Leveraging Maintenance to Minimize Operational Risks and Costs

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ABSTRACT

System redundancy is a common design element in the water utilities industry. While this protects plant performance, it can also mask the risk and cost impact of poor maintenance.

Without 'obvious' breakdowns to drive improvements in maintenance, the maintenance philosophy can become neglected. The life being obtained from the equipment, however, plays a significant part in the return on investment of the assets. When equipment wears out prematurely, not only is maintenance cost affected, but spares levels need to be higher and labour - which can be used for improvement - needs to be utilised for repair.

ABB studies on water industries have found an average of 40% of work orders are preventable, and 22% of those were due to inadequate maintenance. Not only will an effective maintenance program reduce the need to replace or repair equipment, but it will increase the confidence that spare equipment will be in an operating condition when called upon and free up resource to progress improvement plans.

Effective maintenance, therefore, provides an opportunity to better manage and reduce maintenance costs, saves on capital cost through a reduced need for redundancy, and increased confidence that the backup unit will start when called upon.

KEYWORDS

Maintenance, reliability, cost effectiveness, confidence, operational excellence, confidence, risk

1 INTRODUCTION

"1/3 of all maintenance expenditures are wasted because of inefficient and ineffective utilization of the maintenance resources".
***Terry Wireman**, Author of Developing Performance Indicators for Managing Maintenance*

Most industries are concerned with the maintenance expenditure on site – maintenance budget is eroding profitability, and there are always not enough resources or time to get all the tasks done. As Terry Wireman mentions above, however, it is not the headcount or budget that is the major issue – it is the tasks chosen that often do not return the value the business is expecting.

Some inefficiency is brought in by using Original Equipment Manufacturer (OEM) maintenance recommendations – as they do not know the level of local technical skill or how hard or often the site will be using the equipment. Manufactures, for example, will not know how a particular site has set up redundancy: maintenance actions and failure modes for standby equipment is different for operation equipment, so strategies are not interchangeable.

When maintenance work is analysed, it is always found that a lot of the planned work either does not contribute a great deal to the operational losses, or the timeframe for return on that investment is longer than the business expects. A lot of value can be added just by refocusing the current resources.

To first understand the inefficiencies and ineffectiveness on site, benchmarking is required. The value of benchmarking is that it compares what one site is doing with the best performing sites in the same industry. We can then compare actual plans with the sites which make up the top 25% (1st quartile) of sites in that industry.

Learnings have shown that the best performing sites have a stronger focus on proactive tasks (fig1), and it is those tasks which reduce the amount of reactive work that will be required on site. It is often believed that it is expensive to maintain a reliable plant, but the opposite is actually true – it is the unreliable plants which consume the most money in repair costs. By investing to prevent failures, the overall cost can reduce.

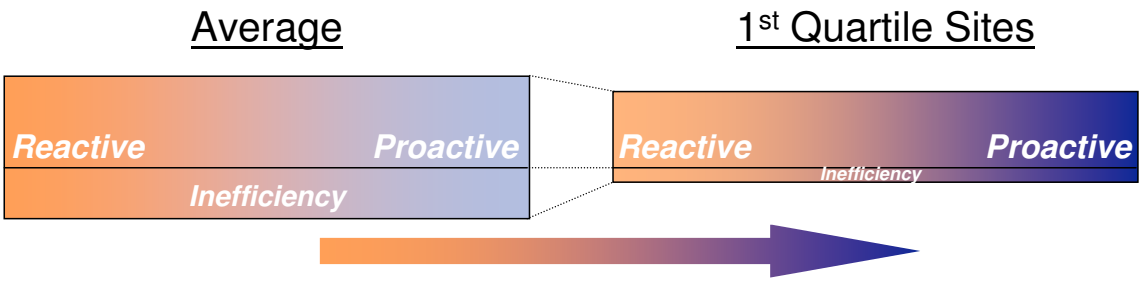

Fig 1 Comparison of Average vs. Top25% sites

Ensuring all critical assets are more reliable and available to be used when required results in greater 'strategic manoeuvrability'. Since reliability and maintenance work is largely an on-going investment, it can be increased or decreased following short/long-term site strategy. Risk based decisions such as these can manage and minimize the effect of a market-driven 10-50% reduction in maintenance spend.

Unfocussed reductions in maintenance spend, however, can result in the critical proactive tasks being stopped and an increase in failure rate, costs and risks.

2 WHAT IS MAINTENANCE?

Traditional definitions of maintenance refer to the monitoring of condition of equipment and the repair or replacement when the equipment can no longer perform its function. It is because of this definition that the 'maintenance department' and the 'maintenance function' become blurred into one.

The dictionary definition, however, states that maintenance is the 'holding or keeping in any particular state or condition; to sustain; to preserve'. This adds a new dimension to the scope of maintenance – it is not only the repair or replacement when necessary, it the reduction of the *need* to repair or replace.

This can then clarify that both maintenance and operations can impact the life of equipment: both have a responsibility in the 'maintenance function'.

- **Misconception**:
  - Maintenance is better inspections and replacing equipment before it gives production problems

- **Modern view**
  - Replacement of equipment is the penalty paid when you can no longer maintain the state of the equipment

With this in mind, it now becomes clear that the maintenance function has three objectives (fig 2):

1. Maximising Equipment Life (increasing the life currently being achieved)
2. Identification of impending failure
3. Minimising consequence of repair / replacement

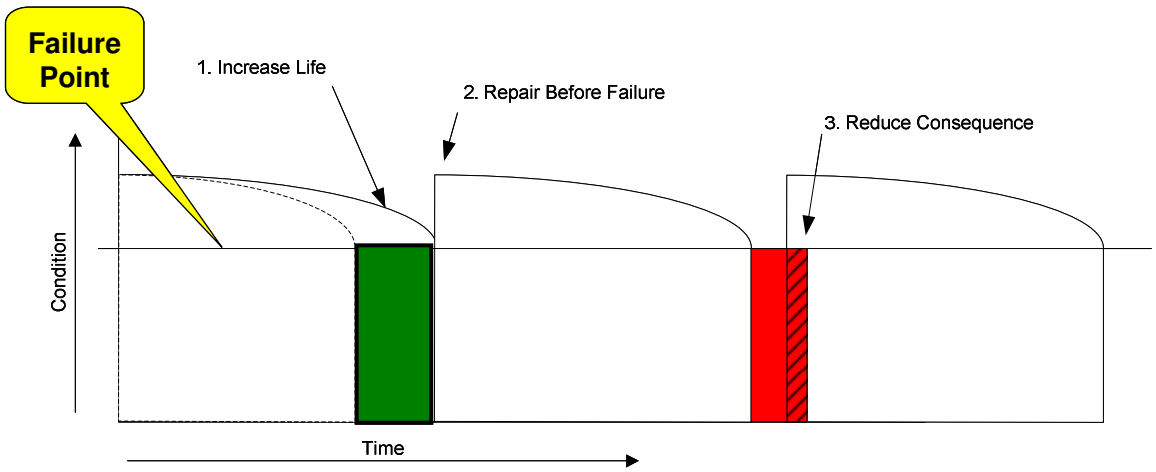

Fig2 Objectives for Maintenance

These objectives are important to understand to be able to leverage maintenance to lower operational risks and costs:

1. Maximising Equipment Life (increasing the life currently being achieved)

While 'production' or supply of water is generally not impacted in the water industry due to redundancy, the risk to availability of supply increases when equipment is not available due to repairs.

The water industry in this case can be unique compared to other industries: improving reliability of the plant may not increase throughput. In this case it is about reducing risk.

Two other aspects of equipment life do produce tangible results however:

- Equipment not failing as often does not need as much maintenance spend. While production may not increase, maintenance spend per unit will decrease. Total operational cost, therefore, will decrease.

- One reason not all planned initiatives can gain traction is that maintenance people are consumed with failures and repairs. Increasing the time between failures mean the trades do no have to attend to the equipment as much and will have more time for continuous improvement.

The life achieved from the equipment can lead to a vicious or virtuous circle. Vicious, because the more repairs the equipment requires means the maintenance department will not have as much time to try and prevent or predict in the first place, and that will in turn lead to more failures. Virtuous, because as the equipment becomes more reliable, the maintenance department will have more time to implement the activities to gain even more benefit.

2. Identification of impending failure (condition monitoring)

It is generally accepted that a planned repair can be as much as … more efficient than an unplanned repair. It is for this reason that knowing what issues are approaching is very beneficial for business planning. Repairs can be planned and scheduled, cost can be budgeted. For this, a clear understanding of equipment function is needed (so it is not replaced too soon or too late), and appropriate inspection methods must be chosen.

It needs to be clear, however, that inspections alone do not increase the current life of the equipment. It simply tells the site you will need to accept cost, labour and risk of availability.

3. Minimising consequence of repair / replacement

The third aspect, assuming as much life is cost effectively being achieved, and appropriate condition monitoring is in place, is the speed at which the equipment ability is reinstated. As already mentioned, in the water industry this may not be related to plant productivity, but it is related to operational risk.

3 MAINTENANCE STRATEGY: PROTECTING YOUR INVESTMENT

Given the objectives above, maintenance is aimed at the best life cycle cost available for the equipment.

Long term, there are four benefits to be achieved by optimising the maintenance strategy (fig 3)

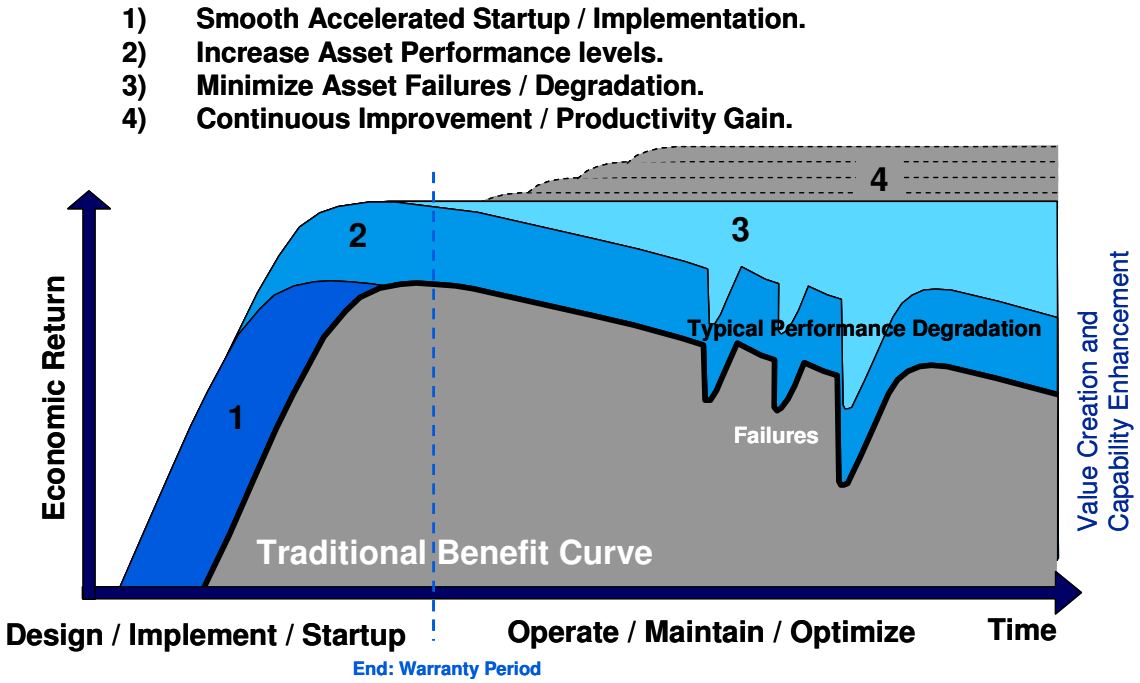

Fig 3 Benefits achievable over equipment lifetime

1. Accelerated Start-up/ Implementation

   A lot of value can be lost during the commissioning of plant unless all the required factors have been considered in choosing equipment, installation and preparation. ABB has achieved up to 10% over customers budget production during start-up phase by ensuring maintenance and performance is designed into the plant.

2. Increase In Asset Performance Levels

   It is important that the operational and design parameters are well known for optimal performance. Between optimising design for operation and setup of equipment, loss due to throughput can be minimised

3. Minimise Degradation

   The true definition of maintenance is the reduction in need to repair. Almost all equipment has some element of randomness in their failure rate, and much of this is due to human factors. By understanding the influences our actions have, we can achieve higher life from equipment than commonly happens

4. Continuous Improvement

   The final option we have is the continuous improvement of the equipment in place through modifications to achieve higher performance than originally designed. This can minimise the need for higher cost capital solutions.

4 LEVERAGING MAINTENANCE

Using the concepts described above, a strategy can be built up on site to achieve the best balance between maintenance cost per unit and acceptable risk.

The objective is not unique to the Water industry (fig 4), but the specific actions can be:

- Fixed Term Replacement of equipment often is not an appropriate strategy: it can often increase costs for no real benefits, so this is only used where it can be proven to be beneficial. This does require Failure Mode Analysis to verify appropriateness.

- Condition Based Monitoring gives the notification period that a failure is pending, so gives the time required to prepare parts, plans, tools etc so it can be repaired as efficiently as possible. There are a great deal of options available to suit a wide range of risks and business impacts

- Preventive maintenance is the activities that achieve the maximum life (looking after the equipment), so more focus is put on this as it will mean fewer repairs will be necessary in the future.

- With more preventive actions (fewer interventions) and improved condition monitoring (faster repairs), the overall time spent on reactive maintenance reduces. In the Water industry, the reduced maintenance volume relates to lower operational risk.

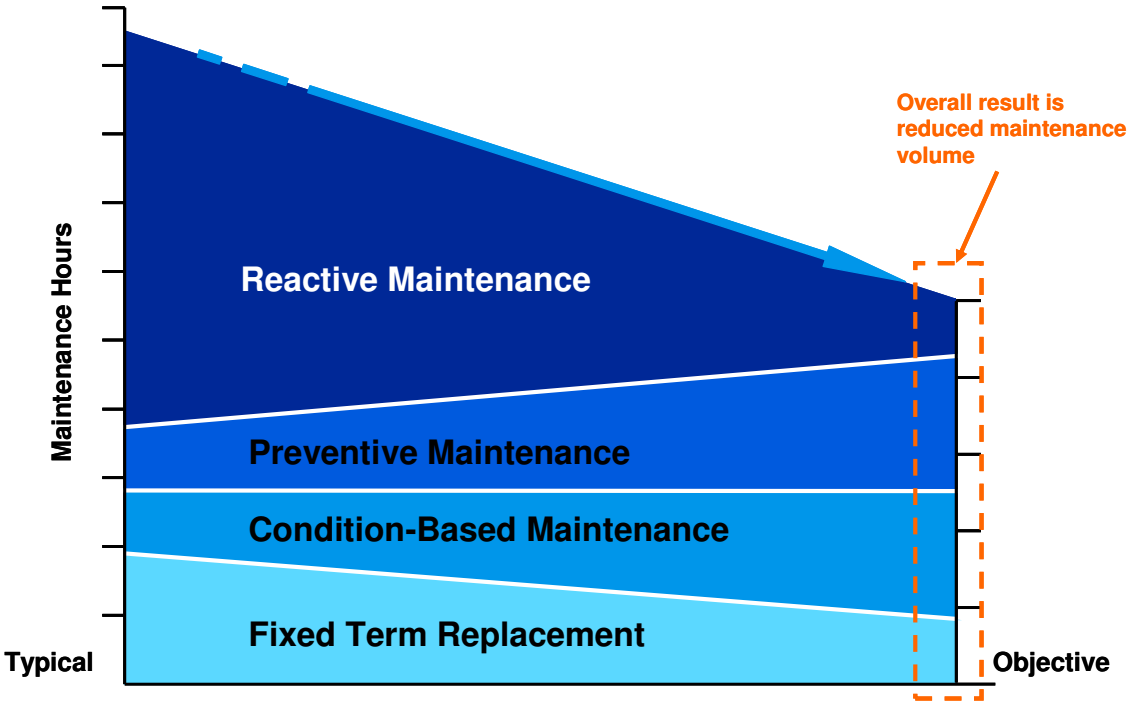

Fig 4: Targeted trend in the maintenance types

Fig 5 below shows the gains achieved on one of the ABB lead sites. This not only shows the reduction of downtime achieved, but at the same time a reduction in the required planned shutdowns. This shows the pure intent of maintenance: reduction in the *need* to maintain – fewer interventions are required, equipment is available to be run when required, labour is not consumed so much on the same repairs and maintenance cost is not as high due to fewer part replacements.

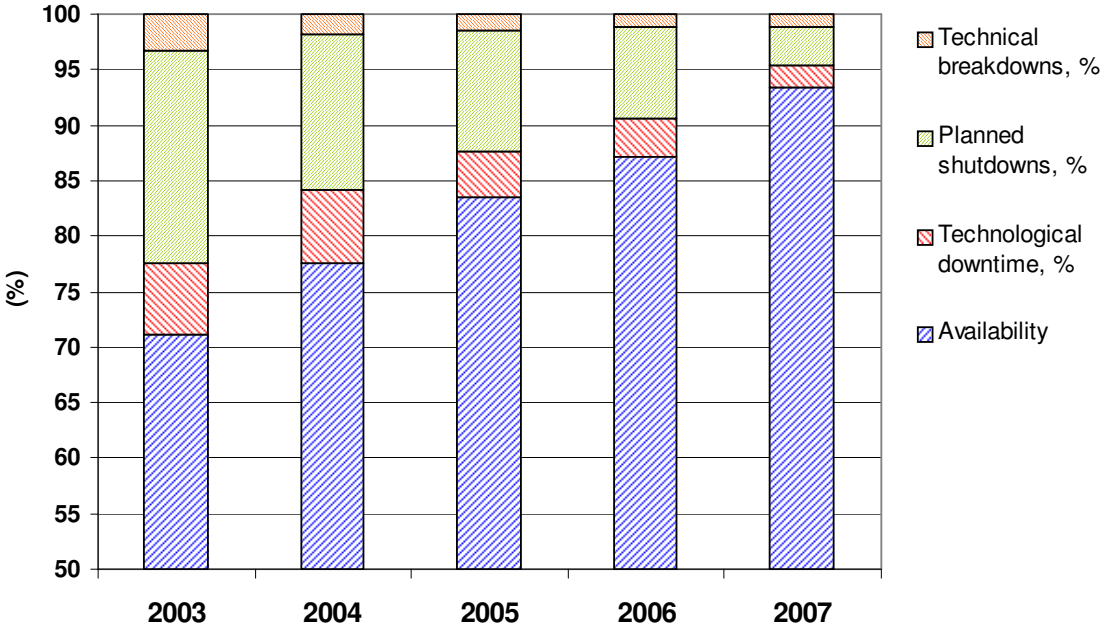

Fig 5: ABB Case Study: Benefits Achieved

As mentioned, the Water industry is different from the 'norm' due to the level of redundancy usually built into the system. While most industries can enjoy higher productivity due to the higher availability, the Water industry would see this as a lower operational risk – the redundant equipment would be available for a greater proportion of time, so there is a higher probability it will be available when called upon. (Fig 6)

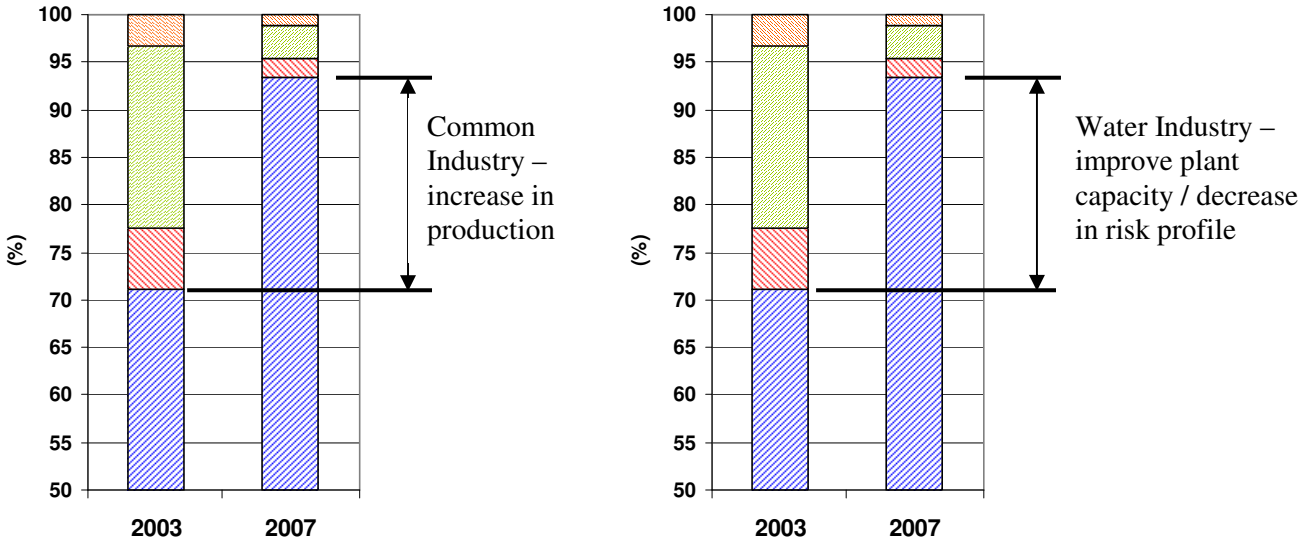

Fig 6: Normal industry gains vs. Water Industry

5 UNDERSTANDING SITE LOSS

To produce the most effective maintenance strategy, actions are customised to each site to ensure the best return on investment.

ABB experience in the water industry has shown that up to 40% of all maintenance work orders are preventable by putting in the correct maintenance strategies (fig 7).

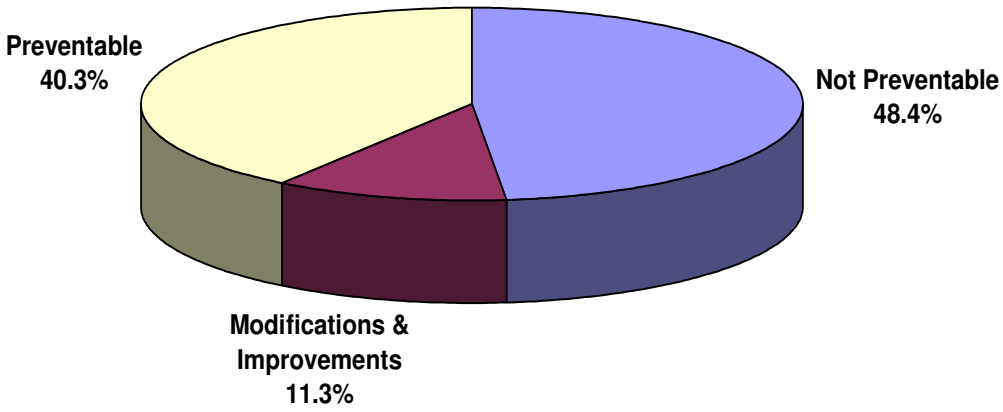

Fig 7: Preventable Work by Number of Work Orders

'Not Preventable' refers to the fact that equipment does wear out / fail and will need replacement at some stage. Regardless how well the equipment is looked after, it will have a life.

'Preventable', however, refers to the fact that a great deal of equipment does not reach its possible life expectancy due to activities and decisions either done or not done to it.

Further analysis into the 'Preventable' work orders showed reasons which caused the loss (fig 8)

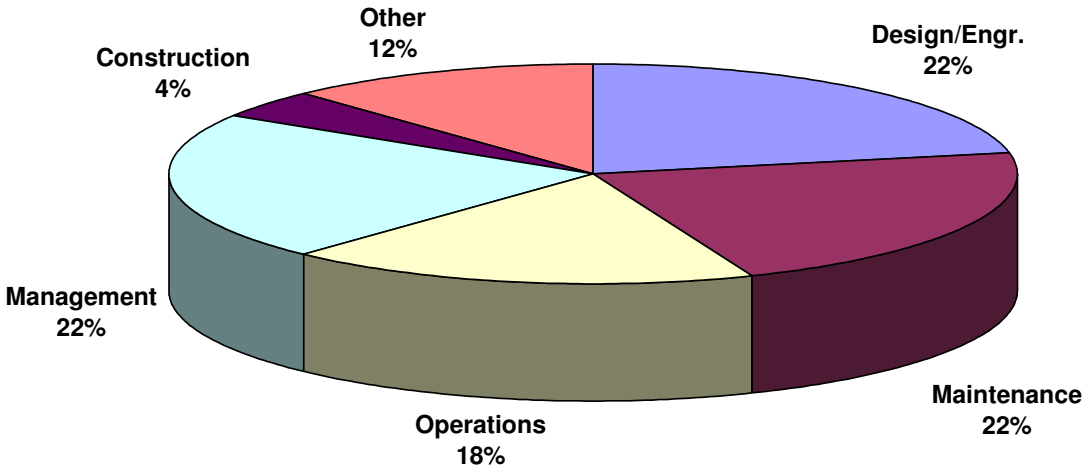

Fig 8: Preventable Work by Category

Design:

Design error relates to whether the correct equipment was chosen for the application. More consideration up front can have a dramatic impact on the life that will be achieved. It is here that 'life cycle cost' (all costs occurred from installation to removal) need to be considered more than just the initial purchase and installation.

It is not uncommon for total equipment costs to be over 3 times the initial installation cost. Ongoing maintenance and energy costs also need to be considered. One reason some equipment is cheap to purchase is that it will fail earlier or be more expensive to maintain.

The maintenance department can have great impact her regarding reliability and maintainability of the equipment.

Maintenance

The single largest issue facing this category is the fact that most companies do not separate Preventive and Predictive maintenance – they call all activities 'PM'. In reality, this makes a dramatic difference:

Preventive Maintenance is the activities that will maximise life: cleaning, lubricating, adjusting, balancing etc. These are the 'looking after' activities.

Predictive Maintenance is the inspections. This is aimed at better planning repairs, and has no direct impact on the life achieved on the equipment.

Best in Class organisations put a lot of focus on the preventive actions.

Note: International maintenance definitions include 'Fixed Term Replacements / Refurbishments' into the 'Preventive' category. This activity certainly doesn't prevent the need to replace / repair, so is not truly preventive. This strategy has its place, but can also lead to over-maintaining and increasing costs.

Operations

As mentioned earlier, 'maintenance' is the preservation of the equipment, and Operations has an impact on that. Insufficient cleaning, adjustment and the way the equipment is started, run and shut down will have an impact.

It is important to know what activities the operators are doing, or not doing, that affects equipment.

Management

Equipment life is determined by everything that happens to it from design onwards. Management decisions regarding expense, design, suppliers, storage, transport methods, contractors used, training given, maintenance strategies chosen etc will all impact the life achieved. It is for this reason that management experienced in the total impact of decisions regarding the equipment is involved with the determination of strategies.

6 DEFINING THE MAINTENANCE STRATEGY

Fig 9 shows that defects either arrive with, or are introduced to, the equipment, and these eventually give the issues seen in industry – loss of availability, speed or quality. Once these become evident, they need to be addresses to bring the equipment back to proper operating condition.

We can then see we have two broad categories in which to minimise defects:

- Proactive – preventing issues occurring on site
- Reactive – identifying and solving issues on site

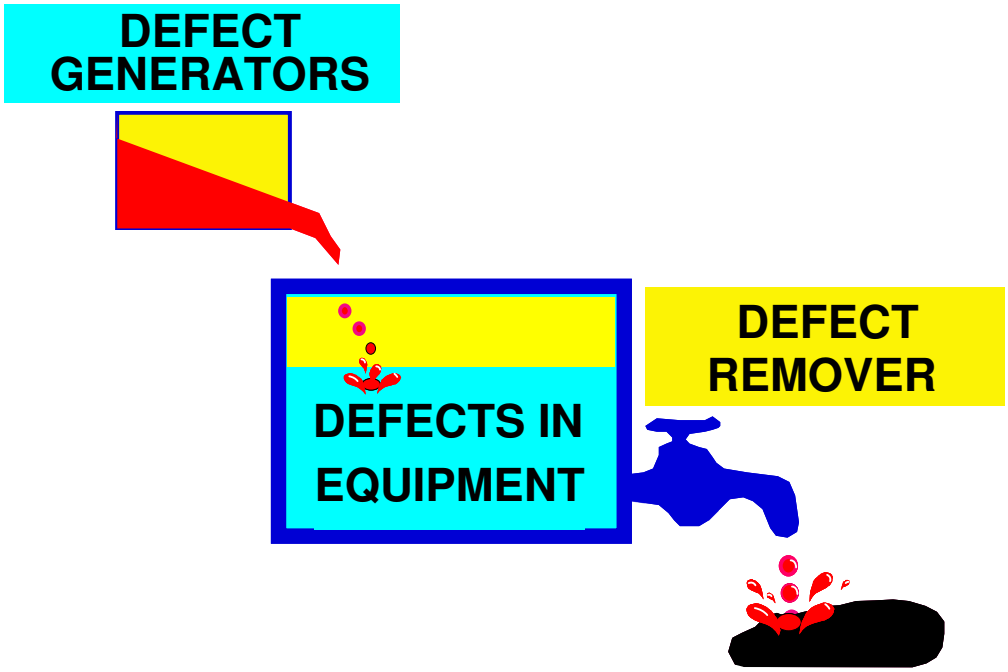

Fig 9: Defect Generation and Removal

Proactive Maintenance is based on the concept that if you have precision inputs, you will have precision outputs. If you don't stop the defects being generated, the maintenance department will spend a great deal of time trying to continually remove them – this is the 'fire fighting' situation many sites find themselves in. Removal of defects by itself is not sustainable, as there will be a constant incoming stream of new defects that will require resolution.

A number of initiatives are available to prevent defects being introduced or being generated in the equipment. These include topics such as:

- Design for reliability and maintainability: materials, design, size etc will make a dramatic effect on the life that can be obtained. Access, lubrication points, lifting gear etc will make a difference to how well, and how fast, the equipment can be maintained. Often the maintenance department will have to modify the equipment for maintainability after installation – and this is more costly and time consuming.

- Precision Maintenance, which clarifies work processes, training and correct tools to ensure the equipment is installed correctly. Issues such as looseness, incorrect fitting, misalignment etc play a significant role on equipment life.

- Lubrication review, to ensure the right type, volume and frequency of lubrication is getting to the equipment. This has a dramatic effect on how long equipment will last.

- Contamination Control, to ensure dirt, heat, water etc does not get into the equipment to wear it out. Contamination is the largest cause of lubricant malfunction.

Reactive Maintenance will always be required. Not all issues can be prevented from occurring, so it is important to have a process to truly understand what went wrong and what can be done to prevent it occurring again. Sites without a strong investigation process will find a lack of progress. They will be doing a lot of analysis and repair, only to either little progress forward, or reoccurrence of issues already seen.

Initiatives used to strengthen the investigation, or Root Cause Analysis, side of maintenance includes topics such as:

- A robust prioritisation process: no business has enough resource to investigate all issues, so it is critical to ensure only the major losses with a reasonable return on investment are targeted. Often on sites it is not clear what the true major loss makers are are. Frequently people will be working on minor issues or issues that will not return value for years. Strategic thinking can be introduced here as fixing one thing at a time can be very inefficient: Focussing on equipment types causing problems across site, or component types (such as bearings which impact multiple types of equipment) can make faster improvements across site.

- Troubleshooting guides: it is impossible for trades, engineers and managers to memorise all possible causes for problems. There are, for example, over 100 possible causes for a pump not to supply sufficient pressure. Without guides and training, investigations can take longer then necessary and often rely on trial and error.

- Root Cause Analysis training: only replacing equipment that fails will do nothing to stop the new component from failing the same way in the same timeframe. It is only the identification of the ‘organisational’ losses, such as procedures, training, tooling, overload of work etc that will stop or slow the reoccurrence.

7 CONCLUSIONS

System redundancy in the water utilities industry can mask the availability losses in equipment. For this reason maintenance is often neglected, which results in a higher maintenance spend than what is necessary and/or overcapitalisation for a given performance requirement.

Up to 40% of work orders in the water industry have been shown to be preventable, which leaves a huge scope to reduce the need to maintain equipment. By improving how equipment is chosen, and the maintenance strategies, such as how the equipment is installed, looked after, monitored, cleaned etc, the equipment not only lasts longer, but will give more confidence that it will be in operating condition when called upon.

Many sites focus their maintenance on repair, but there is a lot more opportunity than that. Maximising life of equipment is a prime focus for the maintenance function, as well as increasing the ability to predict when issues are going to occur. Not only does prediction give notice to organise, but assists greatly in the business planning process.

Maintenance can be better leveraged to achieve lower operational costs and risks. Lower costs as reliable equipment will not need the components or labour costs to repair as often; and risks, as reliable equipment will not be out for scheduled repairs as frequently. When it comes to supply of water, management are interested in availability of function; when it comes to risk, management are interested in availability of equipment (including standby).

Correct maintenance strategy is a virtuous cycle: the more reliable the equipment is, the lower the total maintenance effort will be. Freed time can then be invested to make the plant even more reliable and cost effective.

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