Inspection-based PM

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This whitepaper addresses the overall process of periodic condition inspection, distress discovery and planned corrective repair of physical assets whose in-service failure has to be avoided. The technical and business reasons for carrying out systematic inspections are discussed together with various factors influencing inspection programme implementation. Whilst written mainly with production plant and building services in mind, the principles apply to physical assets in all contexts of use. In the paper the terms 'asset' and 'equipment' are interchangeable. The premise of the whitepaper is that condition inspection underpins the success of PM (Preventive Maintenance).

The fundamental choice - planned or unplanned maintenance?

A summary of the various forms of maintenance, as defined by British Standards (BS 4778, Quality vocabulary), is shown in Figure 1. The primary division is between planned and unplanned activities - maintenance action is either planned in advance, enabling it to be precisely organised and controlled, or unplanned, and so chaotic to a greater or lesser extent.

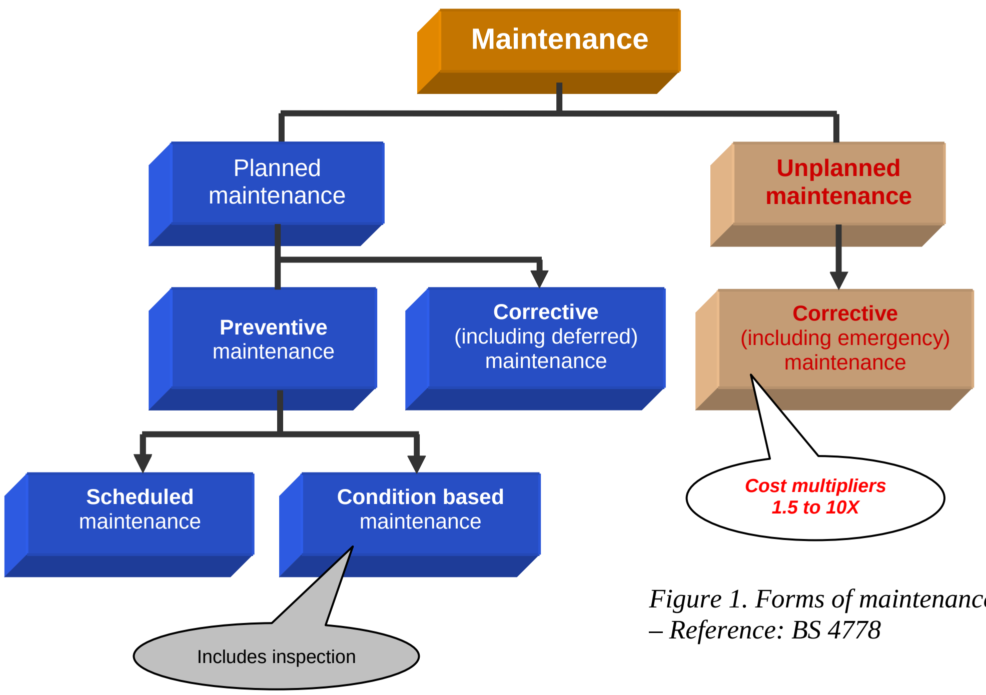

Figure 1. Forms of maintenance – Reference: BS 4778

Unplanned corrective maintenance is the legitimate speedy response to an unforeseen failure of essential equipment (or a seriously unsafe condition). The majority of the maintenance work carried out in many organisations is unplanned, so you might be led to believe that in-service failures can't be prevented. That's not true; most equipment failures are predictable and most disruptive failures are avoidable. The high incidence of unplanned maintenance is due to a fundamental lack of discipline and systematic methods of work.

In the main, unplanned maintenance is failure-driven and often carried out in a panic. Essential equipment has either failed or is about to fail and requires immediate corrective attention - the repair team reacts accordingly. This so-called 'reactive' approach to maintenance is very disruptive to an organisation because prime quality production and service is automatically jeopardised when equipment fails in service. In addition, unplanned corrective work attract cost multipliers varying from 1.5 to 10 over planned jobs, depending on the scale of damage and chaos in each case.

Reactive maintenance is expensive & demoralising

Can any organisation really afford reactive maintenance? In a reactive maintenance organisation, where most corrective work is carried out on an emergency basis, the overall cost of maintenance can easily be double that of an organisation committed to planning its maintenance workload. In 24/7 asset-intensive organisations, because of the burden of shift coverage, it could be even more.

By its very nature, emergency and urgent corrective work can't be properly planned; decisions have to be made on the hoof, under extreme pressure of time and work is often executed on a make-do basis because of non-availability of the correct skills, parts and technical information. As a result, working efficiency and the quality of repairs tends to be poor. In addition, as the old proverb says, 'a stitch in time saves nine' - late repairs cost a lot more money than early repairs. As if all that weren't enough, there's the added burden of secondary, or collateral, damage caused by the initial failure. The sky's truly the limit for some so-called catastrophic failures!

In Figure 2, the incidence of emergency work and its effect on the overall cost of maintenance can be seen for the three alternative maintenance regimes of *Reactive*, *Inspection based* and *World class*. Total cost of maintenance can drop by a third or more by going from a reactive to an inspection-based regime – and this is a conservative figure. Note that 'world class' is an idealised state where the maintenance best practices appropriate for an organisation's type of operations have been adopted. It should be noted that world class is a moving target, as the market leaders are constantly refining and adopting better practices. Inspection-based preventive maintenance will decrease overall costs, increase equipment uptime and reduce risk. It is arguably the most important step on the journey to world class maintenance and the grail of six sigma performance. Unless you're in control of failure, you're not going anywhere!

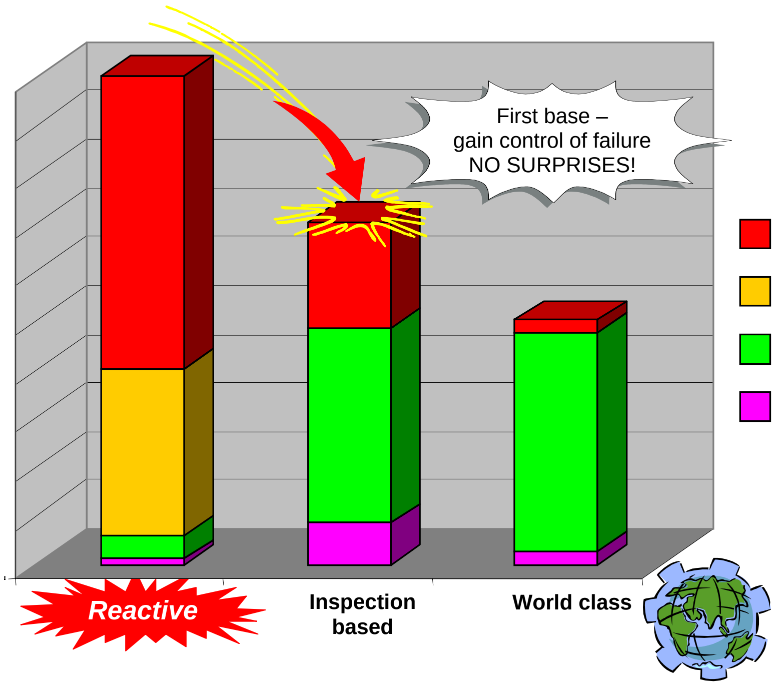

Figure 2. How emergency work affects the total cost of maintenance

There are never enough resources to get on top of the repair workload with a totally reactive maintenance regime. In this environment the equipment dictates to the maintenance team what to do and when to do it. Members of the maintenance team have to respond like automatons to failure events. Whilst maintenance managers and their teams struggle to cope with one failure after another, morale can hit rock bottom. When things don't improve, the best people will move on to better managed organisations. The vicious downward spiral of poor asset performance and high maintenance costs are often the deciding factors sending a poorly managed organisation out of business.

The central human tendency is to concentrate on the needs of today and let tomorrow look after itself – this can be calamitous as far as asset management is concerned. When the consequences of failure of essential functions are ignored, production and services will processes suffer, people or the environment can be harmed and in all cases money is lost. Accidents, disasters and personal tragedy arising from avoidable failures of equipment are a constant topic in the media.

It's only logical that business-disrupting failures should be minimised and planned work maximised. But that's easier said than done. In the reactive environment facility owners and the maintenance team have lost control of their equipment because they have failed to manage the process of deterioration.

Equipment deterioration & damage

All organisations are sustained by the performance of their physical assets and all physical assets deteriorate naturally with age and use. It's called entropy, everything eventually reverts to dust. Asset condition is the basis of function, so deterioration affects an asset's ability to function properly in service. When deterioration reaches a certain point, there's a functional failure and the asset has to be repaired. Functional failure can be total or partial (the equipment still runs/operates but with some loss of functional capability).

Whilst the natural deterioration process can't be stopped, with care and attention it can be brought under control. The 'whole life' and mean time between failures of equipment can be prolonged with basic care (lubrication, cleaning, adjustment and other corrective tasks). All assets derive their *available* functionality from the degree of integrity of their maintained state. Failures can be anticipated and, with proper surveillance, the deterioration process can be tracked and surprises avoided. Lack of equipment care and servicing and ignoring equipment deterioration are the predominant causes of breakdowns and disruptive failures. Lamentably, human failings are at the root of accelerated deterioration and most disruptive failures of equipment.

Equipment can experience functional failure due to causes other than natural and accelerated deterioration. Depending on the equipment's nature or location, it can be at risk of damage by collision, inept use, vandalism, etc. An emergency or other inept repair can also adversely affect an item's original condition. Equipment surveillance programmes should also address these types of downgrading possibilities.

There are many equipment defects that may appear trivial on the surface, for example a broken toggle on a switch, wiring that has become unclipped, extensively damaged paintwork. However, whilst the equipment still functions, the equipment operator's attitude towards it will change for the worse. Equipment that's not maintained in a good overall state becomes more prone to abuse, accelerating its deterioration and likelihood of early failure.

Besides monitoring of an asset's basic condition, prudence and due diligence dictates that an organisation should ensure that the design configuration of its assets are fit for purpose in all respects, and especially as regards SHE (Safety, Health & Environmental) compliance. Inspections should be carried out periodically to discover any unauthorised changes in control and protection set points or logic, overridden operational safeguards and other non-compliant asset configurations affecting integrity.

Condition inspection underpins PM & enterprise performance

Condition inspection is a forward-looking, predictive maintenance activity focusing on an asset's continuing fitness for purpose and the business consequences of an in-service failure. It is the basis of business-focused maintenance.

The most fundamental yet most neglected activity underpinning the success of any preventive maintenance programme is equipment condition inspection. By a programme of inspection-based preventive maintenance, supported by adequate basic care, most disruptive failures can be avoided. Inspection as a maintenance activity has the added advantage of being non-invasive. This is an important advantage, as intrusive maintenance work is itself a significant direct cause of equipment failures.

An asset's fitness for current purpose depends not only on its condition but its design configuration. In-service failures can arise from quality deficiencies in new assets and changes in the asset's conditions of use that may call for performance beyond current inherent capability. Such failures will be detected by the inspection programme, but the required technical responses should include modification or replacement of the asset.

RCM (Reliability Centred Maintenance) logic determines that assets which aren't business-critical are 'run to failure'. This has led some maintenance managers to believe that these non-significant assets can be dropped from the maintenance schedule and virtually ignored. That's far from the truth. All assets have a need for some basic care which includes an appropriate degree of cleaning, lubrication and periodic inspection to detect distress.

Be attentive to equipment's distress

Equipment fails at the component/element level. Well before ultimate failure, equipment usually signals its distress with some observable physical sign, for example, noise, vibration, leakage, high temperature, looseness, erratic motion, presence of cracks, an out-of-limits process parameter, etc. Figure 3. The dog barks before it bites! Distress is therefore generally detectable by some form of inspection. By early detection of developing failure, followed by early repair, breakdowns can be avoided and operating costs minimised. With due regard for safety, most inspection tasks can, and should, be carried out with the equipment on-line/running, that is, in the 'on condition'. Note that in RCM parlance, the warning a component gives before it fails is known as a *potential failure*.

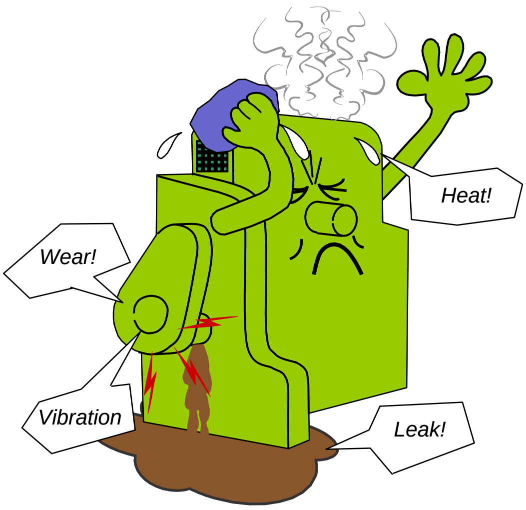

Figure 3. Be attentive to equipment's distress

Whilst the majority of developing failures will signal distress, some types of failure can't be detected by simple inspection because they won't be evident – they're 'hidden'. Hidden failures generally have an adverse impact on safety. A failure only becomes evident when the usually passive equipment or component is called upon to function, for example, an emergency generator, an earthing system on electrical equipment, or safety protection scheme. In reliability jargon these items are prone to 'unrevealed failure to danger'. To avoid injury and business disruption, the presence of such failures must be discovered in good time by carrying out failure-finding tests.

PM planning should take account of these hidden failures and appropriate failure-finding tasks included in the overall programme. By making suitable provisions in the equipment configuration and/or operational procedures, many function-verifying tests (proof tests) can be carried out with the equipment still in service. In other cases the equipment will have to be temporarily withdrawn from use or standby duty.

Without inspection to detect the presence of a developing or hidden failure, disruptive failures will be inevitable. Despite its crucial importance, the majority of asset-intensive organisations don't have a programme of systematic inspection (surveillance) of equipment.

Inspection plans and routes

The list of equipment to be inspected must be established, starting with the most critical and significant systems. The points of inspection (inspection control points), inspection tasks and their required inspection frequency must then be decided.

All parameters related to equipment condition and essential fitness for purpose should be included in the inspection programme. Avoid duplicating inspections on the same assets for different groups of tasks, as this adds unnecessarily to cost. When inspecting to check the condition and operational capability of an asset it makes sense to include checks for compliance, for example, with Work Equipment Regulations.

The inspection tasks to be carried out at each frequency should be grouped and the target items of equipment placed in inspection sequence according to the most efficient *route* around the plant or facility. An inspector's path should be continuous and linear, without backtracking - when marked out on the plan of the plant or facility a route map should not look like spaghetti! The whole plant or facility should eventually be covered by inspection routes.

Adopting a logical sequence for equipment inspection points will assist the inspector's diagnostic thought process. When deciding the inspection sequence for a series of equipment items, the natural production flow and material transformation process should be followed, provided that it's consistent with route efficiency. The inspection sequence within a dynamic asset system or individual asset should follow the path of material movement and energy transfer, that is, forwards from the driver/prime mover and on through the drive train and material flow process. In electrical systems the inspection sequence should follow the flow of current, starting at the distribution board. For a static asset, like a structure, it should follow the path of load transfer, starting at the foundations.

Many organisations have adopted 'red tagging' as part of their condition inspection/defect discovery and repair methodology. A red tag is attached to the equipment for each defect identified during an inspection. The tag is usually in the form of a luggage-type label and tags are only removed after repairs have been made. The tags provide a powerful visual statement of the condition of the equipment population in the workplace. Some organisations encourage their equipment operators to register defective conditions by attaching red tags directly to their equipment.

Get the timing right

In order to ensure effectiveness and efficiency, it's important to get the time periods between inspections right! Inspections have to be conducted often enough to discover developing conditions before they become real problems. Signs of distress need to be spotted early so that fixes can be planned and carried out at the most convenient time and at minimum cost. On the other hand, inspecting too frequently will be a waste of money. Figure 4 shows a simplistic deterioration & failure curve of an item and how the cost of repair is influenced by its timing. The frequency or periodicity of inspection should be determined by the P-F interval, that is, the estimated time interval between the points of potential failure (the point at which distress becomes evident) and ultimate functional failure.

The frequency of inspection will depend on the nature of the components and elements on the target equipment and its context of use . Components and elements subject to high rates of wear, like cutters, jaws, shaft seals and drive belts, or which are operating in corrosive/erosive conditions, or subject to mechanical impact/shock, high vibration or thermal cycling, exposure to abuse and damage, etc, will need to be inspected more frequently than others.

Inspection frequencies should be standardised for ease of administration. Routine is often the key to efficiency. Inspections should be carried out at the same time of the day, day of the week, etc to build up a routine that becomes ingrained in the organisation and second nature to the maintenance team.

To fulfil the inspection programme intent of early discovery of potential failures and then the tracking of failure progression, inspections will generally need to be at a high frequency. Inspection surveys are typically carried out every 4 weeks, but this depends on specific circumstances. For reasons of due diligence, many simple visual checks in manufacturing and building services are carried out daily or shiftly.

In the case of deficient conditions arising from damage or misuse, the prudent frequency of inspection to ensure that these are discovered and rectified within an acceptable timeframe should be decided in consideration of the nature of the foreseen event, its likelihood of occurrence and the seriousness of its consequences.

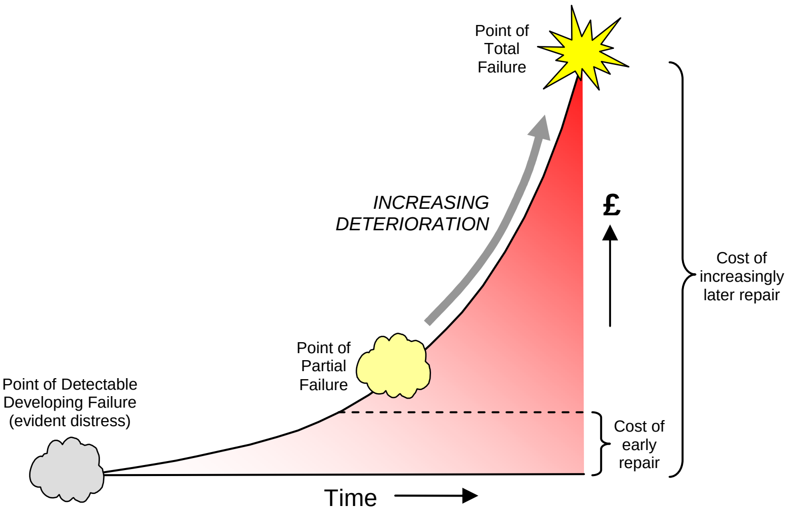

Figure 4. Early detection and early repair slashes maintenance costs and ensures equipment capability & availability

The frequency of testing for critical hidden failures should be determined on a statistical basis in consideration of the 'fractional dead band' and risk assessment of the likelihood and consequences of failure - or, where applicable, statutory regulation, for example, the PAT (Portable Appliance Testing) provisions of the UK's Electricity at Work Regulations.

The PM inspector

PM inspections should be carried out by the most knowledgeable maintenance staff. An individual appointed to the role of PM inspector should be able to sort out immediate repair imperatives from longer term requirements. An inspector should be competent to recognise distress, diagnose its cause, judge its potential operational impact and decide on its urgency of correction. When an inspector is uncertain about the need for a repair or its timing, he should seek further information and consider calling for the equipment to be re-inspected before its next scheduled inspection. It can be advantageous to rotate inspection responsibility around competent members of the maintenance team – this aids buy-in to the PM inspection programme. PM inspection should be introduced to the maintenance team as one of the tools of their trade and not a management initiative on the side.

It can be argued that many small defects could be repaired most quickly by the inspector who discovers them. This would avoid additional administration costs, travel time and delay – it would also provide immediate customer satisfaction. On the other hand, when inspectors are directed to carry out repairs as well as inspecting, there is a natural tendency to devote most time to repairs. Assets early on an inspection round will be repaired, the allotted time will run out and the balance of the assets targeted for inspection won't be inspected, or they'll be inspected in such a cursory way that the inspection report has no real worth. The danger is that when inspection time is diverted, worse problems than those detected and repaired are at risk of being overlooked.

There are also psychological considerations. Repairs are 'now' orientated, whereas an inspector's mindset and timeframe should be 'future'. Repair tasks will draw an inspector's thoughts away from predicting potential problems and when they are likely to occur. The human mind finds it difficult to shift gear backwards and forwards between 'now' and 'future'. In the mind shift, information is lost and judgement can be compromised.

Therefore, for best overall return, the PM inspector should concentrate on finding faults, rather than repairing them. Repair tasks should be limited to minor adjustments. Other repairs are better done by raising a work order and scheduling corrective work with the regular repair team. The time an inspector spends on any single adjustment type repair should be strictly limited – certainly no longer than 10 minutes.

Some types of inspection require excellent visual acuity, so an inspector's eyesight should be tested periodically – including for colour blindness, as necessary.

Don't delay starting

When implementing an equipment inspection programme it's important to just get on with it and not let complete formalisation of inspection checklists hold things up. To get things moving quickly, the initial inspections can be left to the discretion of the inspector - trusting in the inspector's experience, judgement and common sense. The programme can be built up gradually. All too often PM programmes are put off for months whilst every nut and bolt is considered. Analysis paralysis sets in whilst at the same time the plant can be slowly falling apart - this is one of the pitfalls with the classic RCM approach.

From knowledge of the equipment's past behaviour in service and/or the inferred failure modes of its hierarchy of components, the inspector can be left to decide on the inspection control points, including what distress to look out for and the most rational sequence in which to carry out the inspection route. The inspector can draw up the inspection scheme as he goes along. More detailed checklists can be developed over time, again commencing with the critical and most significant assets. Inspection frequencies and routes can be optimised as increased experience is gained.

Even when an organisation's asset register is incomplete or non-existent, the inspector can compile it as he carries out the baseline inspection of the plant or facility. In this case, he should analyse and record the assembly hierarchy of each item of equipment on the fly, identifying the maintenance-significant components and elements.

There can be a downside to this approach. In a large organisation, a standardised methodology across plants and sites is often taken as evidence of management control. Differences in practice, especially in relation to SHE compliance inspections, may be difficult to defend when subject to scrutiny by an external organisation, for example, the HSE (Health & Safety Executive). Standardised inspection frameworks, templates and checklists are an increasing need in industry.

In introducing an inspection programme, choose as much as you can chew on and digest at one time. Do not let the inspection programme balloon out of control so that resources are overtaxed as this will bring the programme into disrepute. Initiating a PM inspection programme with a small pilot initiative in one area is often the easiest way to start. A pilot helps win confidence in all staff, whether they are in operations, maintenance or management. Because the purpose of the pilot is to gain information, everyone is more tolerant of mistakes. You can learn from these and have a much easier time with implementation of the overall programme.

Ensure effectiveness and efficiency

The harsh logic of TPM (Total Productive Maintenance) and Lean Thinking deems inspection tasks to be 'waste'. Although condition inspection is important to sustain equipment reliability, it's a non-value adding activity that should be minimised. The inspection programme should therefore be designed to ensure high effectiveness and efficiency.

Any carelessness in devising and applying the programme can result in continuing disruptive failures or inflated programme costs – this can seriously undermine the programme, particularly in the eyes of management. It's imperative that management sustain their belief in the PM inspection programme and actively champion it. Ideally, management should support condition inspection in conviction of its business necessity, not just passively accept it as a whim of the maintenance manager.

Inspection reporting

Inspection observations must be fully and accurately logged. The inspector can use a paper system to record information, but an electronic system using a handheld computer has huge advantages in terms of administration efficiency, information sharing and repair needs analysis. When the system is electronic, it is easy for an inspector to check on the last reported condition of a control point and check up on any repair carried out since the last inspection. Checking on the integrity of completed repairs adds significantly to the quality of the organisation's repair process. An example of a basic inspection report is shown in Figure 5. When using a paper-based system, a set of short failure and action codes can be devised to aid quick entry on the form.

The inspector should not make his reports verbally, as he will inevitably concentrate on the current most serious problems and not report those that are looming, but not currently critical.

Well-documented data allows an easy comparison of results from one inspection to the next. Machinery and process parameters when logged can be analysed to establish trends in equipment performance to provide an early indication of the presence of a developing fault condition.

By quantifying the condition of an asset on a scale, say from 0 to 100, the deterioration trend of an item of equipment can be established as well as that of the asset population as a whole. Arguably, the larger the asset population of the organisation, the more important this can become. When there are many

Route: Effluent Plant		**Frequency: 2 Weekly**		
Asset	**Element**	**Condition**	**Action**	**Required by**
Clarifier pump	Shaft gland	Leak	Repack	15/08
Air blower 1	Vee-belt	Slack	Tighten	03/08
Air blower 2	Pressure gauge	Sticking	Repair	15/08
Scum scraper	Scraper chain	Worn	Reinspect	07/08
Sump pump 2	Coupling bushes	Worn	Check & renew	21/08
Effluent pump 1	Lube oil	Contamination	Renew. Check seal	03/08
Effluent Pump 2	Motor	Vibration	Alignment	15/08
Sludge pump	Thermocouple	Broken	Repair. Guard wire	03/08
Safety Shower	Lagging	Damaged	Repair. Check tracing	15/10

Figure 5. Example of an inspection report

defects in an asset system, rather than carrying individual repairs, there will come a point when complete refurbishment is required. Refurbishment often requires funds on the scale of a capital investment and the need often comes as a shock to management. Trending the overall condition of the asset base helps avoid sudden surprises. The long term condition of static assets is particularly important as, although they often have a higher value than dynamic equipment, they do not receive the same close attention on a day to day basis.

Inspection access & aids

In order to inspect an inspection control point the inspector has to be able to get to it and see it! The best inspection is at a distance close enough to allow 'hands on' examination. At this distance the inspector can feel, hear, smell and even taste the equipment.

It’s almost invariably the case that, as the inspection programme gets underway, issues concerning physical access will present themselves. Depending on the configuration of the facility, additional safe access ladders, guard rails, platforms and illumination may need to be provided. Portable equipment can be used in the short term but, to facilitate high frequency inspection as well as basic care tasks, fixed equipment is safer and generally less costly over the longer term. When operators and the maintenance crew can’t easily get to all the parts of an asset, some parts will inevitably be neglected - accelerated deterioration and unexpected failures will then be the result. Fixed access improvement should be considered a necessary investment in plant availability and reliability, especially in a manufacturing plant. A well-designed and built plant would have the necessary facilities from day one.

Fault-finding performance can be considerably improved by providing an inspector with appropriate inspection tools. For example, a high powered torch, inspection mirrors, intrascope, digital thermometer, bearing vibration/shock pulse instrument, stroboscope, crack detection equipment, ultrasonic leak detector, etc. In view of the value contribution of the condition inspection programme to an organisation, it is foolish not to provide the right inspection support tools to save on programme expenses!

Over time, other inspection facilitating aids can be added, like the provision of vision windows in machine guards/casings to observe the running of drive belts, chains and other internals. A host of time-saving inspection-facilitating ideas and techniques for 5 Senses inspection can be found in TPM literature – for example, applying telltale marks to fasteners to witness/evidence movement.

Housekeeping

Even when the inspector can get to the equipment, he still may not be able to see it! Proper inspection cannot be carried out when accumulations of dirt and debris obscure inspection control points and mask distress. Equipment should be cleaned up before the time of the inspection. However, caution and judgement is necessary; the process of cleaning can remove evidence of distress, for example, seepage/leakage of fluids. The individual carrying out the cleaning tasks should be alerted to the need to report such conditions.

When the housekeeping in a facility is poor, management should consider launching a 5S or 5C programme along with the inspection programme. Good housekeeping is a basic necessity and is commonly the first step in introducing TPM. As discussed later, autonomous cleaning and checking by equipment operators offers the best way forward for the organisation, but this requires considerable culture change.

Involve equipment operators

An inspector should meet with equipment operators before beginning an inspection route in their area. Operators know better than anyone how their equipment is functioning, so it’s logical that they be quizzed about how it’s performing and whether or not they have noticed any reduced performance, signs of distress or other warnings.

An organisation’s best solution is to train operators to become equipment competent, that is, to understand how their equipment functions, how and why failures occur, and what regular care is necessary to assure reliable working. Unlike a PM inspector, operators are present in an area continuously and have the opportunity to detect equipment distress or loss of capability at the earliest possible moment. An operator has the added advantage of being easily able to check the condition of dynamic equipment off line, during short stops.

Operator checking and equipment care tasks are known as ‘autonomous maintenance’, the second pillar of classic TPM. Operators should carry out regular ‘watch keeping’ inspections at the start of and during their shifts. Autonomous maintenance initiatives are usually destined to lead on to innovation - continuous performance improvement of equipment, work practices and processes. Unless the operators have been trained to high competence in autonomous maintenance, watch keeping inspections should still be supported by more focussed expert inspections by trade specialists or multiskilled inspectors.

Unfortunately, many organisations have not yet achieved the transition to autonomous inspection and routine inspection activities are still the responsibility of the engineering maintenance team. However, failure to fully involve equipment operators in equipment care incurs on-going high penalties for the organisation. Where equipment care rests exclusively with the maintenance department, up to half the total cost of an organisation's preventive maintenance programme can be attributed to high frequency checking, cleaning, lubrication and adjustment activities. Autonomous maintenance presents a huge opportunity to reduce running costs as well increasing equipment reliability and uptime.

Prioritising & scheduling repair jobs

Because of an organisation's available resources and affordability constraints, the corrective repairs listed in the job backlog won't all be able to be done at once. To allow scheduling of jobs according to true business needs (based on the organisation's production and service level goals and acceptable level of risk), the priority of each defect repair job should be decided rationally. That is, the focus should not be on the defect itself, but its potential effect - the consequences of a failure and likely time to failure, if nothing is done about it.

The maintenance manager will have to take account of the seriousness, urgency and likely growth of each listed defect in order to establish true priorities and decide the best allocation of scarce repair resources.

Prioritisation separates the corrective repairs that must be done immediately from those that should be done soon and those that can be done later. This provides the maximum opportunity to plan the work and utilise manpower resources in the most productive way. A smoothly balanced corrective maintenance forward plan is a prerequisite for high maintenance department productivity and efficiency. A 3 to 6 week forward work plan of corrective and other work is the goal to aim for. Proper job backlog management then becomes possible. See Figures 6a & b.

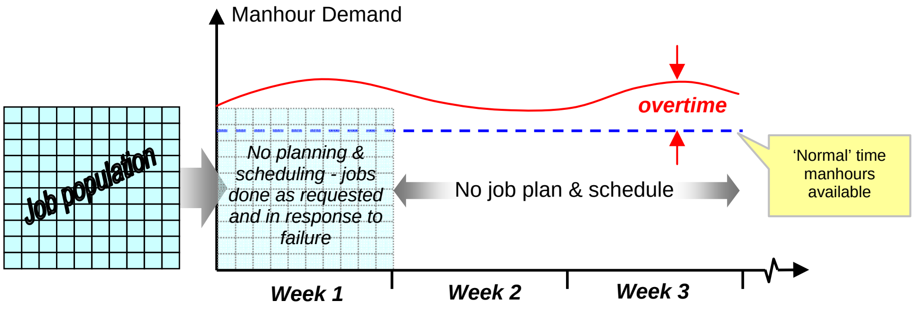

Figure 6a. Reactive - no formal job planning & scheduling – manpower demand is excessive

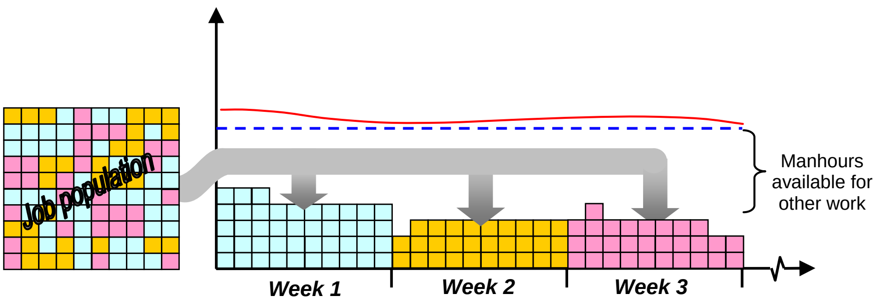

Figure 6b. Planned - formal job planning & scheduling – manpower demand is contained by 'smoothing'

Whatever the time horizon of the forward plan, in order to start gaining control, 80 to 90% of the next day's work should be planned and organised in advance. Work can then be distributed to each tradesman before the end of his current shift so he can mentally plan his jobs before the start of his next work day. Because he is able to have the parts, tools, manuals and drawings and work permits ready, work can be done most efficiently - it can start without administrative delay and right-first-time completion can be expected. In this more ordered environment a tradesman has the time to become more involved with continuous reliability improvement, so gaining a personal sense of real accomplishment.

When an organisation has let equipment deterioration get completely out of hand, it may be necessary to increase overtime working or even employ contractors to cull the backlog of essential repair work. This can easily be the situation following the first systematic inspection of the facility. After this baseline inspection has been completed, an enormous number of defect repair jobs will inevitably be listed. Although this is quite normal, it's easy to feel overwhelmed! Where necessary, management should grit their teeth and take the knock of the additional expense to clear the most urgent jobs. This is the so-called 'bow wave' effect when an organisation first wakes up to its backlog of deferred corrective maintenance. Remember, corrective maintenance can only be deferred, never avoided! Management can take heart that returning essential equipment to a proper condition and functioning state is an investment in increased bottom line performance. The payback will be quick; for a critical asset it may be just days or weeks!

Planning and scheduling need not take up a lot of time – about 5% of available manhours if you are proficient and double that if you're not. There are many jobs that can and should be done with minimal planning – single trade jobs that don't need spare parts. These jobs just need to be properly prioritised.

Planning the tasks to make ready and carry out a specific job is wholly a maintenance department activity. Scheduling, however, is a joint effort between the maintenance and operations departments and the number of 'schedule buster' jobs is a measure of the amount of cooperation between them.

Coordinating the inspection programme

Who should oversee the PM inspection programme? Not a maintenance supervisor! For the initial period at least, it is better that an inspector reports to the maintenance manager or, in a large organisation, a maintenance planner. In the reactive maintenance environment, most of a maintenance supervisor's work is breakdown and urgent corrective repairs. To ask the same person to control an inspection plan that is future-oriented is unreasonable and unwise - he just won't have the inclination and certainly won't have the time. Urgent corrective work often demands intense logistical activity, tracking down parts and other needs, on the spot problem-solving and over-the-shoulder supervision - and then there's the politics. This all takes time. The fix-it-fast maintenance supervisor is traditionally a man of action who often considers data management and paperwork unnecessary diversions. It's not in the organisation's best interest to have him suddenly focused on PM inspections with all the data management this entails. The maintenance supervisor will always be drawn back to present 'fix it' rather than failure-avoidance jobs; this is what he knows best and what management and his peers pat him on the back for. If the maintenance supervisor is assigned to oversee inspection, then when the corrective maintenance pressures get too great, condition inspections will be quietly dropped and inspection resources diverted to fix-it work.

When the inspection regime has become established and demonstrated its worth to all concerned, the condition inspection programme could be transferred to a maintenance supervisor to oversee – provided there's minimal risk of it being undermined!

Cultural change

It takes white knuckle discipline and determination to introduce PM and break free of the vicious downward spiral of reactive maintenance. It is a ground shifting cultural change that should not be under-estimated. The full force of the organisation's leadership is needed to coerce the change. The transition to PM inspection, is a transition to data management - and that means a lot of paperwork where the inspection programme is not computerised.

Metrics

The following measures of performance apply to the processes discussed:

Schedule attainment – the percentage of scheduled work accomplished during the week, based on the work schedule published the previous week. Schedule attainment is compromised by ‘schedule busters’ - unplanned work that breaks into the schedule. In the main, this is emergency work that must be done at once and urgent work that must be actioned within 24 to 48 hours. Schedule attainment is an excellent measure of the amount of cooperation between the maintenance and operations groups and the current efficiency of the PM inspection programme.

Incidence of emergency work (work initiated and executed within 24 hours as percentage of total workload) – this is an indicator of the degree of control of emergent work and asset deterioration. Emergency work is work that requires immediate response, so interrupting other work in progress. Emergency work starts without the right parts or technical information being available. Efficiency goes to the wall and the preventive maintenance programme is compromised.

Defect discovery rate. The number of defects discovered and registered per inspection routine. This metric is a measure is PM inspection effectiveness. To track the efficiency of inspections, the number of defects registered per inspection routine should be measured and trended, together with the defects found on each item of equipment over a period. In the stable state, after the bow wave of initial problems have been attended to, each inspection should discover a reasonable number of actionable defects, that is, repairs or advised re-inspections. A target should be decided upon. Although this will depend on the number of inspection control points listed for each inspection, 6 to 10 discovered defects is a reasonable number to aim for and will keep the inspection team motivated and vigilant. The inspection time interval should be increased or decreased to maintain the target over time.

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