

## The 3 Levels of Reliability

Approaches to achieving perfect reliability has evolved over the years like many other disciplines as outlined in the table below.

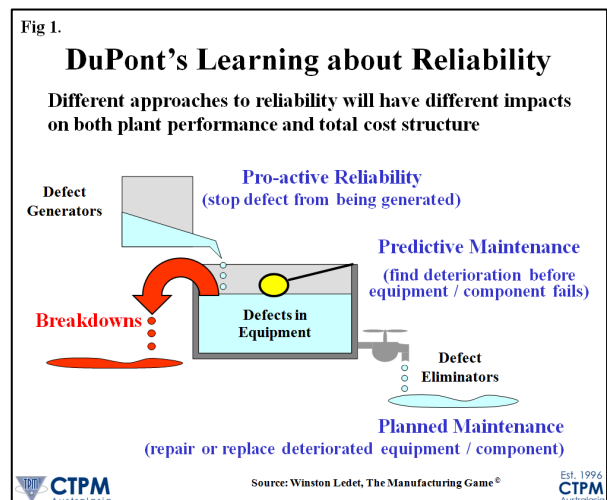
Approach	Methodology	Focus	Enablers	Resp
<b>Reactive</b>	Breakdown Maintenance	Fix it when it breaks supported by basic servicing eg lubricating	Quick response Good diagnostics	<b>Maint</b>
<b>Planned</b> (1950's)	Preventive Maintenance (PM)	Periodic Replacement plus Inspection / Checks leading to Corrective Replacement	Maintenance Management Systems	<b>Maint</b>
	Predictive Maintenance (PdM)	Condition Monitoring leading to Corrective Replacement	Monitoring Equipment with Technical Expertise	<b>Maint</b>
<b>Designed</b> (1960's)	Productive Maintenance	Reliability focus in plant design	Life Cycle Costing	<b>Eng</b>
<b>Toyota: Maintenance can't do it by themselves, Operators needs to be involved</b>				
<b>Pro-active</b> (1970's)	Total Productive Maintenance (TPM)	Equipment Defect Identification and Elimination	Clean for Inspection Train for Inspection	<b>Prod</b>
<b>DuPont: Maintenance can't do it by themselves, Everyone needs to be involved</b>				
<b>Learning</b> (1990's)	TPM & Lean (TPM <sup>3</sup> )	Equipment Defect Avoidance and Equipment Management	Goal Alignment Ownership Engagement of all	<b>Prod</b>

It was Toyota, as they developed their Toyota Production System that came across the importance of getting the Operators involved in finding equipment defects or problems at the earliest possible time. This was taken from the concept of Prevention at Source and taught to the Japanese by Dr Edwards Deming as he promoted a quality approach to improvement.

DuPont, the American chemical and specialties conglomerate, in their search for best practice in reliability, came across the impact of this thinking being successfully applied at similar plants to their own in Japan through their global Maintenance Benchmarking Studies of the early 90s.

To help explain this new learning, they developed a slide (refer to Figure 1) to explain the different approaches to reliability they had discovered.

Their previous approach to reliability, like many other leading companies, was to apply and perfect Planned and Predictive Maintenance activities to minimise breakdowns so as to significantly reduce costs from expensive breakdowns. This approach



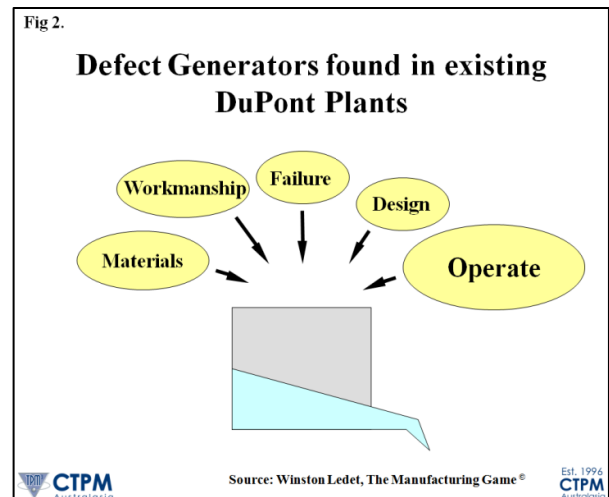
was achieving high reliability, however, when benchmarked to similar Japanese plants practicing Prevention at Source for Equipment through their TPM activities, their number of work orders generated were some 10 times higher and their costs were some 30-50% higher.

They also acknowledged that when downturns occurred in their industry, maintenance was often a high agenda item for Senior Management to seek cost reduction with Preventive / Predictive activities reduced to create short term savings often having dire consequences in the long term when plant reliability took a hit (and Senior Management who made the cuts had moved on).

As a result of the benchmarking study, they realised that in their plants they generate equipment defects which get stored in the equipment until they create deterioration that if not picked up on, will lead to failures or break downs.

Planned and Predictive Maintenance was well known to them, however this concept of Prevention at Source for Equipment and stopping the equipment defects from being generated was a whole new opportunity to significantly reduce their maintenance spend.

Firstly they needed to understand where the defects were being generated and how many were being generated from each source to allow prioritising of their improvement efforts. Figure 2 is a summary of their learning where the area of each source of defects indicates the magnitude of defects they found for their existing plants (sadly new plants often have a different profile with a larger proportion allocated to Design unless the new plant or equipment has been specified using a Prevention at Source for Design approach).



DuPont found that equipment defects or imperfections (anything that could lead to early or accelerated deterioration of component life) are subtle and not always obvious. They are often difficult to identify and correct because they are traditionally accepted as the norm. They "flow" into plant & equipment due to various reasons:

- **Materials:** imperfections in the maintenance materials we use due to wrong purchases, poor repairs or poor storage;
- **Workmanship:** the poor way we carry out our maintenance activities often due to the environment we work in or the pressures from production to complete the job quickly;
- **Failure:** one failure may lead to other failures as a consequence of the initial failure;
- **Design:** poor initial design or changes to the initial design requirements of our plant & equipment due to output requirement changes; and
- **Operate:** the way we operate our plant & equipment due to lack of training or lack of care and the environment we operate our plant & equipment in.



Equipment defects play a major part in causing "losses" in equipment performance, however a key learning from DuPont was that all personnel need to be involved in Equipment Defect Avoidance, not just the Maintenance and Production departments.

Their learning was that the key to achieving the best reliability at the lowest possible cost was 'to eliminate the generators of equipment defects (Prevention at Source for Equipment) rather than just focusing on identifying and removing them'. This involved engaging the entire organisation in reliability thinking so as to stop the defects from being generated. From Figure 2 we can see that Operate was the biggest source of defects and as such engaging the Frontline was critical to having the biggest impact on reliability.

## A Simple Reliability Analogy

Is your Plant & Equipment like a company vehicle?

The vehicle is purchased by your company to a specification and comes with an Operator's manual and a Service manual. The vehicle is owned by your company, however it is sometimes allocated to a specific person to care for it and arrange its regular service. The servicing and major repairs are conducted by Mechanics (**Tactical** experts) while minor servicing (topping up oil, water, air etc) are done by the person (**Frontline**). The Designer (car company) who is focused on minimising the Life Cycle Cost of the vehicle (**Strategic**) through standardising components with other models and focusing on maintainability (minimizing maintenance costs over life of vehicle) as well as prepares and provides the Operating and Service Manuals.

However, some vehicles are not allocated to specific personnel and are common pool vehicles. These vehicles normally have much higher operating costs, are less reliable, are in poorer condition and have a significantly reduced resale value (worth to your company).

To achieve the best possible reliability at the lowest cost you need to apply the learning above to your Plant & Equipment.

The Plant & Equipment is purchased and owned by your company and hopefully comes with technical specifications on how to operate it (SOPs) and service it (Maint / Service Manual).

The key difference is whether we allocate the ownership to the Production Manager and Operators through the application of Australasian TPM & Lean we call TPM<sup>3</sup>, or keep it as a common asset looked after by Maintenance (traditional strategy of 'I operate – you fix').

### ***'the cost and reliability implications are enormous'***

The TPM<sup>3</sup> approach first establishes Production Area Based Teams of 4-8 personnel including a designated Team Leader with ownership to their plant & equipment and responsibility for the frontline care of their equipment. The next step is to create a Tactical Maintenance capability that not only provides good traditional maintenance support but also can train the operators in

Equipment Care while responding rapidly to small issues and equipment defects identified by the Operators. Finally there needs to be a strategic capability established to take responsibility for ensuring any new plant & equipment is 'User Friendly – easy to operate, maintain, train people on and uses standardised components'; maintenance is conducted across the site to a quality standard, and that major overhauls and special technical support is co-ordinated.

This approach is too often described as applying the 3 Levels of Reliability (as summarised in the table below) to ensure **the best possible reliability at the lowest cost** of the Plant & Equipment.

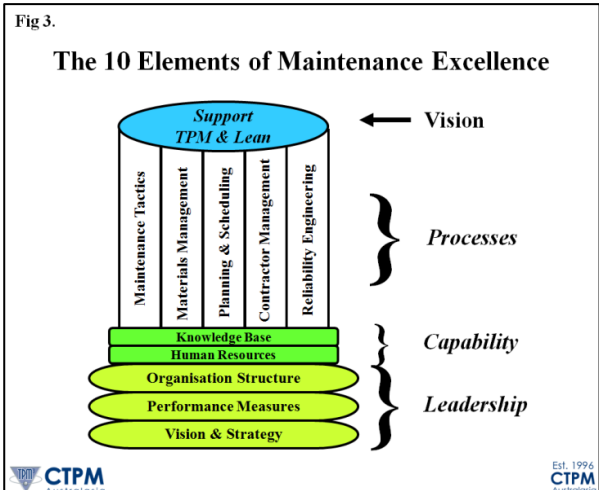
3 Levels of Reliability	Who	Key Role
<b>Frontline</b> Care of Equipment	Operators in Area Based Teams	<ul style="list-style-type: none"> <li>• Operate Plant</li> <li>• Ensure Basic Equipment Conditions</li> <li>• Minor Servicing</li> </ul>
<b>Tactical</b> Maintenance	Area Maintenance	<ul style="list-style-type: none"> <li>• Breakdowns</li> <li>• Planned / Predictive Maintenance</li> <li>• Support Frontline Care of Equipment</li> </ul>
<b>Strategic</b> Maintenance	Central Maintenance	<ul style="list-style-type: none"> <li>• Standardise components / practices / lubrication</li> <li>• Major Overhauls across site</li> <li>• Technical expertise across site</li> </ul>

## Key Maintenance Management Strategies that supports the 3 Levels of Reliability

The starting point should be to progressively engage all maintenance personnel in production focused Cross-functional improvement teams striving to understand and improving Overall Equipment Effectiveness losses. The aim here is to improve plant performance to free up time for further improvement activities while also building relationships between Production and Maintenance.

This should then be followed with introducing Formal On-going Improvement Activities for Maintenance, initially focused on reducing Time Lost by Maintenance personnel to free up their time to support Production Area Based Teams followed by improving the 10 Elements of Maintenance Excellence Management (refer to Figure 3).

The Maintenance Improvement Teams typically include Work Area Management / Maintenance Process Management (WAM / MPM) Area Based Team improvement activity and Maintenance Improvement Teams (MIT) Cross-functional Team improvement activity.





This will allow time and capability to focus on developing the 3 Levels of Reliability.

1. Assist Operators in their learning to better understand and care for their plant & equipment (ie address the primary source of equipment defects) through TPM<sup>3</sup> Activities such as Focused Equipment & Process Improvement (FE&PI) Cross-functional Team improvement activity and Work Area Management / Operator Equipment Management (WAM / OEM) Area Based Team improvement activity;
2. Develop maintenance capability in Preventive / Predictive Maintenance, Planned & Corrective Maintenance, Process Capability and ability to respond rapidly as required to any unforeseen situation affecting the safe operation of the plant & equipment; and
3. Provide reliability expertise.

## Applying this learning to the DuPont Defect Generators

The 3 Levels of Reliability should focus on addressing all 5 Defect Generators as shown in the table below.

Defect Generator	3 Levels of Reliability	TPM <sup>3</sup> Activities
Materials	Tactical	<ul style="list-style-type: none"><li>▪ Maintenance Excellence Management Elements – Knowledge Base (E5), Materials Management (E7), and Reliability Engineering (E10)</li></ul>
Workmanship	Tactical	<ul style="list-style-type: none"><li>▪ Maintenance Excellence Management Elements – Human Resources (E4), Knowledge Base (E5), Maintenance Tactics (E6), Planning &amp; Scheduling (E8), and Contractor Management (E9)</li></ul>
Failure	Tactical & Strategic	<ul style="list-style-type: none"><li>▪ Maintenance Excellence Management Elements – Reliability Engineering (E10)</li><li>▪ New Equipment Management</li></ul>
Design	Tactical & Strategic	<ul style="list-style-type: none"><li>▪ Maintenance Excellence Management Elements – Reliability Engineering (E10)</li><li>▪ New Equipment Management</li></ul>
Operate	Frontline	<ul style="list-style-type: none"><li>▪ Maintenance Excellence Management Elements – Vision &amp; Strategy (E1), Performance Measures (E2), Organisation Structure (E3), and Human Resources (E4)</li><li>▪ Focused Equipment &amp; Process Improvement</li><li>▪ Education &amp; Training (Base Skills)</li><li>▪ Education &amp; Training (Mastery Skills)</li><li>▪ Education &amp; Training (Team Skills)</li><li>▪ Work Area Management</li><li>▪ Operator Equipment Management</li></ul>

*For more information about CTPM's approach to achieving perfect Reliability and the 3 levels of Reliability, please contact Ross Kennedy on +61 2 4226 6184; or email: [ross.kennedy@ctpm.org.au](mailto:ross.kennedy@ctpm.org.au); or visit CTPM's web page at: [www.ctpm.org.au](http://www.ctpm.org.au)*