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Most Industrial Operations Make Their Equipment Fail

Let a Plant Wellness Way EAM System-of-Reliability End Your Business Risks Forever

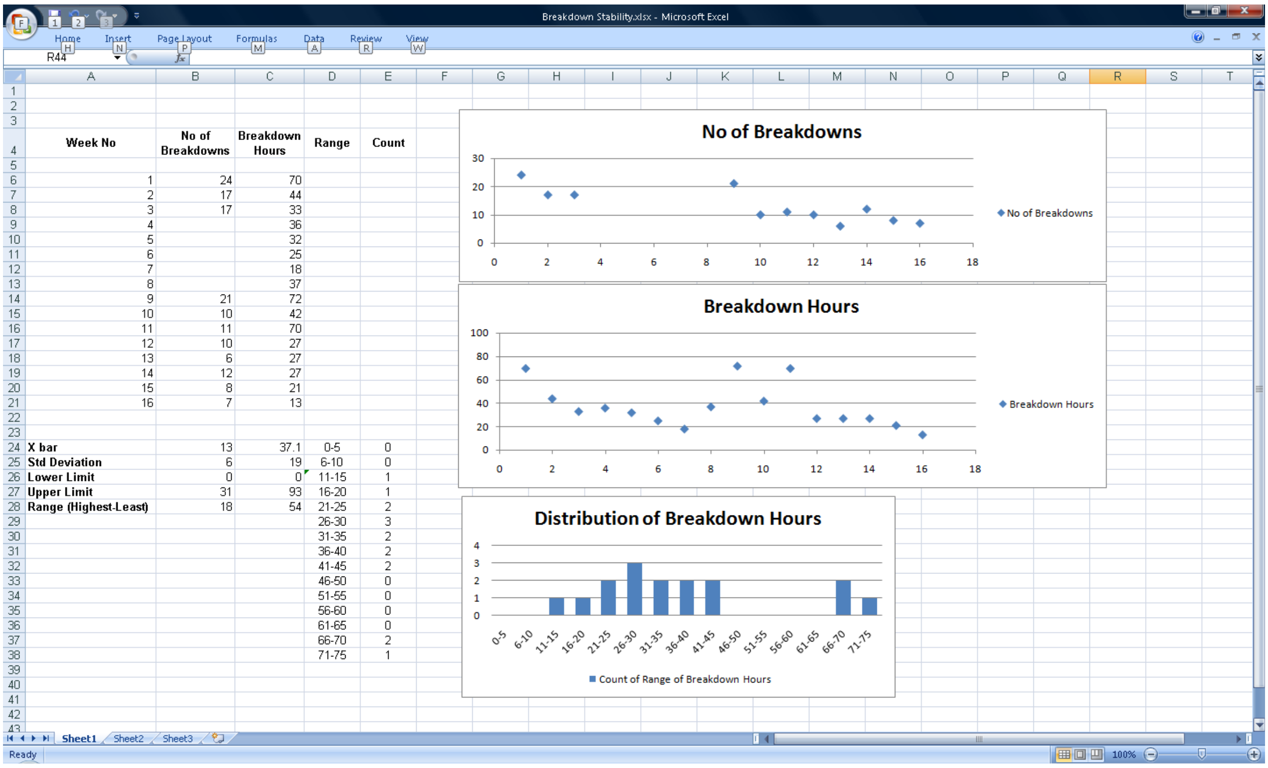
Abstract:

Most industrial operations make their equipment fail. High reliability does not result from doing maintenance. Rather, it is the result of using quality management processes when doing the maintenance. Organisations with high equipment reliability are designed with business processes built to create reliability. Reliable equipment is a 'product' that they produce.

Most industrial businesses make their equipment fail. Their business processes are designed to cause equipment breakdowns. An analysis of a real example illustrates this common problem.

Figure 1 shows two scatter plots developed from a plastic pipe manufacture's plant maintenance history. The top plot is the number of breakdown work orders raised each week over a four-month period. The lower plot is the number of maintenance hours needed to fix those breakdowns. The distribution curve at the bottom is the frequency of hours spent each week on breakdowns. The breakdown distribution plot is telling—it is bimodal. This company has two stable processes that each create breakdowns—one makes regular weekly failures, and one makes sporadic catastrophic failures.

Analysing if Your Business has a Stable Process of Causing Breakdowns

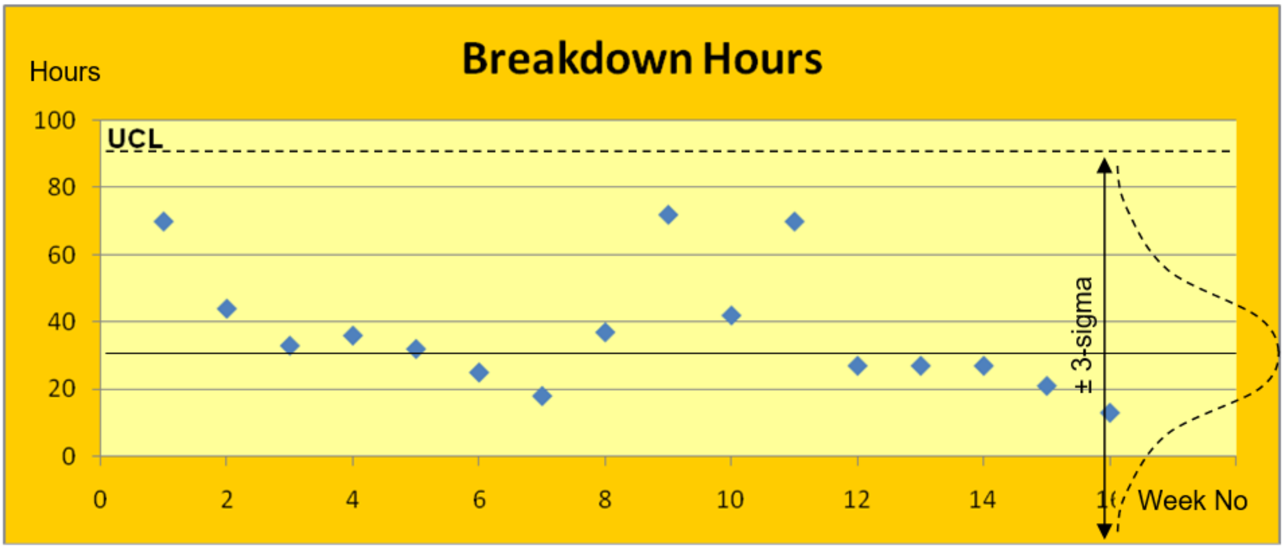


Week No	No of Breakdowns	Breakdown Hours	Range	Count
1	24	70		
2	17	44		
3	17	33		
4		36		
5		32		
6		25		
7		18		
8		37		
9	21	72		
10	10	42		
11	11	70		
12	10	27		
13	6	27		
14	12	27		
15	8	21		
16	7	13		
X bar	13	37.1	0-5	0
Std Deviation	6	19	6-10	0
Lower Limit	0	0	11-15	1
Upper Limit	31	93	16-20	1
Range (Highest-Least)	18	54	21-25	2
			26-30	3
			31-35	2
			36-40	2
			41-45	2
			46-50	0
			51-55	0
			56-60	0
			61-65	0
			66-70	2
			71-75	1

Figure 1 – Business Processes that Cause Equipment Failures and Breakdowns

The distribution curve for regular failure has 'settled' around 26-30 hours of breakdown a week and will remain there forevermore. The distribution plot warns us that within this operation there are regular and on-going causes of equipment failures which randomly arise to take-down the plant. Everywhere within their production machinery are defects waiting to become production problems. In time the defects become the failures shown on the weekly breakdown graphs.

Graph 1 is the time series of the company's total breakdown hours per week for sixteen weeks. Important information about the company's way of operation can be exposed by using basic statistical analysis. If the graph is representative of normal operation, the time series can be taken as a whole. The average breakdown hours per week are 31 hours. The standard deviation is 19 hours. The Upper Control Limit at three standard deviations is 93 hours. Since all data points are within the statistical boundaries, the analysis indicates that the breakdowns are common to the business processes and not caused by outside influences. This company has a statistically stable system for producing equipment breakdowns. Because the breakdown creating process is stable, the future generation of breakdowns is predictable and certain. If this time series is a true sample of normal operation, it can confidently be said that there will always be an average of 31 hours lost to breakdowns every week in this business. This business has built breakdowns into the way it operates because the process of breakdown creation is a stable and inherent way of operation. This company makes breakdowns as a 'product'. The only way to stop them is to change its business processes to those that prevent breakdowns.



Graph 1 – Breakdown Hours per Week

None of the breakdowns had to happen. They resulted from a bad reliability creation process. If truth be told, this company built themselves a breakdown creation process—they never had a reliability creation process. Had there been a true reliability creation process in the operation then not one failure would have occurred. For this business, its breakdowns were a natural result of the way the company worked. The company involved is now a much better company, but they had to change their maintenance and reliability processes to do that. To stop failure, they changed to methods that prevented the causes of breakdowns; they stopped the defects starting.

Understanding Quality

In his book 'Out of the Crisis', W. Edwards Deming, the now deceased quality guru, advises that "quality must be built-in"[1]. He requires that quality be quantified in terms of engineering measures that, when achieved, would deliver customer satisfaction. In his view a product or service has the

[1] Deming, W. Edwards, 'Out of the Crisis', Page 49, MIT Press, London, England, 2000 edition

right quality when the customer is so satisfied that they boast about it to people they meet. The quality of the product or service is designed to ecstatically satisfy the customer. Word-of-mouth markets it.

What is important to know about quality is that it must be measurable. Quality is not left up to people to interpret what they think it means. It needs to be quantifiable – a length, a thickness, a resultant force or pressure, a colour, a smell, a viscosity, a period, a rate of change. You require a specific engineering value, even a collection of values, which defines a level of performance. Once the values are attained, the performance is certain, and the required quality is achieved.

Quality, Deming tells us, is installed at the source. It is designed in and made part of the product or service. Quality is a definite and 'hard' measure that can be clearly identified. The same certainty over quality, but applied to equipment parts, is necessary to deliver the outstanding equipment reliability and plant availability that produces world-class production performance.

To make quality you need a target and a range of acceptance. It is impossible to know how to control quality until standards of allowable variability are set. Once a standard is specified it is then possible to measure if the processes used to achieve it can meet the standard. For the business reflected in Graph 1, the processes used can never deliver long periods of breakdown-free operation. They are not designed to produce a breakdown-free week. It is nearly impossible in this operation to expect more than a couple of days without breakdowns. This company needs to fundamentally change its business processes if they want to improve their equipment reliability. Their current reliability management does not work. In fact, it causes breakdowns.

Were the company to set a target average of (say) ten breakdown hours a week, it is clear from Graph 1 that the current operation cannot achieve it, and a search for the methods and strategies to reach 10 hours breakdown per week would start. The great challenge for this company is to replace years of destructive practices in operations and maintenance with those processes and methods that produce high reliability. This change would start when they decide to create business processes that make more uptime.

Maintenance Cannot Deliver World-Class Reliability

Equipment is not reliable because it gets maintained. High equipment reliability has only a little to do with the maintenance done on equipment. All industrial operations in the world maintain their equipment, yet the vast majority suffer from poor equipment reliability. Even doing maintenance to a planned schedule will not deliver you reliable equipment. High reliability is mainly due to factors other than maintenance, which you will read of soon.

Figure 2 is representative of the maintenance strategies available to organisations and the plant availability they can achieve. It stems from work done at DuPont Chemicals by Winston Ledet or R. Schuyler. It provides a hint of an answer to what makes exceptionally reliable plant and equipment.

Point 'A', with 90% Availability, cannot be reached by reactive operations. These unfortunate businesses are doomed to always have costly maintenance and poor production performance. 90% Availability can be achieved by operations with a combined Preventative, Predictive and Planned Maintenance strategy. They will see better production performance and lower maintenance costs. By changing strategy to one with a Reliability-growth, Precision Maintenance and Defect Elimination focus, a far greater operating profit margin and maintenance performance awaits operations which do that for the very same maintenance cost. Point 'B' shows that availability and, by implication equipment reliability, has little to do with how much money you spend on maintenance. It is the choice of maintenance strategy that matters most. For the identical maintenance costs, the strategy selected has the greatest effect on production and maintenance performance.

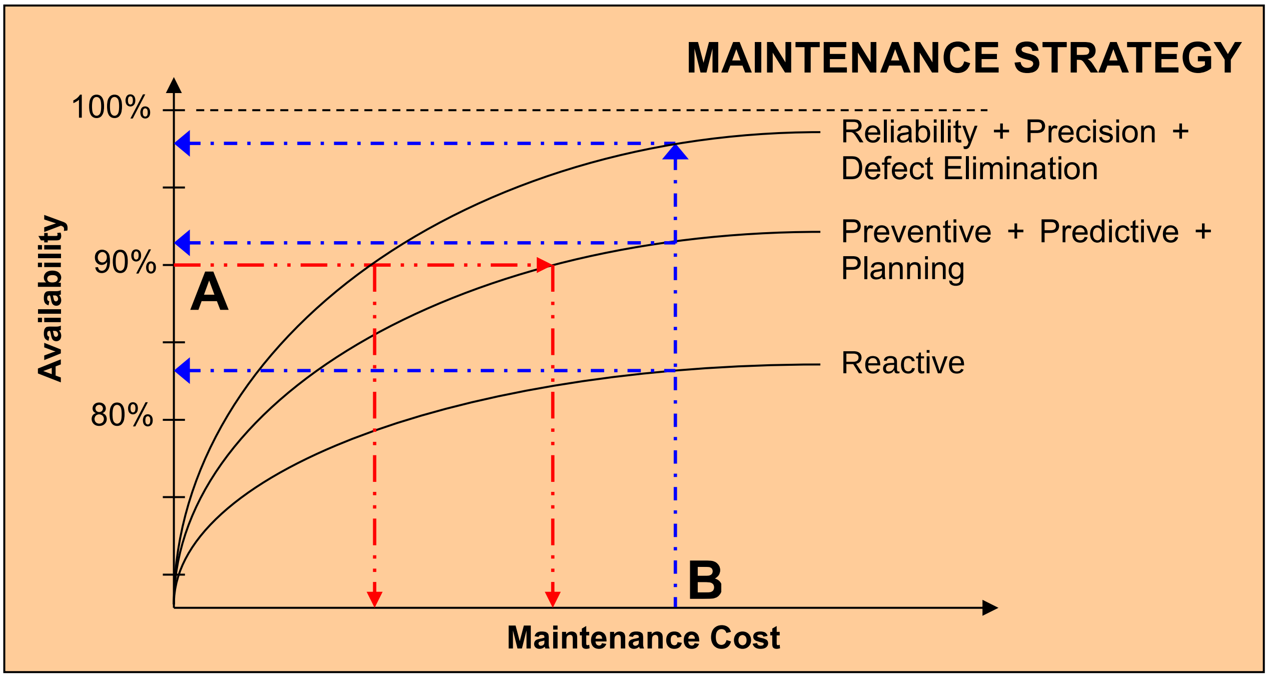


Figure 2 – Higher Plant Availability and Equipment Reliability is the Result of Changing Maintenance Strategies and not Spending More Money on Maintenance

Reactive Maintenance is an easy but disastrous business decision for an organisation's management to make. It leads to poor equipment utilisation, much production downtime and high operating and maintenance costs. Unless your products sell at high premiums, and you can easily afford to pay for the excessive operational costs of using reactive maintenance practices, your business would struggle with high production losses and unsatisfactory operating profit.

Combining Preventative, Predictive and Planned Maintenance together leads to higher plant availability and subsequent improved operational performance. This maintenance strategy involves being prepared and organised to do necessary equipment maintenance before there is an equipment breakdown. Replacing parts before they fail can bring higher equipment reliability. The approach minimises plant downtime and reduces equipment maintenance costs by preventing unplanned production loss. It turns what would have been a breakdown into a planned production schedule stop. There is no cost of lost productivity from a breakdown because the plant is instead scheduled to be down for maintenance. When you look closely at what is done in a Preventative, Predictive and Planned Maintenance strategy you see that it is simply trying to maintain equipment part's quality at a level to produce a certain production performance.

The Reliability-growth, Precision and Defect Elimination strategy is not really a maintenance strategy. It requires that Preventative, Predictive and Planned Maintenance be done, but it now adds quality management into the mix. The use of Reliability-growth, Precision and Defect Elimination practices introduces quality control methodologies. Such a business decision leads to the use of practices and methods that produce outstanding plant and equipment availability.

Improved equipment and production process reliability appears as improved production plant availability. Table 1 lists the number of days of lost production in a continuous operation for different levels of availability. To go from a reactive operation of 80% availability to a Preventative, Predictive and Planned Maintenance operation of 90% availability means halving the number of days lost to downtime. To go from 90% to the Reliability-growth, Precision and Defect Elimination possibilities of 95% availability again requires having the downtime lost. The analysis from Graph 1 tells us that it is impossible to halve the downtime losses using a company's current processes. The downtime is the result of the processes. Halving downtime requires changing to business processes that produce the necessary uptime.

For Continuous Operation Plant		
Availability %	**Downtime** Days per Year	**Uptime** Days per Year
80	73	292
85	55	310
90	37	328
95	18	347
98	7	356
99	3.7	361.3
99.5	1.8	365.2
99.9	8.8 hrs	364.7

Table 1 – Maximum Allowable Downtime

All three maintenance tactics shown in Figure 1 involve doing maintenance, but only one strategy leads to outstanding equipment reliability and world-class production performance with low equipment maintenance costs. The Reliability-growth, Precision and Defect Elimination strategy has quality control as the key difference between it and the other maintenance tactics. Using quality systems and practices produce the dramatic improvement in the cost-benefit performance of the Reliability-growth, Precision and Defect Elimination strategy. Therefore, I can say with confidence that high equipment reliability has little to do with the maintenance done on equipment. High reliability is mostly dependent on the reliability engineered into the equipment, the quality of workmanship used during equipment manufacture, installation and reassembly, the quality of the parts used, and the quality of the operating practices. If none of these are 'hard measures' with defined limits, quality outcomes are impossible to achieve with certainty and so anything can happen.

Changing Wrong Business Processes

If quality makes all the difference to gaining ultrahigh production equipment reliability and outstanding operational performance and results, then it is a factor every operations manager, production manager and maintenance professional needs to know about and understand well. This often requires changing well entrenched misunderstandings that cause equipment failures.

An example of such a classic misunderstanding present in industrial businesses that makes their equipment breakdown is the tightening of fasteners. This misunderstanding is the root cause of many looseness and vibration problems. Figure 3 shows the variation in the typical methods use to tighten fasteners[2]. The method that produces the greatest variation, ranging ± 35%, is 'Feel- Operator

[2] 'Fastener Handbook – Bolt Products', Page 48, Ajax Fasteners, Victoria, Australia, 1999 edition

judgement', where muscle tension is used to gauge fastener torque. Even using a torque wrench has a variation of ± 25%, unless special practices are followed that can reduce it to ± 15%.

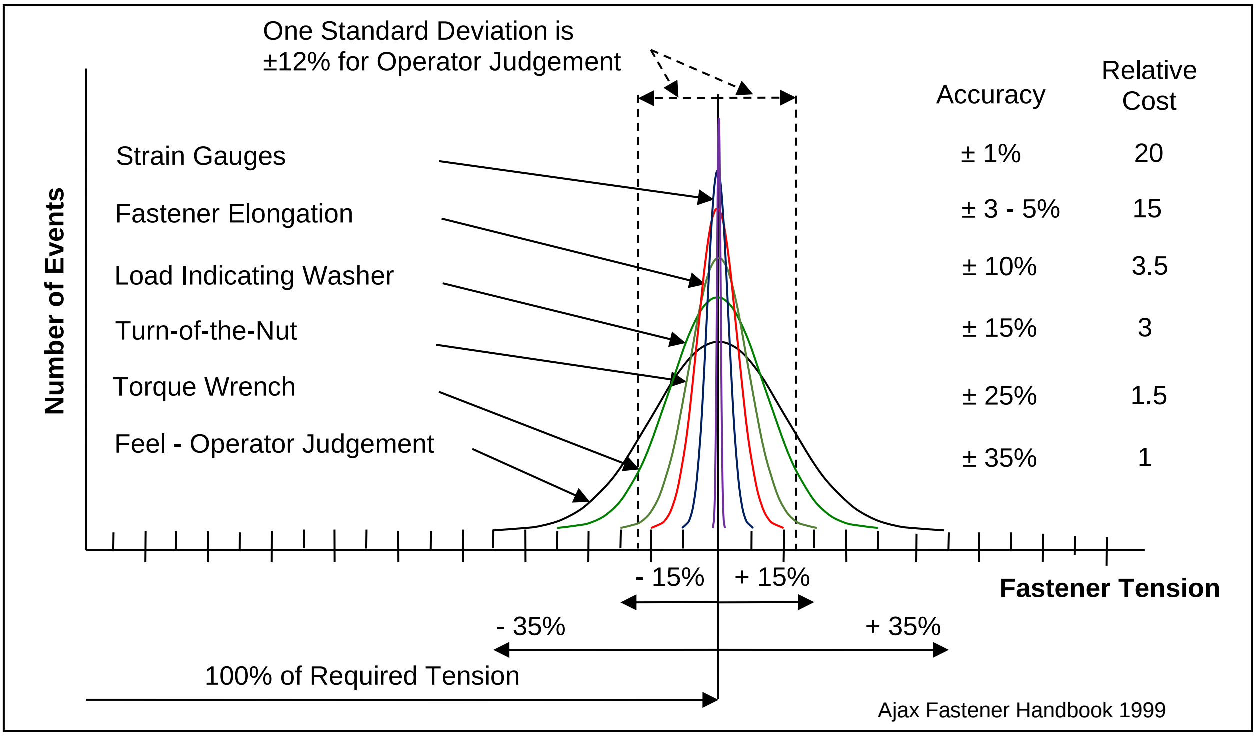


Figure 3 – Variability in Methods of Providing the Correct Torque for Fasteners

It is impossible to achieve high accuracy when tightening fasteners using muscular feel. Those companies that approve the use of operator judgement when tensioning fasteners must also accept that there will many cases of both fastener looseness and broken fasteners. The natural consequence of the management decision to use operator judgement when tensioning fasteners is higher rates of fastened joint failure. It cannot be otherwise because the process used to torque the fasteners has a high amount of inherent variation. It would be a very foolish manager or engineer who demanded that their people stop fastened joint failures by ensuring correct fastener torque but only allowed them to use operator feel or tension wrenches to control the accuracy of their work. Such a manager or engineer would come to believe that they have poorly skilled and error-prone people working for them, when it is the processes that they specified and approved which is causing the failures. They may rant and rave that they have fools and idiots in their crew, when in fact it is they that totally misunderstand the real cause of the failures.

To stop fasteners failing requires a process of fastening that delivers the required shank extension. Torque is a poor means for ensuring proper fastener fastening. It is the fastening process that must first be changed to one that can guarantee the desired fastener performance. Only after that management decision is made and followed through by purchasing any necessary technology, quality controlling the new method to limit variation and training the workforce in the correct practice until competent, that the intended outcome can always be expected.

The use of operator-feel when tensioning fasteners is a management decision that automatically leads to breakdowns. Any operation using people's muscles to control fastener tension has breakdowns built into its design. It is why the late quality guru W. Edwards Deming said his famous warning to managers, "Your business is perfectly designed to give you the results that you get."

Poor equipment reliability is the result of choosing to use business and engineering processes that have inherently wide variation. These processes are statistically incapable of delivering the required performance with certainty, and so equipment failure is a normal outcome of their use and must be regularly expected. Failure is designed into the business.

Install Quality Management into Operations and Maintenance

Deming also gives us a method to address poor business processes. The first step is to measure the statistical performance of the current process. (He warns to use appropriate statistical methods and requirements if valid interpretations are to be made.) The initial analysis shows-up if the current processes are statistically stable. Management can then decide to accept the inherent performance of the process and stop expecting better results than their business is designed to produce. Or they can decide to improve the business processes to those that inherently deliver better outcomes. The company shown in Figure 1 has the choice of leaving the breakdown creation process as it is and accept that they will always lose 31 hours a week on average from breakdowns, or it can start to change its processes to include methods that increase equipment reliability.

Deming suggests that any new methods first be trialled and tested to prove they actually do produce improvements. Like the original analysis, the new methods are tracked and trended to statistically confirm they do deliver better results. When a technique is proven successful it is integrated into the business processes through procedural changes and one-on-one training until individuals are competent at the new method. If a trial is not successful it is discarded and the learning from the trail is used to select a new option to test. In this way a company builds into its own design the processes that automatically deliver better performance.

The above quality improvement technique is the famous ‘Plan-Do-Check-Act’ Deming Cycle, a methodology created by Walter A Shewhart and championed by his apostle, Deming.

Conclusion

Equipment reliability is a business process. Like all business processes it is designed by management choice. If you want high reliability, it is necessary to create the processes that will deliver it with certainty. If you use business and engineering processes with wide variability and expect them to deliver reliability, you are running your business on hope and luck and not by good practice. To get high reliability you need to apply quality management systems and quality control in the processes you use to deliver reliability. Adopt the right processes in your company, quality control how the people and processes deliver reliability, and use the Deming Cycle to learn how to improve the processes to world-class performance.

My best regards to you,

Mike Sondalini
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