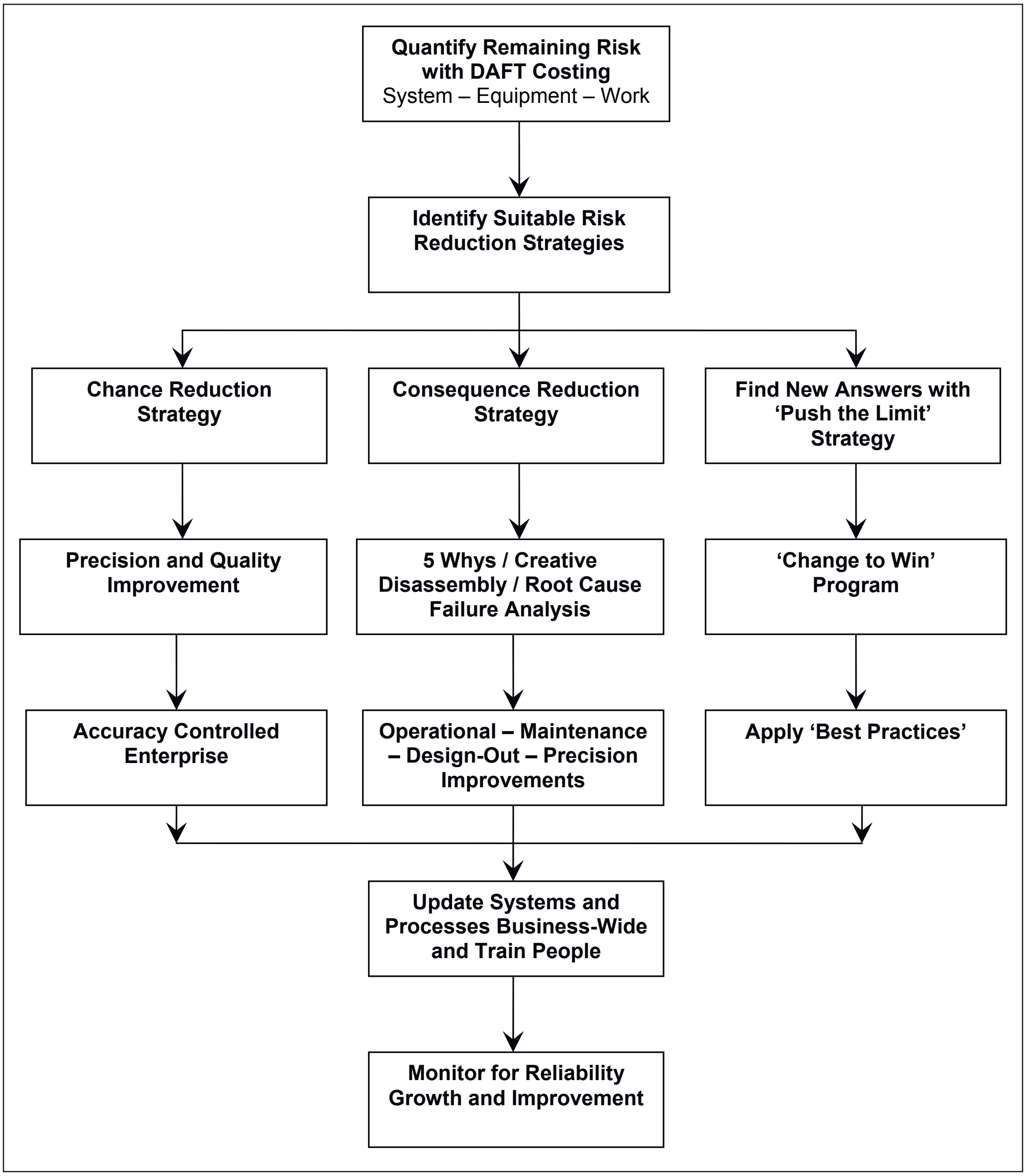
PROCESS 6 – Operating Risk Continual Improvement



Description of Process 6 – Operating Risk Continual Improvement

Description of Process 6 – Continual Improvement

The war against risk never stops. No improvement secured must ever be lost. No new risks must ever enter your operation. Work on reducing and removing all operating risks remaining.

Quantify and Prioritise Remaining Risk:

Assess the risks remaining in your operation by using DAFT Costing to measure the potential business-wide losses from equipment failures. Use double-Pareto charting to prioritise and focus your failure reduction efforts to get maximum returns.

Identify Suitable Risk Reduction Strategies:

Reduce the chance of risk on your targeted high priorities. Use the Reliability Growth Cause Analysis (RGCA) method to spot new opportunities for reliability improvements.

‘Change to Win’ Program:

To get permanent changes in your operation you will need the support and commitment of the people there. The ‘Change To Win’ program is a process to involve people in making permanent improvements in how they work and what they do to lift reliability.

Apply ‘Best Practices’:

To get world-class performance, use world-class practices. Better results need better standards and better practices. Find them and bring them into the operation. Make them the ‘way we do things around here’. Don’t wait for problems to justify improvement; make improvements so that there won’t be any problems.

Update Systems and Processes Business-Wide:

To make good change permanent, include it into all documents and business processes. Imbed it in the work processes and make necessary information easily available to everyone. Use your business systems to trap world-class practices in the business so they are used always and never lost. Train and retrain your people to the best practices.

Monitor for Reliability Growth:

Use Key Performance Indicators and Reliability Growth Plots to track the direction and progress made. Address and improve those activities not yet performing well enough.

19. Failure Root Cause Removal

Highly reliable organisations do not accept things going wrong. They proactively focus on preventing problems entering their operation and find, then fix, those that remain. They set control mechanisms, standards and checkpoints in place to spot and stop the defects that turn into future failures. They look for what can go wrong before it does and prevent it happening. They learn from their problems and proactively act to prevent them. If your operation is having equipment and production problems, you need to discover what they are and how to solve them! To solve problems fast you need to draw together relevant information and knowledge. The vast majority of production problems are the same ones repeated by different people in different plants at different times. You should only need to solve a problem once. Let everyone else in your business use the answer and get any new training they need. This puts Series Reliability Property 3 to work for you and you get reliability growth across the business and not just in one machine.

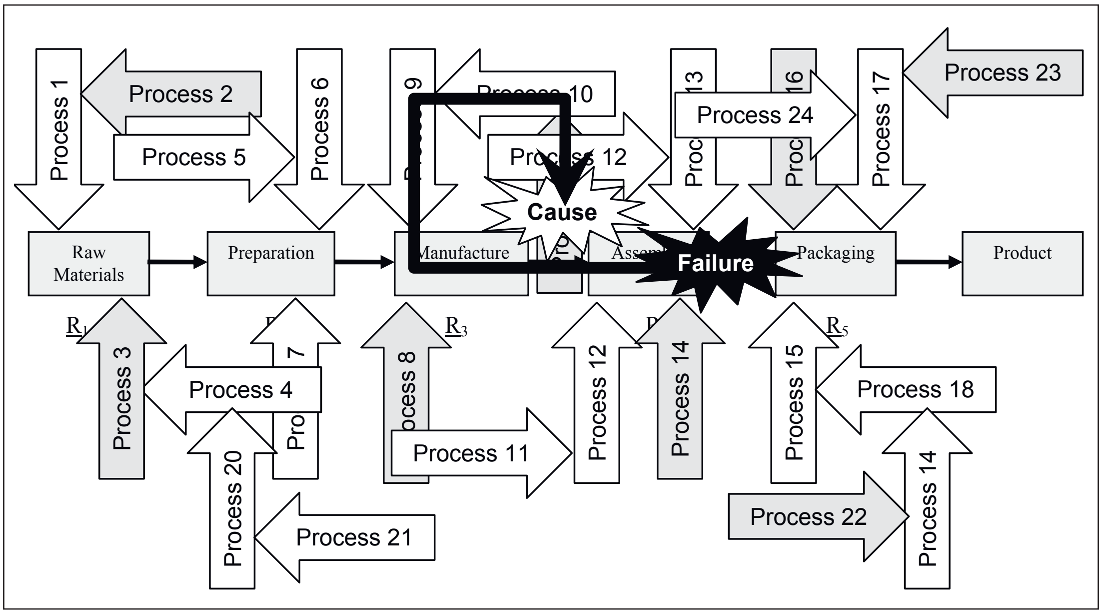


Figure 19.1 – Failures Occur throughout the Process Chain.

If your industrial maintenance management practices and asset management processes do not deliver sustained high production performance, there are underlying root causes which need addressing. Nothing happens by accident. Most often production equipment problems and failures are only symptoms of the real causes. The real causes are hiding deep within an operation's processes and habits. Until you solve the underlying issues that produce the failures they will continue to happen. Determining the real problem is finding the root cause. There are special techniques for determining the root cause of a problem. One technique used for procedural failures is the '5 Whys'. For equipment failures Root Cause Failure Analysis is often favoured. For the tens of thousands of defects in your plant and equipment waiting to become failures, we use creative disassembly to fix them [80].

World-class operations recognise the interconnectivity of their processes and work hard to ensure right results at every stage, in every process. Figure 19.1 shows a failure in product assembly. The root cause traces back to manufacture, where it leaves the process and enters another, then a second and a third. The defective item started its life elsewhere and ended up

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[80] Brown, Peter, Wishaw, Max, 'Precision Maintenance for Engineers' Course, Industrial Training Associates, Perth, Australia, 2000.

causing problems in Assembly. There are innumerable opportunities for errors and defects to occur in all processes. Process after process connects with others such that a tangled web of interaction occurs around and along every process. Errors, mistakes, and defects can come from everywhere. Any process that goes wrong impacts on numerous others downstream of it. Much time, money and resources will be wasted. The problem needs to be fixed. That will take more time, money and resources. If you want an operation where good results are natural and excellence abounds – ensure your processes allow no defects to enter your business.

Creative Disassembly and Defect Removal

Creative disassembly is part of precision maintenance where machines and equipment are built to the quality standards that ensure defects are removed and failures never happen. The method requires identification of flaws with machinery and their immediate correction. It operates at the equipment parts level and strikes at the heart of the thousands of defects making-up the base of the equipment failure pyramid. By reducing the number of defects in machinery fewer opportunities present themselves for catastrophic failures. The plant operator and maintenance technician become the root cause analysts for their operating plant and equipment. Instead of operators only running the plant and the maintainer only replacing parts and doing maintenance, they are trained to find the reason for a failure and correct its root cause. They are given authority to follow-through and do all necessary work, including scheduling production outages to do the precision maintenance needed to prevent repetition of the problem.

There are three phases to creative disassembly analysis – pre-shut-down, pre-strip-down and strip-down. During the work comparisons are made against specified ACE 3T precision standards. When defects are detected they are removed or corrected, and the equipment is returned to the applicable precision standard when re-built.

1. **Pre-shut-down data collection**
   a. Records from the CMMS, parts usage, repetitive maintenance and operating problems
   b. Condition monitoring data such as vibration and bearing characteristics, thermography, oil analysis, etc
   c. Checks for running softfoot and machine distortion while operating; identify resonance problems and poor supporting and hold-down structures.

2. **At shut-down, but prior strip-down, take measurements and detailed observations**
   a. Where thermal growth occurs collect the hot growth and alignment readings
   b. Identify witness marks showing relative movement between parts
   c. Notice presence of unusually deposits from wearing parts like drive belts and couplings
   d. Take lubricant samples for analysis and patch testing of wear particle count while still hot
   e. Check for static softfoot distortion problems.

3. **Strip-down measurements and investigative observations**
   a. Look for witness marks and tell-tale evidence of incorrect operation and behaviours
   b. Mark relative positions of bearings to later confirm correct location
   c. Inspect bearing wear patterns for evidence of spalling and other failure modes
   d. Incorrect roller or race motion, cage damage, fretting corrosion, out-of-roundness, shaft straightness, etc
   e. Inspect for damage and wear patterns on moving parts such as gear teeth, pulleys, belts, etc.

Take time to do the job of creative disassembly and precision rebuilding well. It leads to world class equipment performance as more and more defects are removed from your plant and machinery.

Root Cause Failure Analysis

Root Cause Failure Analysis (RCFA) tracks problems down to their roots to identify the necessary changes that would stop the problems reoccurring. Whether a breakdown of a piece of equipment, an industrial accident, or the failure of a business plan, root cause failure analysis will help to identify the reasons for the incident. It provides the necessary depth of analysis to find the causes and then develop useful changes to remove them from the operation. The effectiveness of RCFA in solving production problems and improving production performance is well proven. Root Cause Failure Analysis solves both common cause failures and special cause problems. As each RCFA improvement project is successfully completed the plant reliability and productivity rise higher and higher. Figure 19.2 shows how to use RCFA to improve operating performance.

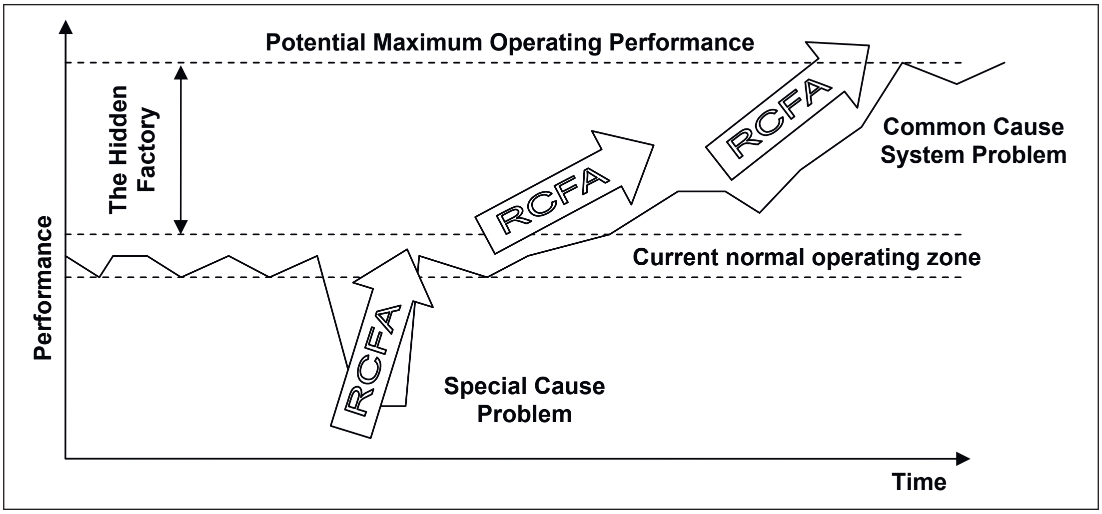

Figure 19.2 – Use of RCFA to Correct Common and Special Cause Problems.

Many companies train their key people on Root Cause Failure Analysis. It starts life with a rush and then dies from insufficient time and resources. RCFA is a powerful concept when used all the time. As an enabling tool for problem solving it is best used continuously 'on the shopfloor'. If reserved for investigating major failures by engineers and managers, then use of RCFA will die-off quickly. Saving RCFA for major failures guarantees that major failures will continue because it is not used to solve the small problems that grow into major failures [81]. To remove catastrophes you must remove the tens of thousands of chances for defects to align with opportunity and progress to failure. Make RCFA live every day where the risks reside – in your processes and on the shopfloor!

A formal RCFA course will teach you the technique of using Fault Tree Analysis (FTA) to find root causes and to build successful methods to prevent them repeating. During the course you spend a great amount of time understanding and practicing RCFA so that you are comfortable to use it. A good RCFA course has a hands-on, practical focus intended to help Attendees understand where equipment failure causes come from and how to find and remove

[81] Nelms, Robert C, 'The Latent Causes of Industrial Failure ....How to Identify Them, and What to Do about Them', Failsafe Network, Inc. Montebello, VA, USA.

them. The method brings a team of 3 to 6 knowledgeable people together to investigate the problem using evidence left behind from the failure. Deciding the composition of the team is more about including all the skills and knowledge needed to find the cause and solve the problem, than getting a certain number of people into the team. The team brainstorms to find the many causes of a fault. The solution selected must prevent the problem recurring.

Improving existing plant performance requires the elimination of repeat failures. RCFA is a search for the 'root cause' of the problem. Effective RCFA is about seeking simple solutions that control the causes of problems. Like a detective, we look for causes from the effects and evidence and trace them back to the first cause. The process starts by defining a problem and identifying all possible causes. We ask, "How can the effect arise?", and answer with a cause or combination of causes. Each cause is then taken as an effect and we continue to ask how that one arose. With this method of questioning a cause and effect chain is established. During analysis a fault tree, as in Figure 19.3, is developed. Starting with the failure it is progressively traced back to each cause that could have led to the previous cause. This continues until each trail can be traced back no further. Each result of a cause must clearly flow from the one before it. If it is clear that a step is missing between causes, it is added in and evidence is required to support its presence. Using what evidence remained after the fault, as well as discussions with people involved in the incident, all the non-contributing causes are removed and the contributing causes are retained. Once the fault tree is completed and checked for logical flow the team then determines what changes to make to prevent the sequence of causes and consequences from again occurring.

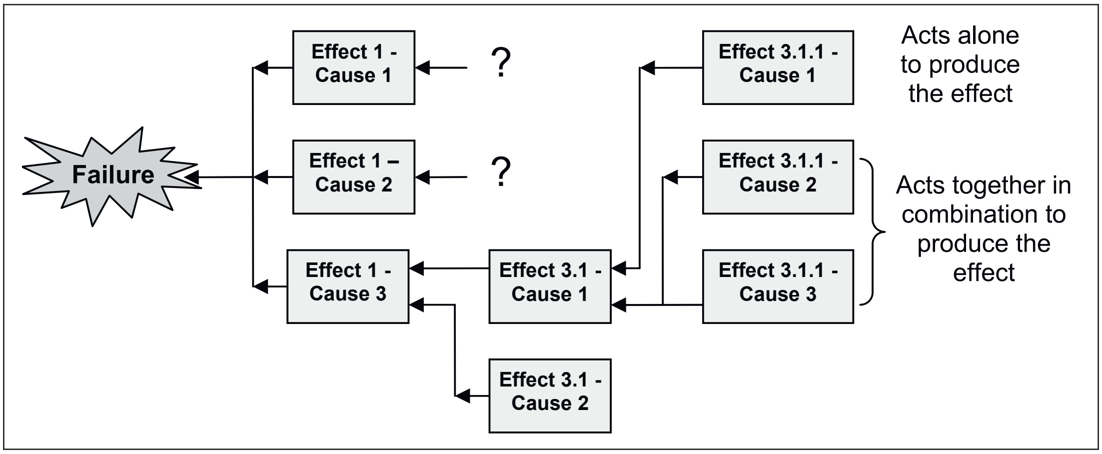

Figure 19.3 – Root Cause Failure Fault Tree.

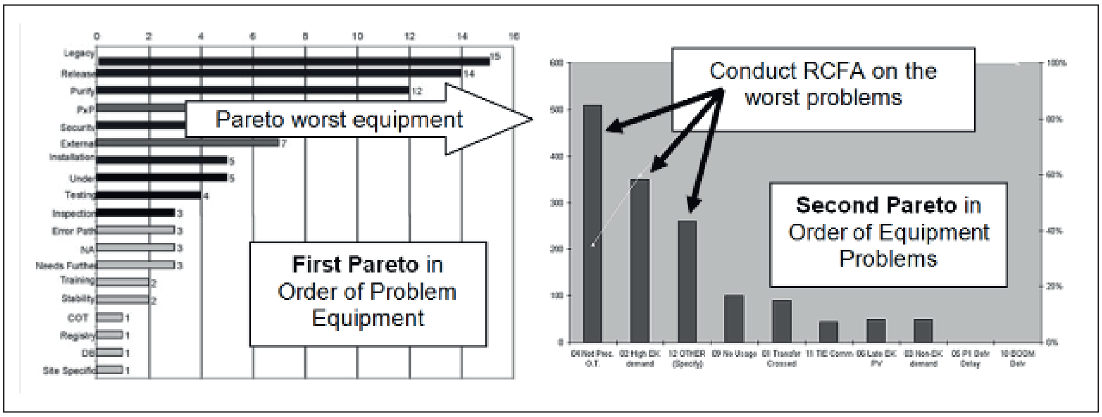

Figure 19.4 – Double Pareto Chart Method used to Identify Equipment and Problem Priorities.

When RCFA is used to address common cause problems you first select the least reliable equipment for improvement and solve its problems, then do the next worst equipment, and so on. By fixing the worst equipment you improve reliability using the Series System Property 1 – 'The reliability of a series system is no more reliable than its least reliable component'. You work your way through the least reliable equipment in your operation one after the other, gradually improving the whole system reliability. The approach starts by producing a Pareto chart of the 'bad actors' equipment in an operating plant. Equipment across the operation is charted in order of DAFT Cost impact. The worst performing equipment items are then identified on the chart. The second step is to make another Pareto chart for each of the worst equipment showing the DAFT Cost of each problem on that equipment. Finally RCFA is applied to address the causes. Figure 19.4 is an example of the double Pareto approach.

World class companies take the learning from an RCFA and apply it throughout their business. They use Series System Reliability Property 3 with what they learn and fix every other similar problem. They know that what went wrong with one machine is a symptom of their business processes, and it can happen again. With each RCFA they improve their entire business.

Preventing Reoccurrence of the Failure

It is not necessary to remove the root cause to prevent the failure. The failure can be prevented by breaking the chain of events anywhere along the fault tree. But a defect not removed remains behind to restart the same failure sequence, and perhaps hundreds of other failure sequences as well. Often the fault tree leads to an initial design problem. In such a case redesign maybe necessary. Where the fault tree leads back to a failure of procedures it is necessary to fix the procedural weakness, or to install a method to protect against the consequence of the procedural failure. It includes doing all necessary training. Figure 19.5 is a sample fault tree for the moral story of the kingdom lost because of a missing horseshoe nail. The story goes that before an important battle a king sent his horse to the blacksmith for shoeing. He was one nail short for the king's horse, as he had shoed all the knight's horses for battle. The groomsman told the blacksmith to do as well as he could. The blacksmith warned him that the missing nail might allow the shoe to come off. The following day the King rode into battle not knowing of the missing horseshoe nail. In the midst of the battle he rode toward the enemy. As he approached them the horseshoe came off the horse's hoof causing the horse to stumble and the King to fall to the ground. The enemy saw the King fall and was quickly onto him and killed him. The king's troops seeing the death gave up the fight and retreated. The enemy surged onto the city and captured the kingdom. The kingdom was lost all because of a missing horseshoe nail.

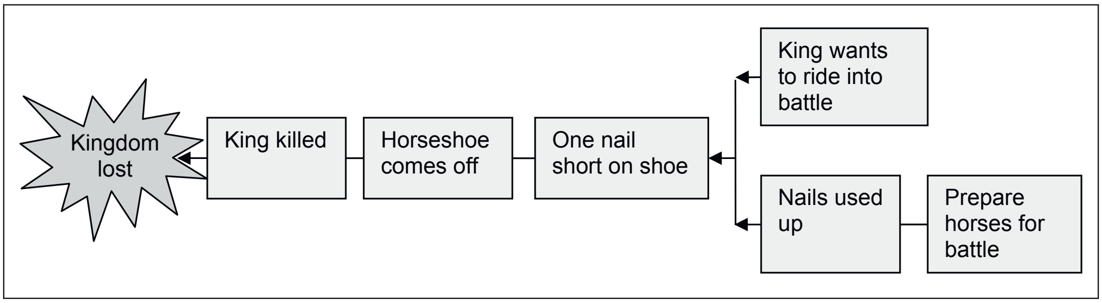

Figure 19.5 – RCFA Fault Tree for the Missing Horseshoe Nail Story.

The Fault Tree explains step-by-step how the events leading to the king's death unfolded. Notice that two separate event 'branches' had to occur together for the sequence to continue to the fateful end. Prevent any of the causes and the kingdom could have been safe.

In our story the next king chances the same death if he does not fix what killed the previous king. It is critical to all future kings that they know how a missing horseshoe nail can kill them. Don't keep what is learnt in an RCFA secret – tell everyone; improve your processes company-wide with the learning; get the knowledge out and into use quickly. Use Series Reliability Property 3 and everyone gains a lot from a small amount of effort. There is one more question for you to consider – should the blacksmith be drawn and quartered? Was it his fault that the king died, or was it a process fault that he ran out of nails?

The 5-Whys – Creating Why Trees

The '5-Whys' is a simple way to try solving a procedure problem without a large detailed investigation requiring many resources. It is a simple form of root cause analysis [82]. It is used to explore the real cause of a problem or situation. Most obvious explanations have more underlying problems. By repeatedly asking the question, 'Why?' you peel away layers of symptoms that can lead to the root cause. The 5-Whys help to determine the relationships in a problem. It is one of the simplest investigation tools easily completed without statistical analysis. When problems involve human factors this approach is easiest because it is less stressful. Start with a statement of the situation and ask why it is happening. Then you ask 'Why?' of the answer to the first question, and so on. The question 'Why?' is asked five times. By refusing to be satisfied with the first explanation you increase the possibility of finding the true root cause of a situation. Although this technique is called '5 Whys', five is a rule of thumb. You may need to ask the question fewer, or more times, before you find the root of a problem (there is even school of thought that seven 'whys' is better; that five 'whys' is not sufficient to uncover the real truth).

A '5 Whys' Questionnaire Form is used to record the analysis. Just like an RCFA, a team of people competent and knowledgeable in the problem are used to brainstorm the situation. After describing the problem the team develops a cause and effect tree relationship back to the root cause using the 5-Why method. The consensus response to each question is written in the appropriate space on the form. Once the trail to the root cause is found the team is asked to use the available evidence to prove each answer would really cause the previous one. The 3W2H set of questions is used to help confirm the right cause from all those possible. If an answer does not satisfy the evidence, the team identify what is missing and correct the answer. The team continues confirming the veracity of each cause-effect connection against the evidence until all connections are confirmed.

The 3W2H set of Questions

To gain insight into an event you need to ask poignant questions that verify what really happened to cause the incident. If the problem is to be solved its real causes must be known with certainty. Otherwise the proposed solution may not work because it does not stop the true cause-effect path. The 3W2H acronym is a useful device to help remember the questions to ask. For each cause-effect connection answer the 3W2H questions to draw-out details of the cause-effect relationship. There must be real evidence that each answer is the right one for the question asked.

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[82] Some contents for this topic are from the website http://www.isixsigma.com/library.

- With what – *the physical evidence of what happened*
- When – *the exact time in the process chain*
- Where – *the exact point in the process chain and physical location in the facility*
- How – *the actual activity and actions being performed prior the incident*
- How much – *the engineering specifics of the activity, e.g. height, weight, speed, colour,…*

Completing a 5-Why Questionnaire Form

Use a one-page form like the example in Table 19.1 to record the questions, answers and evidence.

1. Write down and describe the specific problem to formalize and clarify it. It helps the team members to focus on the problem.
2. Calculate the DAFT Cost impact of the problem on the whole operation.
3. Ask 'Why' the problem happened and write the answer below the problem.
4. If the answer provided does not identify the root cause of the problem that you wrote, ask 'Why' again and write that answer down.
5. Continue asking 'Why' until the team agrees it has identified the problem's root cause.
6. Confirm each answer with the evidence. If the evidence does not support the answer seek an answer that fits the evidence.
7. Identify solutions that will break the cause-effect chain.
8. Implement the simplest solution.

The estimated DAFT Cost is the 'Defect and Failure Total Cost' and is the total organisation-wide cost of the failure. Identify every dollar lost across the whole organisation. It will make implementation of a solution easier for management to accept if you have a strong business case.

The example in Table 19.1 is the analysis of a failure to get to work on time. As you can see, the Five Whys lead the team to the root cause of being late to work – losing all the money in a poker match (but it is not the real cause of the person's problem). To prevent the car running out of gas he needed money to buy fuel. The simple solution to the problem is to carry a credit card, rather than to teach the person to 'bluff' a hand. There is no need to solve the last cause to fix the problem.

Notice the comment regarding 'Latent Issues'. The honest, true cause of the problem was being unable to control ones money. Latent issues are the underlying beliefs and values that make us act as we do. These beliefs and values encourage our behaviours along certain paths. They are the habits we have adopted and now no longer question. Many of these habits do not lead us to good results. The '5 Why' table includes the question of latent issues so we are forced to see our true selves, and not think that because a problem is prevented it cannot happen again. It will happen again, in some way or another, if we do not change our beliefs and values.

Progress and development is an evolutionary process not a revolutionary process. Those companies that evolve fastest are more successful than those that wait for change to be imposed on them. If you want rapid evolution in your operation help the people there to develop problem solving skills and knowledge. Give those with the problems the tools they need to team-up and find the solutions for themselves.

Table 19.1 – A 5-Why Analysis Form.

Why Tree Questionnaire Form			
Team Members:			**Date:**
Problem Statement: On the way to work your car stopped in the middle of the road.			
Estimated DAFT Cost: Taxi fare x 2 = $50, Lost 4 hours pay = $100. Plus big stress caused at home and at work!			
Recommended Solution: Carry a credit card to access money when needed.			
Latent Issues: Gambling away all the money shows a lack of personal control and responsibility of money.			
Why Questions	**3W2H Answers** (with what, when, where, how, and how much)	**Evidence**	**Solution**
1. Why did the car stop?	Because it ran out of gas in a back street on the way to work	Car stopped and standing at side of road	
2. Why did gas run?	Because I didn't put any gas into the car on my way to work this morning.	Fuel gauge showed empty	
3. Why didn't you buy gas this morning?	Because I didn't have any money on me to buy petrol.	Wallet is empty of money	Keep a credit card in the wallet
4. Why didn't you have any money?	Because last night I lost it in a poker game, I played with friends at my buddy's house.	Poker game is held every Tuesday night	Stop going to the game
5. Why did you lose your money in last night's poker game?	Because I am not good at 'bluffing' when I don't have a good poker hand and the other players jack-up the bets.	Have lost money in many other poker games	Become better at 'bluffing'
6.			
7.			

20. Precision Maintenance Skills and Standards

Precision Maintenance is the strict adherence to exacting machinery health standards for the entire equipment life cycle. It improves machines and equipment to quality standards where low stresses occur during operation. Precision maintenance maintains plant and equipment to the specifications that eliminate the defects and parts failures that cause breakdowns. As a consequence it saves large amounts of money for the companies that use it because:

- their machines and equipment are built not to fail
- there is reduced need for maintenance because parts don't wear as quickly
- they maximise quality production and stop scrap because machines work properly
- they have vastly fewer stoppages and slowdowns since there are far fewer breakdowns
- fewer spares are used since machines don't need them
- plant availability and productivity is maximised because machines are reliable.

Outstandingly reliable equipment, with exceptional uptime, that delivers unfailingly high production of top quality product is no accident. Realising remarkable machinery reliability through Precision Maintenance has been practiced by progressive, proactive organisations since the mid-1980s; achieving both outstanding production performance and the best maintenance cost reductions of all maintenance strategies. Once Maintenance, Operations and Production Managers learn of precision maintenance they acknowledge that it is a great concept and totally valid; but few implement it. You gain the benefits of precision from your equipment when the business processes used to design it, select it, install it, operate it and look after it create precision in your operation.

Financial and Operating Benefits of Precision Maintenance

The two graphs in Figure 20.1 tell a remarkable story – when machine vibration levels fall, so do the maintenance costs; dramatically at first, then gradually and continually as use of precision practices improves. That means machinery does not breakdown. It runs brilliantly for longer and plant availability, throughput and utilisation are at their maximum. As a consquence there is more time to make more product at less cost to sell for more profit using fewer people.

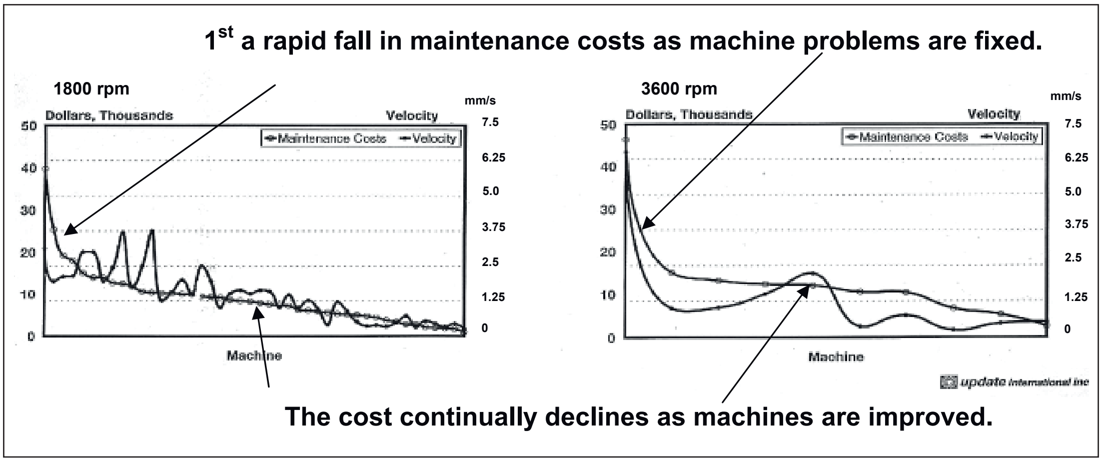

Figure 20.1 – Maintenance Costs Fall When Overall Machine Vibration Levels Fall.

83 Buscarello, Ralph T., Update International, Lakewood , Colorado, USA, 1993.

Table 20.1 shows results of a machine vibration survey in a large industrial facility. It records bearing vibration levels taken while operating the equipment, along with their previous year's maintenance costs. Low bearing vibration is 1mm/s to 2 mm/s, at 8 mm/s a machine is running very rough. The costs for equipment with low vibration are 70% – 80% less than for machines that ran rough. When equipment is built to fine standards that prevent distortion and provide healthy internal conditions it runs smother and its parts suffer substantially less stress and fatigue.

Table 20.1 – Machine Vibration to Maintenance Cost.

Machine Type	Highest Velocity mm/s	Dollars Spent Last Year	Lowest Velocity mm/s	Dollars Spent Last Year	Savings with Precision
Single Stage Pumps	5.6	$3,200	2.0	$650	80%
Multi Stage Pumps	4.8	$6,100	1.5	$1,100	82%
Major Fans & Blowers	9.0	$900	2.8	0	100%
Single Stage Turbines	3.8	$8,200	1.0	$2,000	76%
Other Machines	7.8	$11,850	3.0	$3,700	69%

There is no mystery why Precision Maintenance lets you make more, ship more, sell more and profit more, while doing it all at less cost – it improves the operating conditions of parts within machinery and reduces their stress levels. Quite literally, your people make your machines run better. Using precision definitely pays well. It is how maintenance contributes to operating profit – by making machines run precisely so failures don't happen. The money that would have been spent on repairs is retained as greatly improved operating profit.

The list below are the thirteen requirements for a precision maintenance program:

1. Accurate fits and tolerance at operating temperature
2. Impeccably clean, contaminant-free lubricant life-long
3. Distortion-free equipment its entire life
4. Forces and loads into rigid mounts and supports
5. Laser accurate alignment of shafts at operating temperature
6. High quality balancing of rotating parts
7. Low total machine vibration
8. Correct tensions in all fasteners
9. Correct tools and test equipment in the condition to do the task precisely
10. Only in-specification parts are installed
11. Creative disassembly to find and remove defects and failure causes
12. Proof-test that precision is achieved
13. A business process to consistently apply the requirements in a successful way.

There is nothing in the list that should not already be standard practice in every industrial operation. But it hardly ever happens. The reason is the exacting standards required to deliver the excellent equipment health that delivers failure-free operation are not specified in company quality systems. They are not taught to engineers, nor to operators and maintainers, and are not important to those supervising work quality. So everyone works to their own level of misunderstanding, which leads to variation, confusion and inaccuracy. Defects are thereby created all the time that cause operating problems and equipment failures. It is as predictable as night following day. But it does not need to be that way. It requires determining and setting standards for every piece of plant and equipment in an operation, down to the nuts and bolts, for all electrical connections, motor base plates, gearboxes – every component – that addresses issues such as:

- Distortion
- Looseness
- Lubrication
- Cleanliness
- Shaft alignment
- Balancing
- Temperature
- Vibration
- Assembly accuracy
- Installation accuracy
- Tools and condition for use
- Skills and their competency
- Job Records
- Calibration of equipment
- Everything else the equipment parts require for a lifetime of low stress, health and wellness.

These standards are measurable, they define the 'engineering numbers' that are proof of compliance to the standard. Standards are needed for such issues as:

- the correct tension in every fastener
- the number of threads protruding from a tightened nut
- the maximum size and amounts of contamination you will accept in your lubricant
- the exact gap between parts and the test to use
- the size and dimensional tolerance for a shaft at a bearing location
- the amount of damage you will accept in a part before you replace it with new
- the exact distance along a shaft from a datum to mount a shaft seal
- the exact alignment accuracy between drive shafts.

Every part on every machine and piece of equipment in an operation will requires standards that guarantee their health. Once you have standards that you can measure, you can prove if a thing is right or not. With measurements to prove the minimum standards are met, you know almost without question that you are within requirements. You are virtually certain that the job is right and the equipment will run precisely and operate under precision conditions. What uncertainty remains would be due to the risk of using out-of-calibration test equipment that gave a false reading. But the quality management system controlling the condition of your maintenance tools will prevent that.

Starting a Precision Maintenance Program

When you start a precision maintenance program your intention is to introduce precision requirements into the everyday workplace practices. Everything that relates to the plant and equipment will need to meet those standards. That includes controlling the quality of the original equipment manufacturers, project and design selection, procurement and storage, plant and equipment installation, operations and maintenance, and all subcontract work sent out. It requires confirming the quality of the work performed was to the standards. You need records of how well equipment was built, what was used to build it, the exact conditions it was built under and how it was operated and maintained over its entire life. Nothing during the life cycle that affects the health and wellness of the equipment is left to chance. If you do leave things to chance to decide it is certain that many times it will go badly because not everyone one knows what is right. Those that do not know the right answer, and have no way to find it, will guess. If that happens then chance and luck take over decision making in your company.

Introducing Precision Maintenance requires training in best-practice precision skills, supported in the workplace by a top-class engineering 'body of knowledge', including machinery and maintenance standards. If you want equipment in your operation at consistently high reliability, the maintenance and operations people need to develop higher work skills and quality practices that they may not yet have. To develop those skills requires setting high levels of excellence and then training people to them. Many managers, operators and tradespeople will not believe they need such high skills in their operation. This of course is a fundamental error in their thinking. They do not realise that their current processes are not capable of delivering the reliability they want. It explains why many businesses that are busy with improvement efforts still suffer poor availability and breakdowns; they are improving practices that have naturally wide ranges of outcome. Providing tradespeople with a tension wrench to tighten fasteners has little effect reducing fastener problems. Using a process that delivers ±25% variation when you need ±10% variation depends on luck for its success.

The last item in the list of key Precision Maintenance requirements is the glue that keeps the rest together. It requires installing a business process that ensures the other requirements are delivered to every machine and equipment item in the operation. The solution is to use the Accuracy Controlled Enterprise procedural tools to turn precision into standardised practices. With ACE in place you have the tool to drive amazing equipment reliability and production results. You solve equipment performance problems forever. More importantly, it lets you make Precision Maintenance a habit throughout your operation. Introducing a Precision Maintenance Program consists of:

1. Corporate approval to implement precision maintenance and precision practices
2. Agreement across the operation on the plant and equipment to be precision maintained
3. Agreement across the operation on the precision standards to use for the plant and equipment
4. Agreement across the operation on the best practices to be applied to meet the standards
5. Agreement across the operation on the measurement methods that will prove compliance to standards
6. Writing ACE 3T procedures for all maintenance and operational activities on the selected plant and equipment
7. Conducting a gap analysis to identify necessary test equipment, specialist tools and facilities

8. Identify any needed skills to be learnt by on-the-job training and expert support
9. Applying the ACE 3T procedures and refining their use
10. Monitoring the effect of the program on plant performance
11. Continually improving the use of precision skills and practices
12. Expanding the program to other plant, equipment and sites.

Setting Precision Quality Standards for Your Equipment

The solution to equipment reliability problems starts when the management of a business set standards and promote them, train to them and enforce them. The standards you need already exist, and have existed for decades. Your challenge is to bring them alive in your operation. The list below is an example of some of the books and international standards that provide the necessary information and guidance.

1. Accurate Fits and Tolerance – *ISO/ANSI Shaft/Hole Tolerance Tables*
2. Clean, Contaminant-Free Lubricant – *ISO 4406*
3. Distortion-Free Equipment – *Shaft Alignment Handbook – Piotrowski*
4. Forces and Loads into Supports – *Shaft Alignment Handbook*
5. Accurate Alignment of Shafts – *Shaft Alignment Handbook*
6. High Quality Balancing of Rotating Parts – *ISO 1940*
7. Machine Vibration – *ISO 10816*
8. Correct Torques and Tensions – *ISO/ASME Bolt, Stud and Nut Standards*
9. Correct Tools in Condition – *'As-New specification'*
10. Only In-specification Parts – *OEM specifications, Machinery Handbook*
11. Failure Cause Removal – *'5-Why'; Creative Disassembly; RCFA*
12. Proof-test – *Precision measuring tools; Condition monitoring technologies*
13. A system to use the standards successfully – *ACE 3T, ISO9001*

This list maybe incomplete for your operation's needs and you may have to look for additional standards to those listed above; but it is a good start. Note that there are not always international standards for every standard you need to set. In that case, use the recommendations of experts in the field. For example, when setting standards for equipment distortion and shaft alignment use the advice in John Piotrowski's 'Shaft Alignment Handbook' until you need to set higher standards. At that point you maybe the world-leader in a field of expertise and you will be setting quality standards that one day we will all follow.

You will only have done the job of introducing precision maintenance well when:

- you have written and published specific precision standards company-wide

- you have held seminars to explain and discuss them with all the people that need to know and use them
- you have purchased the measuring and testing equipment you need to prove compliance
- you have written ACE 3T procedures for all activities
- you have trained people to the standards and they can achieve them competently, and
- you have a document management system that records all important equipment information over its life and allows everyone fast access to the information they need to make right decisions.

Too few companies are that good. But it does not need to be that way.

Engaging the Workforce

The international benchmarking group Solomon Associates identified through their benchmarking surveys some years ago that, "Maintenance success is (ultimately) determined by decisions of craftsmen and supervisors." [84] The Solomon Associates survey found that in the end what matters most in achieving maintenance and operations success is the skills and knowledge of the shopfloor people doing maintenance on the plant and equipment.

If you want precision maintenance reliability, you will need to bring your peoples' machinery skills and engineering knowledge right-up to the level where they can deliver world-class machinery performance. This is what the ACE 3T procedural tool does for you. For Precision Maintenance to work it needs your shopfloor people and maintenance supervision to want it and to learn the necessary new skills. It requires the right engineering know-how and knowledge in the workforce, it requires procedures used in a very specific way to provide statistical quality control of maintenance work. When done properly you will maximise production for little maintenance cost.

Though your shopfloor people deliver Precision Maintenance, it is Maintenance and Operations Managers who start the change, sustain it and keep improving it. The great problem for industry is to find a reliable way to introduce the necessary changes in working practices so that precision thinking becomes the natural way to work. The journey to Precision Maintenance success needs a sound, safe and encouraging method to change the way people work. There needs to be a safe approach for maintainers to gain understanding of Precision Maintenance – its work quality requirements, the skills needed, and the procedural methods to make Precision Maintenance successful for the operation. Starting a Precision Maintenance program requires a well thought-out and structured change management process that gets your people to want to introduce and to work to higher-skilled, meticulous practices. You can do this with the 'Change to Win' change management team process explained in the 'Change To Win' workbook available on the CD accompanying this book. The 'Change To Win' program involves people in setting the higher standards that they have to meet, and helps them recognise the need to be up-skilled to meet them.

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[84] Solomon Associates, Maintenance Practice Analysis, circa 2002.

21. Change Management for Workplace Innovation

Change hardly ever works when forced onto people. We don't respond positively to force. You have to work with human nature, not against it. We need the opportunity to come around to it by ourselves [85]. That means helping people discover the good and better ways for themself. Once they find-out how to do a thing better, and are encouraged by their managers and supervisors to use the better practices, they will be highly likely to adopt the 'change' and make it a natural part of doing their work. You want a process where people welcome 'change' and positively support it.

'Push the Limit' Concept

Figure 21.1 shows the 'push the limit' method of continual progress and improvement. It is the remedy used by world-class companies to protect themselves from turning into average performers. They intentionally force themselves out of their comfort zone by setting higher targets and standards to reach, and then look for the ways to reach them [86]. Becoming world-class means adopting the same mentality as is used by world-class organisations to get to the levels of excellence they occupy. 'Push the limit' starts the planning process.

Figure 21.1 – Push the Limit Improvement Model.

Driving Continuous Improvement with ACE 3T Procedures

Once ACE 3T procedures are developed they become a means to push innovation and continual improvement. The advancement of work quality and skills is driven by resetting the tolerance range to one that is more demanding. Once people continuously achieve the 'good' standard, good is no longer good enough. A new 'best' practice standard is set, the 'best' standard becomes the 'better' requirements and the old 'better' is reset as 'good'. This puts the 'precision principle' into operation and harnesses people's desire to improve their skills and simplify processes. Figure 21.2 highlights how the ACE 3T standard is changed to drive improvement.

Task Step No	Task Step Owner	Task Step Name	Materials and Tools and Their Condition	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)	(Include diagrams and pictures)	Good	Better	Best			
		Higher Standards Drive Improvement									

Figure 21.2 – Driving Quality Improvement and Innovation with Higher ACE 3T Standards.

85 Carnegie, Dale, 'How to Make Friends and Influence People', Simon and Schuster, 1936.
86 Wardhaugh, Jim, 'Maintenance – the best practices' Presentation, Maintenance IQ's Reliability and Maintenance Congress, 2005.

The 'Change To Win' Team-Based Business Improvement Program

'Change To Win' is a structured change management program used to introduce needed changes, best practices and innovative improvements into an organisation. The program uses a team-based process for helping people to learn for themselves of better ways and better practices which they can include into their work. A team consisting of the manager, the supervisor and people from the affected workplace is assembled to introduce needed changes with the help of a facilitator. They are responsible to understand the issues, find the solutions and plan how the organisation will adopt the changes, including trialling the ideas and implementing them into standard practice. Together they use their individual expertise to find ways that 'push the limit' and bring better methods into the operation.

Internalised ideas and values can change when new knowledge is found that contradicts current beliefs and causes cognitive dissidence. The 'Change To Win' approach is to let people discover new knowledge for themselves and then use it to fix their problems. To give people the chance to learn new ideas and develop ownership of them, the 'Change To Win' program gets team members to research and investigate a range of options to address a problem. It encourages team members to go outside of their personal comfort zones and look for better practices and technology they don't yet know of. Driving workplace evolution is the job of the 'Change to Win' 100-day program and its 5-Wheels of Change shown in Figure 21.3.

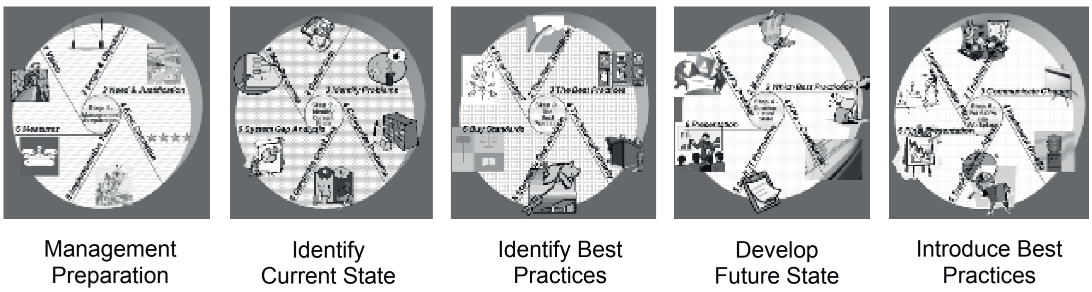

Figure 21.3 – The 5 Wheels of Change in the 'Change to Win' 100-Days Program.

The usefulness of an innovation to a business needs to be proven. People will only change current practices if the evidence and the support structure is in-place to make the change. A non-threatening way to do that is with a trial project to show people just how good an innovation is. A 'Change To Win' program is a change project limited to 100 days. 100 days is short enough for people to wait for evidence, yet long enough to do the project well. Once the 'experimental' project is a success, you have real proof from within the business that the change works. With each success more 100-day projects are started, until everyone becomes involved in making positive changes.

The 'Change To Win' approach is not for problem solving, though it can be adapted to do so. Solving problems is done with 'Root Cause Failure Analysis', 'Creative Disassembly, or the '5-Whys'. The 'Change To Win' process is a behaviour change process that improves organisational performance by introducing and integrating higher standards of performance into business processes. The 'Change To Win' program is used to change a company by bringing best practices into the workplace. Examples include introducing TPM (Total Productive Maintenance) into an Operation; introducing Lean Manufacturing into a manufacturer; introducing a new software system into a business; introducing an ISO 9001 quality system into a company, introducing a 5S good workplace habits program into a factory or office, and introducing Precision Maintenance into the production workforce.

The 'Change To Win' Workbook

The 'Change To Win' program uses a simple workbook that each team member follows over the 100-day period. It is a friendly, low-risk, low-cost strategy to introduce changes into an operation. The teams start at the front of the workbook and each week they progress on agreed tasks until the project is complete. At weekly meetings the team reviews progress on the action plans. When the workbook is completed, the program ends.

The 'Change To Win' Program workbook is provided in the CD accompanying this book. It is part of the Plant and Equipment Wellness Methodology you brought. The 'Change To Win' workbook contains the complete change management process to apply. The workbook is self-explanatory. It uses a team facilitator to guide and encourage the 100-day change process. The facilitator helps teams to work their way through the workbook and apply the process. They keep the team on-track and on-schedule. Like everything that people do, the more often we do it the better we become. Once a facilitator uses the 'Change To Win' program with two or three teams it will become second nature to them.

The example used in the workbook for applying the 'Change to Win' method is the introduction of Precision Maintenance into an organisation. Though shopfloor people deliver Precision Maintenance, it is Maintenance and Operations Managers that need to start the change, sustain it and keep improving it. The journey to Precision Maintenance success needs a sound, safe and encouraging method to change the way people work. Starting a change initiative like Precision Maintenance requires a well thought-out and structured change management process that gets people to want to work to new, higher-skilled precision practices. Instead of risking that your improvement project becomes another failed management fad, you use this practical process to help people buy into the change; first with their heads, and then with their hearts and souls as they see the change begin to work.

22. The Plant and Equipment Wellness Vision

This last chapter summarises the purpose of this book with an image of its aim, which is to provide the tools for creating a business system that produces outstanding equipment reliability and life cycle profits. Plant and Equipment Wellness brings people, processes, capital and culture together in the never ending cycle of Figure 22.1. Ongoing innovation and learning lifts the organisation and its people to world-class excellence by making excellence how they do their work.

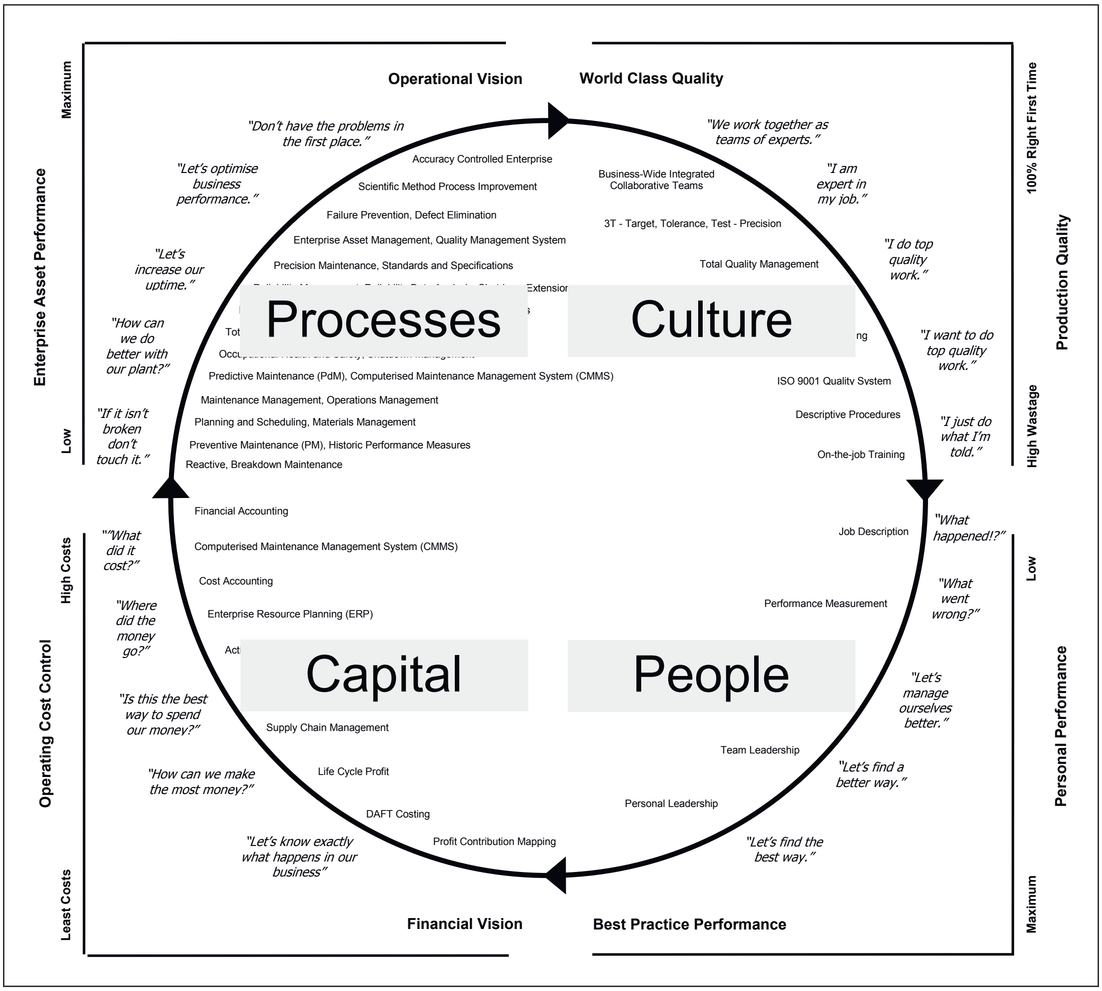

Figure 22.1 – Plant and Equipment Wellness.

What will your operation look like if you made a movie of how it performs at world class levels? Will it include adopting the necessary business processes, practices, culture and capital requirements to create an organisation that looks after the health and well-being of its machines and equipment? Focusing business-wide effort on providing for the health and wellbeing of machines and their parts may seem misguided. In a world growing ever more competitive and demanding there must be many things more important than building business systems and processes to look after machines. That of course is the trap that most industrial organisations have fallen into in the past. They don't realise that their machines support everything they want the business to achieve. No plans and dreams will be realised without machines that can make products with the quality, cost and delivery that customers willing buy. Nothing else matters to your customers but getting the best value for their money. Long-lasting success depends on the wellness and lifetime reliability of your machines' parts. Ensuring the health of the parts automatically produces highly reliable machines, plant and equipment. An operation full of plant and equipment that never stops making top quality products, for the least cost, run by the most competent of people and working in an environment of continual learning and innovation has a great chance of success.

Start a new world-class future by mapping a path to it. What are the steps along the way? What Plant and Equipment Wellness methods and processes will you use to get world-class performance from your operation?

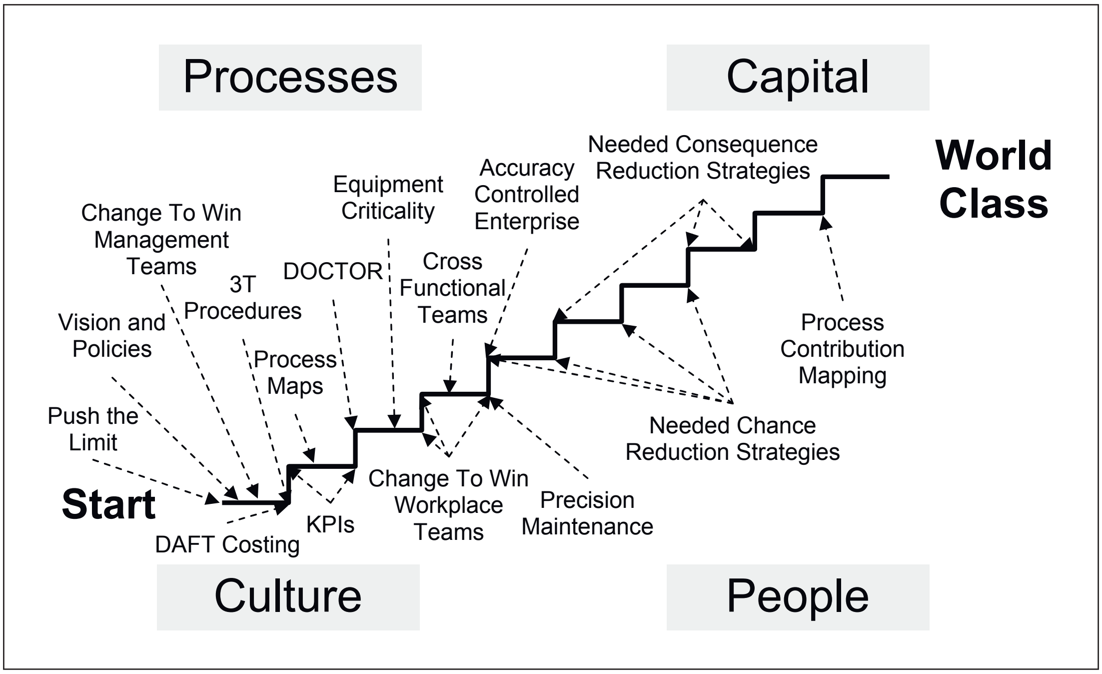

Figure 22.2 – The Steps on the Path to World Class Performance.

I hope that you now question your beliefs and understandings of what you need to do in your organisation to help it, and its people, to be the best of the best in your industry.

My best regards to you,

Mike Sondalini
www.lifetime-reliability.com