

PHYSICS OF FAILURE AND ITS ROLE IN MAINTENANCE

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Abstract

The majority of the challenges in the field of maintenance are associated to failures and their prevention. Understanding why, when and how components fail should therefore play an important role in many aspects of maintenance management and engineering. The key issue of maintenance is finding the optimal balance between minimizing the effects of failing (sub-) systems on the one hand, and minimizing the maintenance costs on the other. For critical systems, where failures have serious consequences in terms of costs, safety, environmental effects or consequential damage, measures are generally taken to prevent such failures from occurring and spending a considerable budget on preventive maintenance is then justified. However, for many critical applications in the industries, company, organization, military, aerospace and nuclear power sectors, this risk avoidance has resulted in a very conservative maintenance approach. Many components are replaced far before they reach the end of their actual service life. Maintenance programmes are then effective (in preventing failures), but not very efficient.

Keywords: maintenance, components, failure, preventive.

Introduction

Any electronic instrument or piece of equipment can be considered as a system. A system can be defined as “anything formed of component parts connected together to make a regular and complete whole”.

An instrument or piece of equipment can have sub-systems made in blocks to perform specific functions. These sub-systems are made-up of electronic circuits, which are forms of electronic/electrical or electromechanical component parts. The failure of a component in an equipment may lead to the failure of the system. Failure is said to be the inability of a system to perform its required function. The need for continuous performance of an equipment requires that it is given regular maintenance. It is, therefore imperative that the meaning of maintenance is well understood.

Maintenance

Maintenance, in general, can be defined as efforts taken to keep the condition and performance of a machine always like the condition and performance of the machine when it is still new. Maintenance activities can basically be divided into two parts: planned maintenance activities and unplanned maintenance activities.

Planned maintenance is maintenance that is organized and carried out with thought to the future, control and recording in accordance with the plans that have been determined previously.

The type of maintenance cannot be equated for each equipment, which depends on the method, cost and critical level. This is all the activities carried out on an equipment in terms of proper installation, good servicing, routine checks, repairs and replacement of faulty parts in order for such equipment to operate at its maximum output throughout its useful life. An equipment or instrument is considered to have failed when under any of these conditions:

- a. when it becomes completely inoperative
- b. when it is still in operation but unable to perform the required function any longer
- c. When it becomes unsafe for its continued use.

Maintenance Strategy

This is a plan or scheme put in place by a person responsible for maintenance to ensure that the exercise is effectively carried out and does not result in the total breakdown of activities in an organization. If carefully constructed it will help in applying maintenance practices which will most effectively care for the equipment. This will prolong the working life of the equipment and reduce the need for spare parts.

Types of Maintenance

There are five different types of maintenance and these are as follows:

1. Fixed Time Maintenance

This is servicing of an equipment periodically at regular intervals. The particular maintenance requirements will probably vary with the level of service. For example, the requirements for 12 monthly service will be different for those for 3 monthly.

2. Condition Based Maintenance

This type of maintenance requires the use of human senses to know when it is needed. In the course of operating an equipment one may see signs of smoking, electrical sparks, feel for excessive heat, smells for signs of burning and some others. The condition at which the equipment is will necessitate that it should be opened up immediately for maintenance. This act will assist in preventing further damage. Some more complex systems have sensing devices built in to them, and alarm systems to detect variation from the norm.

3. Opportunity Based Maintenance

This is carried out when an equipment is opened up for repairs and this opportunity is used to do any other maintenance tasks which are due in the near future, such as routine servicing and the replacement of any parts which are at the end of their useful life. Also, the opportunity can be used to replace a broken part which had occurred before opening the equipment but had no effect in its operation.

4. Design-Out Maintenance

This maintenance type is used on an equipment which has a part that is failing regularly due to an apparent design weakness. It may be possible to upgrade the weak part and effectively change the design for the better. If a particular part is not available one may be able to change the design to allow a more common part to be used. In spectrophotometry, for example, it may be possible to modify a simple car headlamp bulb to enable it to function as a tungsten source.

5. Operate to Failure Maintenance

These are cases whereby an equipment is not given general routine care but it is allowed to fail before any other maintenance is attempted. This is widely used on electronic equipment which normally are not just taken to a mechanic for servicing while still functional. They are only opened up when they have broken down. This means that an equipment is operated to failure before it is opened up for maintenance.

Planned Maintenance Scheme

This is a strategy that is put in place to ensure that all equipment receive the most appropriate type of maintenance at the right time. It can be defined as “work carried out with forethought control and records”.

The planned maintenance policy for any organization must be carefully considered and planned in advance. It must include records which are compiled and maintained to measure the result of maintenance and to serve as a guide to the future planning.

Establishing A Planned Maintenance Scheme

1. Take inventory of all items to be maintained. Reference each item with a letter to indicate its location. A simple exercise book may be used with each item having its own page in the book, or a card system may be employed with each item having its own card. The entry should include all relevant technical details on the item.
2. Describe the maintenance tasks which are to be performed. This may be achieved by listing the tasks to be completed at each scheduled maintenance point. This is normally done in a maintenance Record Card.
3. Finally, wherever any maintenance is carried out on a piece of equipment a record of what has been done must be kept. This may be a form of job report specifying date, fault detected, cause.

Classification of Maintenance

The type of maintenance cannot be equated for each equipment, which depends on the method, cost and critical level. The following types of maintenance methods are commonly used in several industries.

- Preventive Maintenance
- Predictive Maintenance
- Corrective Maintenance
- Breakdown Maintenance

i. Preventive Maintenance:

This is the practice or arrangement whereby a piece of equipment or instrument are regularly checked, oiled, greased or cleaned according to manufacturer's specification for effective performance. This maintenance method is normally carried out at a specified time of a year and in that case the entire working system is shut down. Fund is normally provided to ensure that spare parts and some other materials meant for such maintenance are provided. The essence of this form of maintenance is to ensure that the equipment does not break down and thus performs to specification.

ii. Predictive Maintenance:

Predictive maintenance is a method for doing maintenance by replacing parts based on predictions using a tool. The point is if the preventive method is only based on the schedule, then the predictive method is based on the results of the measurement.

This method can also use the five senses, for example in bearing inspection can be distinguished from the sound produced. Or checking temperature, by touching it we can feel the difference or abnormality of the equipment.

Examples: Tachometer, to measure the rotation of the Thermometer, to measure the temperature of the Ampermeter, to measure amperage

iii. Corrective Maintenance

This method is applied to an equipment that has failed and thus broken down due to either improper operations or a defective part. It is concerned with the detection, location and repairs of faults as they occur. This requires a good understanding of system fault location methods in addition to an understanding of overall system and circuit operation. In addition to equipment, it is also intended for parts that have a short life cycle (reduce the frequency of damage) and speed up repair time.

In other words, this method is to extend MTBF (Mean Time Between Failure) and accelerate MTTR (Mean Time To Repair) because of its reliability (activity to prevent recurrence of damage) and maintainability (activity to speed up repair time).

Example: The operator has difficulty checking the oil volume of the generator engine, so improvisation is done by making a measuring cup equipped with a scale.

iv. Breakdown Maintenance

It is a method where inspection and replacement of parts are not carried out, so with this method we leave the equipment damaged and then we fix it or replace it. Usually this method is applied to equipment / machines with consideration:

Equipment is only optional (additional) so that if it is damaged it does not interfere with production

The cost of repairing / replacing cheap parts

Insignificant damage

Easy and fast repair

Total productive maintenance (TPM):

Total productive maintenance is a maintenance activity that involves production operators in maintaining equipment / machinery in addition to activities carried out by maintenance operators.

Examples are cleaning, lubricating, tightening nuts & bolts, daily checking (checking equipment / machine state), simple repairs (replacing leaking hoses, welding tips) etc.

The objectives of the TPM are:

Develop operators that are able to detect damage signals as early as possible. Because it is the production operator that really knows the state of the equipment to even the most detailed part.

Creating a neat, clean workplace so that any irregularities can be detected as early as possible.

Maintenance Procedure

Maintenance procedures that should be considered when preparing the planned maintenance program include:

1. Carrying out repairs needed when plant or equipment breaks down;
2. Predicting, from a history of breakdowns, the life expectancy of parts, bearings, etc., the tasks to be carried out and the frequency to be established;
3. Checking the condition throughout the plant of equipment, its running hours, readings of different responses (e.g. vibration, temperatures, current, etc.);
4. Monitoring the operating cycle and, where appropriate, seasonal shutdowns of plant, equipment (e.g. production process, 24-hour duty, etc.).

Maintenance systems

The benefits to be accrued from the implementation of a program of planned maintenance can be found in the efficient and economical operation of the plant and equipment and the utilization of resources (i.e. plant and equipment and manpower) while also maintaining a sound standard of safe working and environmental conditions for operators, other occupants and employees within the workplace. Maintenance systems vary, depending on the location of the plant and equipment and/or company policy. Systems can range from the complete maintenance of plant and equipment using all available methods to their replacement on failure. To meet the company's requirements it is then necessary to decide on the maintenance system that provides the most satisfactory benefits overall. What training can and cannot do to reduce

Equipment Failure

Equipment failure refers to any event in which any equipment cannot accomplish its intended purpose or task. It may also mean that the equipment stopped working, is not performing as desired, or is not meeting target expectations.

Examples of equipment failure include: engine failure or misfire, brake failure or stop controlling device failure, suspension of operation due to heat or other environmental conditions, failure due to defect in the electronics or circuits, power failure or fuel supply failure, etc.

Equipment failure leads to loss of asset availability, deviation from standard procedure, not meeting the quality and expected target quantity, loss of time, labor and money, and loss of integrated system. Equipment failure can be prevented or reduced through proper maintenance management, inspection, timely finding of problems, rectification of problems, and repair.

Overall equipment effectiveness

In an ideal condition, equipment would operate 100% of the time at 100% capacity, with an output of 100% good quality.

The difference between the ideal and the actual situation is due to various losses in the process and factory. There are six types of wastes that reduce the effectiveness of the equipment and these six big losses are grouped in three major categories: downtime, speed losses and defect losses.

Downtime

Downtime refers to the time when the machine should be running, but does not. It includes two main types of loss: equipment failures, and setup and adjustments.

Equipment failures

Sudden and unexpected equipment failures, or breakdowns, are an obvious cause of loss, and an equipment failure means that the machine is not producing any output.

Setup and adjustments

Changeover of products may require some period of shutdown so that internal tools can be exchanged. The time between the end of production of the last good part and the end of production of the next good part is downtime. This downtime loss often includes substantial time spent on making adjustments until the machine gives acceptable quality on the new part.

Speed losses

A speed loss means that the equipment is running, but it is not running at its maximum designed speed. Speed losses include two main types of loss: idling and minor stoppages, and reduced speed operation.

Idling and minor stoppages

When a machine is not running smoothly and at a stable speed, it will lose speed and obstruct a smooth flow. The idling and stoppages in this case are caused not by technical failures, but by small problems. Operators can easily correct such problems when they occur, but the frequent halts can dramatically reduce the effectiveness of the equipment.

Reduced speed operation

Reduced speed operation refers to the difference between the actual operating speed and the equipment's designed capacity. The goal is to eliminate the gap between the actual capacity and the designed capacity.

Defect losses

A defect loss means that the equipment is producing products which do not fully meet the specified quality characteristics. Defect losses include two major types of loss: scrap and rework, and startup losses.

Scrap and rework

Loss occurs when products do not meet quality specifications, even if they can be reworked to correct the problem. The goal should be zero defects – to make the product right the first time.

Startup losses

Startup losses are yield losses that occur when production is not immediately stable after starting the equipment, so the first products may not meet specifications. This is a latent loss, often accepted as inevitable.

An equipment is made up of electronic components or a combination of electronic and electromechanical parts. When a component fails or a part is damaged, it leads to a failure of the equipment or system. The failure rate of an equipment may be influenced by different weighting factors, depending on the environmental and operating conditions, in which an equipment is put to use.

Environmental Stresses

Environmental stresses on equipment may be due to effect of factors which are external to the equipment such as the weather (atmospheric pressure, wind temperature, humidity, e.t.c), sea

water and so on. Any equipment which operates outdoors cannot escape the full effects of the weather in its locality.

Remedy

Most of the effects that are due to environmental conditions can be remedied by providing adequate ventilation or through forced air-cooling.

Operating Stresses

These effects may be due to the operating conditions to which an equipment is exposed. Some of the operating conditions that can cause damages to equipment are voltage surges, current surges and frequency changes. These problems can be minimized by the use of protective devices in the equipment.

OEE calculation

The OEE calculation provides information about how effectively the machine is running and which of the six big losses needs improvement. Overall equipment effectiveness is not only an indicator to assess a production system, but is also important for improvement. Overall equipment effectiveness is calculated by combining three factors that reflect these losses: the availability rate, the performance rate and the quality rate.

The availability rate is the time the equipment is really running vs the time it could have been running. Low availability rates reflect downtime losses.

Availability rate = (operating time – down time) / total possible operating time

The performance rate is the quantity produced during the running time, against the potential quantity, given the designed speed of the equipment. A low performance rate reflects speed losses.

Performance rate = total output/potential output at rated speed

The quality rate is the amount of good products vs the total amount of products produced and a low quality rate reflects defect losses.

Quality rate = good output/total output

OEE = availability rate × performance rate × quality rate.

Types of equipment failure

Types of Failure By: (Parth Gajjar (116170319007) Submitted To: Prof. G. R. KHUN), are: Yielding, Fracture, Elastic deformation, Wear, Buconcentratoin, buckling, Corrosion, Fatigue, Caustic embrittlement and Stress.

1. **Yielding:** A yield strength or yield point of a matrial is defined in engineering and materials science as the stress at which a material begins to deform plastically. Prior to the yield point the material will deform elastically and will return to its original shape when the applied stress is removed. Once the yield point is passed, some fraction of the deformation reversible. will be permanent and non-

2. **Fracture:** Under tensile stress plastic deformation is characterized by a strain hardening region and a necking region and finally, fracture (also called rupture).

3. **Elastic deformation:** This type of deformation is reversible. Once the forces are no longer applied, the object returns to its original shape. Elastomers and memory metals such as Intimal exhibit large elastic deformation ranges, as does rubber. However, elasticity is nonlinear in these materials. Normal metals, ceramics and most crystals show linear elasticity and a smaller elastic range.

4. **Wear:** In materials science wear is erosion or sideways displacement of material from its "derivative" and original position on a solid surface performed by the action of another surface. Types of Wear: Adhesive wear, Abrasive wear, Surface fatigue, Fretting wear, Erosive wear

5. **Buckling:** In practice, buckling is characterized by a sudden failure of a structural member subjected to high compressive stress where the actual compressive stress at the point of failure is less than the ultimate compressive stresses that the material is capable of withstanding. For example, during earthquakes, reinforced concrete members may experience lateral deformation of the longitudinal reinforcing bars. This mode of failure is also described as failure due to elastic instability. As shown in fig. A column under a concentric axial load exhibiting the characteristic deformation of buckling.

6. **Corrosion:** Corrosion is the gradual destruction of materials, (usually metals), by chemical reaction with its environment.

7. **Fatigue:** In materials science, fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading. The nominal maximum stress

values are less than the ultimate tensile stress limit, and may be below the yield stress limit of the material.

8. **Caustic embrittlement:** Caustic embrittlement is the phenomenon in which the material of a boiler becomes brittle due to the accumulation of caustic substances.

9. **Stress concentration:** This discrepancy is explained by the presence of very small, microscopic flaws or cracks that are inherent to the material.

Operator Failure (operator error)

Operator error (or human error) is broadly defined as the cause of an unintended consequence due to a bad decision, distraction, voluntary deviation from the procedure and so on. More simply, it is “a failure of a planned action to achieve a desired outcome.” Infact, This is the inability of a person in charge of an equipment to operate it correctly so as to give the required performance. This failure can be due to the person having an inadequate knowledge of the procedures for operating such equipment. The incorrect operation of an equipment can lead to its total breakdown. Operator failure can be minimize by providing adequate training to a person in charge of an equipment. Also, no any unauthorized person should be allowed to handle an equipment. This is a period of time during which an equipment is not working. Downtime occurs in an equipment due to conditions such as those of environmental stresses, operating stresses and manufacturing defects. It may also be due to an equipment being shut down for a routine maintenance. Operator error is the subject of much research, particularly as it relates to health & safety, quality assurance, and productivity in industrial, manufacturing and construction contexts. In fact, it has been designated as the main cause of multiple disasters and accidents. Generally, it can be broken down into different categories:

Performing the task incorrectly or over the expected time allotted

Most operator tasks in a process or manufacturing plant are described in procedures. Procedures detail the sequence of steps the operator needs to perform (to clean a piece of equipment for example), indicate the risks and hazards to be expected while performing the tasks, the necessary personal protective equipment (PPE), lockout/tag out requirements and more. In this particular case, the operator is either missing the correct knowledge or know-how to perform the task correctly, and training is the primary solution.

Failing to perform or omitting a task

A failure to perform or omit task may indicate a lack of adherence to the procedure. This could be because omitting the task is de facto normalized in the plant (because it's faster, safer, easier, cheaper or any other reason). These violations are also known as shortcuts, workarounds or non-compliance, depending on which side of the task execution you are sitting. They are extremely common and are difficult to get rid of. They may require a process or procedure redesign, review of the plant culture for normalizing violations, review of safe work rules and much more. While training can play a part, it is typically not the leading fix.

Performing an extra or non-required task or tasks out of sequence

These are considered slips or lapses, or unintended actions. They are more prevalent in situations where the operator is familiar with the task and lacks concentration or focus during its execution. Training is of limited use in these cases which require improving the context of the task execution (encouraging focus and concentration) or improving the procedure/system so that slips and lapses are less probable.

Failing to respond adequately to a contingency

This is most frequently encountered when the operator faces an unexpected situation and will incorrectly apply a familiar (but ultimately incorrect) response. In other words, the incorrect task is applied while believed to be the correct one. These errors in decision-making can be attributed to a lack of experience and/or training. An interesting strategy here is to build into the training a number of plant cases (and their correct response) which the operator is not expected to encounter frequently, thereby compensating for the long floor experience required to actually witness those cases.

Making a training response irrelevant

When doing root-cause analysis, the common reflex is to stop investigating upon reaching the "operator error" stage. While this may be accurate, it is not enough to take a correct decision on what needs to be fixed, so the situation doesn't happen again. Training may or may not be a correct response, and even if it is, not all types of training will apply.

Here are five steps to ensure training is indeed relevant:

1. Perform full root-cause analysis, using the 5-whys method or other, until the ultimate root is uncovered.

2. Determine if the corrective action requires training (or a process, procedure or system redesign).
3. Determine if training applies to all operators, a specific team or individual and if training should be about reviewing the basics or providing further practice
4. Keep in mind training itself may be part of the issue and need improvements, either in content, structure or application
5. Monitor and confirm the results of the corrective training, as a continuous improvement best practice.

Malfunction

An equipment is said to be malfunctioning if it fails to work correctly. This may be due to improper operation procedure, bad alignment of the parts, partial damage to some parts or components and operational stresses. Whenever this occurs a skilled person should be consulted for advice and possible remedy. Infact, To malfunction is to fail to work properly. If your toaster spits out a charred, smoky mess no matter what setting it's on, your toaster is definitely malfunctioning.

When something functions, it works. Adding the prefix -mal (meaning "bad") to function indicates bad or unsuccessful functioning. When a computer malfunctions, you could lose your data. A malfunctioning car could cause an accident or leave you stranded. This word is typically used in reference to technology, tools, and gadgets. However, if you make a stupid mistake, you might joke that your brain has malfunctioned.

Down-Time

The term downtime is used to refer to periods when a system is unavailable. The unavailability is the proportion of a time-span that a system is unavailable or offline. This is usually a result of the system failing to function because of an unplanned event, or because of routine maintenance (a planned event).

The term is commonly applied to networks and servers. The common reasons for unplanned outages are system failures (such as a crash) or communications failures (commonly known as network outage).

The term is also commonly applied in industrial environments in relation to failures in industrial production equipment. Some facilities measure the downtime incurred during a work shift, or during a 12- or 24-hour period. Another common practice

is to identify each downtime event as having an operational, electrical or mechanical origin. The opposite of downtime is uptime. what causes downtime?

Causes of Down-Time

The common causes of downtime and how to avoid them

One of the biggest issues in any organization is when an application goes down. Downtime can lead to a bad user experience and, ultimately, cost the business money.

At a breakout session during the 2017 Google Cloud Next conference, Google's director of customer reliability engineering, Luke Stone, explained some of the top reasons for downtime and how developers and IT can fight them.

Here are some common causes of application downtime and how to avoid them.

SEE: Scheduled downtime policy (Tech Pro Research)

1. Overload

Overload, very simply, is "when demand exceeds capacity," Stone said. One way to respond is with load shedding--work to shed the excess load before it crushes the application. When at capacity, return errors before doing any work. Calculate the capacity of your service and determine what you can handle at the application server, and then serve an error to every request past that number.

2. Noisy neighbor

Users can bring spam, or another workload (backups, etc) can become a noisy neighbor. In this instance, you can't shed the load evenly, because it will unfairly affect normal users. To deal with noisy neighbors, Stone recommended putting in limits, like request limits for each user to cancel out spam bots and bad actors. You can also try to limit by IP address, but that could affect good users. So, make sure to make it configurable so you can easily help people who were wrongly affected.

3. Retry spikes

When you start rejecting users, they'll start retrying because they don't know why they were rejected. Clients can't tell the difference between a single failure and a broken service. These retry spikes can lead to a cascading failure, Stone said. To fix this, implement aggressive backoff and try to guess when the service will be overloaded so you can plan for that.

4. Bad dependency

In this issue, suddenly dependency gets really slow and requests are piling up. This problem happens when your application's input and output aren't communicating correctly. Your client must become a "defensive driver" so it doesn't overload your backend systems. You can also approach this problem with dynamic load shedding, Stone said. In the future, the organization should simulate a disaster scenario with sudden, massive load tests to figure out where the pain points will be.

5. Scaling boundaries

When an organization wants to serve more requests, they can often run into issues as they try to scale. This can cause a bottleneck between the application you're building and a service (like an API) that it is relying on. To solve the problem, Google relies on what Stone called "sharding," where a consistent workload is broken up into little chunks that can be done separately. Stone recommended sharding early and using more shards to increase capacity.

6. Uneven sharding

This occurs when one shard becomes more busy than the others, due to popularity or hot spotting, Stone said. To fix this you'll need to reshard, which can be done by splitting shards that have gotten too big, or using a shard map to determine which shards will become the most popular. If possible, leave the non-problem shards alone when you reshard, Stone recommended.

7. Pets

This is derived from the "cattle, not pets" phrase. The death of a pet is sad and hard to deal with, while the death of cattle is the cost of doing business. A "pet" is a workload or system that has too much human involvement, or is regarded as too important. Pets needs to be acknowledged and documented, so people other than the "handler" feel encouraged to work on them.

8.Bad deployment

This is the no.1 case of outages in every organization that Stone has worked in, he said. The best technique for handling outages caused by deploying bad code is having a good way to recover if you do. A tried-and-true rollback process will help, Stone said, but you must know when a deploy is happening. Also, progressive rollouts can help by being slow enough to detect problems that emerge slowly, Stone said. A good ramp up strategy is to go from 1%, to 5%, to 10%, to 50%, to 100% in stages.

9. Monitoring gaps

Many users have monitoring gaps between what the user is experiencing and what the system is telling them. Certain issues like how many errors you're serving, or your average latency can help better predict what the user is seeing. If you detect that users are unhappy, then you can further move down to checking your CPU, RAM, connection errors, and other metrics to try and determine what's wrong.

10. Failure domains

Stone described failure domains as a "chunk of your infrastructure that can fail altogether at the same time." Examples would be a VM, a certain zone, or even a certain region. To mitigate this issue, think ahead of time and try to determine which of these areas could be your failure domains and put your backups and data elsewhere. However, these domains should be used for rollouts and disaster testing so if the problem is caused by a downed zone, for example, you know it might not be an application issue.

11. Power Outages

Power outages account for 23% of downtime. For large-volume data sites, that percentage drops to 13%, but for all other sites, power outages account for 28% of downtime.

12. Usage Spikes/Surges

Usage spikes and surges account for 13% of downtime. For large-volume sites and all other sites, the percentages rise to 19% and 15%, respectively.

13. Natural Disasters or Weather Events

While frightening, natural disasters and weather events account for a very low percentage of business downtime — only 10%, in fact! That's great for all, but what about the businesses or nonprofits who believe they reside in a "safe zone," weather wise? Just like everyone else, they can't be complacent about their company's disaster recovery plan! When you look at the primary causes of downtime above, it's easy to see why no one should take data protection lightly or have the "it won't happen to us" mentality. No matter how safe you think your area is from a natural disaster, you're always going to be far more likely to lose data due to a server malfunction or by an employee.

14. Third-Party Supplier or Cloud Outages

10% of downtime can be attributed to third-party supplier or cloud outages.

15. Don't Know/Unsure

7% of downtime is caused by unknown issues.

16. Other

2% of downtime can be attributed to other causes.

Repair

Repair means responding to the breakdown of equipment and undertaking work to correct the problem in order to return the equipment to a working condition.

Before equipment can be repaired, you need to be aware that there is a problem! Therefore, there should be a clearly understood system for reporting faults and breakdowns and equipment users should be encouraged to report faults and breakdowns as soon as possible. If there is no back-up equipment, a breakdown will mean that the service the equipment was providing will come to a halt.

Overhead

Overhead (By ALICIA TUOVILA Reviewed by MARGARET JAMES Updated May 9, 2021)

What Is Overhead?

Overhead refers to the ongoing business expenses not directly attributed to creating a product or service. It is important for budgeting purposes but also for determining how much a company must charge for its products or services to make a profit. In short, overhead is any expense incurred to support the business while not being directly related to a specific product or service.

Understanding Overhead

A company must pay overhead on an ongoing basis, regardless of how much or how little the company sells. For example, a service-based business with an office has overhead expenses, such as rent, utilities, and insurance that are in addition to direct costs of providing its service.

Expenses related to overhead appear on a company's income statement, and they directly affect the overall profitability of the business. The company must account for overhead expenses to determine its net income, also referred to as the bottom line. Net income is calculated by subtracting all production-related and overhead expenses from the company's net revenue, also referred to as the top line.

Overhead expenses can be fixed, meaning they are the same amount every time, or variable, meaning they increase or decrease depending on the business's activity level. For example, a business's rent payment may be fixed, while shipping and mailing costs

may be variable. Other examples of fixed costs include depreciation on fixed assets, insurance premiums, and office personnel salaries. Overhead expenses can also be semi-variable, meaning the company incurs some portion of the expense no matter what, and the other portion depends on the level of business activity. For example, many utility costs are semi-variable with a base charge and the remainder of the charges being based on usage.

Overhead is typically a general expense, meaning it applies to the company's operations as a whole. It is commonly accumulated as a lump sum, at which point it may then be allocated to a specific project or department based on certain cost drivers. For example, using activity-based costing, a service-based business may allocate overhead expenses based on the activities completed within each department, such as printing or office supplies.

What are different types of overhead?

Broadly speaking, overhead can be organized into three main types. Fixed overhead includes expenses that are the same amount consistently over time. These can include rent and depreciation on fixed assets. Variable overhead expenses include costs which may fluctuate over time such as shipping costs. Semi-variable costs are a blend of the two. Utilities are an example of a semi-variable cost.

How is overhead calculated?

Since overhead is often considered a general expense, it is accumulated as a lump sum. This is then allocated to a specific product or service. There are a number of different ways of calculating overhead, however, the general rule is the following: $\text{Overhead rate} = \text{Indirect costs} / \text{Allocation measure}$. The indirect costs are the overhead costs, while the allocation measure would include labor hours, or direct machine costs, which is how the company measures its production.

Conclusion

“Run to fail or repair easily costs somewhere between three and 10 times as much as a good maintenance program. When the equipment does fail, the actual repair costs are exorbitant, and you typically didn't plan for them so there's a financial issue. The cost of additional labor for unplanned or reactive maintenance and repair is higher than doing routine preventive maintenance because all of a sudden, you're not in control of the resources.”

Recommendation

It is recommended that further studies be carried out on Implementing effective equipment maintenance program in industrial work place, organizations and homes.

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