

Maintenance and Reliability Engineering

By: Suvarna Ooi, Editor, Dimension Publishing Sdn. Bhd.

In the past, maintenance has mainly been related to breakdown maintenance and time-based preventive maintenance. At that time, maintenance of this sort was acceptable since the cost of maintenance and production as well as the demand for quality was low, and the process was heavily dependent on manpower.

Time has changed and with it came higher expectations. With the present demand for value, quality of product, satisfaction and comfort, consumers are unwilling to tolerate breakdowns, unavailability or even higher prices. A higher quality product with a reasonable retail price is what makes the product more demandable. As the market becomes highly competitive and globalised, consumers are more exposed, educated and have more power to compare and choose.

According to Engr. Luk Chau Beng FIEM, Peng, Chairman of Mechanical Engineering Technical Division of IEM, in the old economics, $COST + PROFIT = PRICE$, nowadays $MARKET DEFINED FIXED PRICE - COST = PROFIT$. Mathematically, they may look similar, fixing the price in 'commodity sandwich' industries produces leverage for the lean manufacturer. This translates to innovative products, lower cost of supply chain, mass production, higher productivity, higher plant reliability, etc. Hence, a maintenance program must optimise the owner's costs and maximise equipment availability.

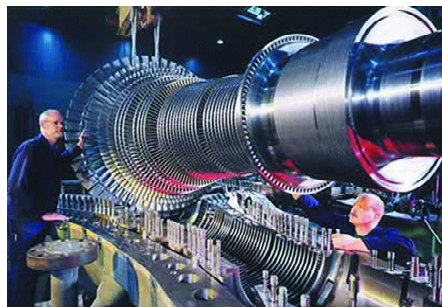
The traditional approach in the handling of the maintenance function vis-à-vis the operations function in a manufacturing or processing environment is to have separate departments handling each function. However, at times, Engr. Dr Ramlee Karim stated that this does not result in the optimum utilisation of manpower. For example, when the facility is running well, the operations staffs are kept busy.

However, when the facility is down, the roles are reversed with the maintenance staffs racing against time to bring the facility back online and the operations staffs are unable to carry out their work. To overcome this imbalance,

some organisations have integrated the two functions especially for small, day-to-day maintenance activities. The major maintenance work is then farmed out. This not only gives a sense of pride and ownership to the operations staffs, but also saves on overall manpower costs.

ELECTRICAL INSTALLATION MAINTENANCE

Electricity cannot not be detected by our five senses; sight, smell, hearing, taste and touch. Hence, within the field of electrical installation maintenance, it is the duty of care towards safety to oneself and to the general public that installation and equipment has to be properly maintained. According to Engr. Mah Soo, under the Electricity Supply Act 1990 and Regulation 1994, there are mandatory requirements on the maintenance of electrical installations and protective devices and competent control in the



Regular preventive maintenance programs is essential to any operations.

operation and maintenance as well.

As electricity could not be easily detected without aid, the type of maintenance works to be carried out has to be planned by people who understand the basic fundamentals of electricity, its generation, transmission and distribution as well as the electrical installation, plant, equipment and appliances.

Engr. Mah Soo pointed out that good knowledge of electrical basics and the utilisation and operation mode will help indicate the weak links due to wear and tear, aged deterioration of the insulation and wiring and other live components of the related equipment, and manifestation of hot spots due to the heating property



Sultan Salahuddin Abdul Aziz Power Station

of an electric current flow will help one to draft out a maintenance plan.

Knowing the intended usage and utilisation, preventive maintenance programs could be drafted through detail study, knowledge and experience. Giving a thought towards safety aspects to personnel operating the equipment would also be of help. Database of the maintenance program and its effectiveness is one way to measure and monitor for continuous improvement. Engr. Mah Soo stressed that this is one of the aspects for success in the Reliability Centred Maintenance program.

He pointed out that when equipments are well maintained, their reliability in performance will improve, downtime will be reduced and productivity will increase. Most important of all, it is safety to all during the operations that is important.

MECHANICAL INSTALLATION MAINTENANCE

The ultimate goal of mechanical engineering installation is to provide fitness for purpose facilities to maximise the investor's yield and ensure longevity of the asset life cycle and occupational safety and health. In the building construction industry, Engr. Lum Youk Lee explained that mechanical services typically include air conditioning, fire fighting, automation control, lift escalator, plumbing and sanitary service, fuel gas systems and others. Generally, these items affect the functionality of the building operation and life safety of the occupants in emergency situations.

From a real estate value point of view, overlooking the mechanical service maintenance of a building will result in

the depreciation and marketability of the building. For example, Engr. Lum pointed out that this could result in leakages on walls, fungus growth due to mismanagement of the air-conditioning system, and frequent breakdown of operation facilities such as lift and water.

From an operational point of view, mechanical services contribute 50-70% of the total energy consumption in a building, which is mainly from the air-conditioning system. Ineffective maintenance of such equipment will normally result in higher costs of replacement/refurbishment, reducing the asset's lifespan and causing the equipment to have a very low level of system reliability (frequent breakdowns).

Engr. Lum believed that the issue with maintenance is more 'philosophically' related rather than 'technical'. While many people believe in paying a premium price for a high quality product, in general, we often do not practice paying a premium price for maintenance to enjoy longer and smoother equipment usage. The common practise is to buy counterfeit spare parts as well as outsourcing maintenance to backyard contractors instead of the principal supplier.

According to Ir Lum, the idea of 'maintenance' needs to be re-oriented, instead of viewing it as a 'cost centre'. Maintenance should be implemented from a 'profit centre' point of view, i.e. you make it cleaner, it run smoother, it

consume less energy, and your customer will continue to pay you rental.

Routine inspection and parameter logging is the most effective and easiest way to monitor and maintain the basic functionality of equipment, as well as being the cheapest and simplest form of preventive maintenance. Ir Lum stated that the next level will be the implementation of predictive maintenance initiatives, where critical failures are foresaw prior to critical breakdowns that leads to costly downtimes.

He said this can be achieved by introducing a higher level of analytical thinking on the operational parameters (for example, analyse and act on irregular readings) or apply predictive maintenance tools such as thermography or vibration analysis on running equipment.

CIVIL AND STRUCTURAL APPRAISAL AND REHABILITATION

Civil and Structural Appraisal and Rehabilitation entails a process covering documentary verification, detail inspection, mapping of defects, verification of causes, site and laboratory testing, structural analysis, material selection, design, selection of remedial measures, repairs, strengthening, protective works and follow-up inspections.

Engr. Choo Kok Beng pointed out that some of the biggest maintenance issues are the lack of a preventive

maintenance culture, adequate human resources and budget. He stated that all civil structures should be inspected regularly and an inventory of the structures' condition be prepare to identify those requiring remedial actions. Regular maintenance can extend the economic lifespan of civil structures, reduce the cost on expensive remedial works or replacement and provides better safety for users.

CHEMICAL FACILITIES MAINTENANCE

Chemical facilities maintenance entails a function to keep items or equipment in a facility in, or to restore them to, a serviceable condition. Like many engineers, Engr. Juares Rizal pointed out that some of the maintenance issues in this area are those relating to planning, support, organisation (human resources), and materials.

To resolve some of these issues, he believes that precision planning and the implementation of scheduled maintenance activities is needed. One solution, he pointed out, is through maintainability engineering i.e. the application of scientific knowledge, methods and management skills, to the development of a facility's equipment, systems, projects or operations that have the inherent ability of being effectively and efficiently maintained. ■



Engr. Luk Chau Beng, M.I.E.M., P.Eng.
Chairman,
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Maintenance is just one of the activities carried out to ensure reliability. Reliability, on the other hand, is the main driver for continuous production and profitability at comparative market cost. Hence, in this era, we should be talking about the life cycle cost of the product and how to achieve high reliability.

Reliability cannot be just met by practicing prudent maintenance alone. It encompasses Design + Procurement + Construction + Commissioning + Operation + Maintenance together with Cost Management in areas such as parts, labour, energy, risk and raw materials. This equation leads to (Availability X Yield X Quality) and eventually equals to Overall Equipment Effectiveness (OEE).

In the last few months, there have been several hot issues in the local media on defects and maintenance. Just take a simple illustration; the new pipes running across the ceiling had been poorly constructed whether due to incorrect materials, incorrect installation or even poor design. It leaks in January at location 'A', leaks at location 'B' in February and so on, and at each leak the maintenance department will repair the leak at that location.

Can system reliability be overcome just by maintenance alone? This depends on how sophisticated the system is and how much money the owner is willing to spend in carrying out tests. However, if the system has been properly designed and erected, this sort of failure will not occur.

HOW CAN THESE MAINTENANCE ISSUES BE RESOLVED?

Figure 1 shows how the gap between design, operations and maintenance can be closed. Process, operations and maintenance experts are involved in the design. Maintainability and operability are the primary focus

areas, and objectives and rewards are lifecycle cost minimisation driven with constant feedback to avoid the repurchase of problems.

Design for Reliability

Below are some examples of design for reliability:

Mechanical:

- Are all nuts, bolts and screws suitably locked to prevent loosening under vibration?
- Are all bolt length adequately specified – not too long or not too short?
- Is it possible to incorrectly assemble any component or part?
- Has flow direction been identified on all pipelines for gases, air and/or liquids?
- Is there protection from static electricity provided where fuels or propellants are used?

Electrical:

- Has the effect of load variation on voltage and frequency been considered?
- Has the effect of transients due to load switching been considered?
- Is there a fail-safe operation in the event of power failure?

- Are the connections suitable for the environment and location in which they are used?
- Is each cable and wiring room sufficiently current rated at maximum operating temperature?

Design for Maintainability

Maintainability is the ease, economy, safety and accuracy with which the necessary maintenance of a product can be undertaken and can be measured either in terms of probability or in the level of resources required to maintain the item.

Some principles of design for maintainability are:

- Modularise design to reduce maintenance guesswork
- Reduce the opportunity for hidden error
- Design repair tasks, alignments, adjustments, lubrication, etc in a way that eliminate the need to disassemble components
- Don't locate visual inspection points more than a feet away from the inspector's eyes
- Don't rely on the maintainer's memory, convert instructions into procedures

When this is achieved, it will reduce the time to complete scheduled or unscheduled maintenance, reduced maintenance errors and maintenance related injuries. It also minimises the personnel training requirements and improve troubleshooting performance.

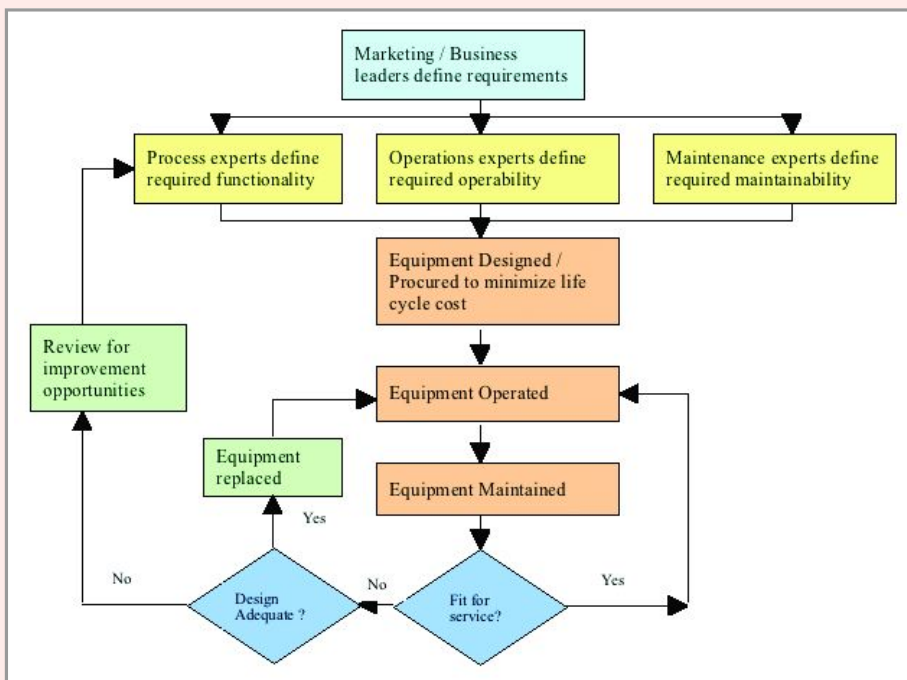


Figure 1: Closing the gap between design, operation and maintenance

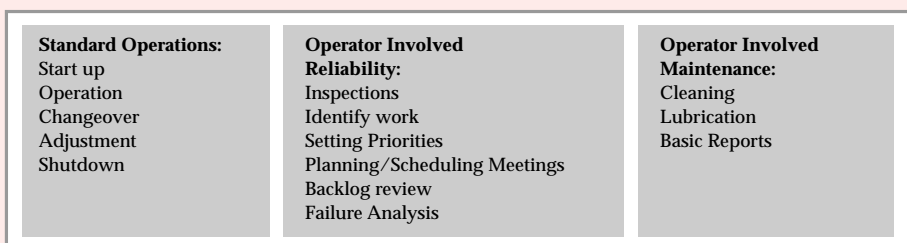


Figure 2: Operate for reliability

Operate for reliability

Figure 2 shows the equation where the objective is to get operation into reliability and operate the machine so as not to induce failures.

Just by keeping the plant clean, one can cut the failures and emergency work tremendously since it is easier to inspect and identify failures. Some other examples of activities that can be carried out are:-

- Predictive maintenance
- Standardise work for cleaning, lubrication and daily checks
- Creating internal ownership
- Improve tools and techniques
- Consistent training and evaluation
- Collect data on downtime
- Create equipment improvement teams
- Create Total Productive Maintenance area coordinator

Maintain for Reliability

Figure 3 shows the journey to world-class maintenance. One of the most popular approaches is Reliability Centred Maintenance where several questions are asked

Table 1: Maintenance strategies option

MAINTENANCE STRATEGY	ACTION REQUIRED	RCM-BASED OBJECTIVE
Run to failure	Repair or replace upon failures	Non-critical. Cost to control or detect failure exceed benefits
Schedule discard or restoration	Repair or replace on time or in cycles	Asset has a well documented Mean Time Between Failure and a small standard deviation
Proactive Condition Monitoring	Employs sensors and monitors to automate shutdown of equipment	Self preservation – avoid injury, environmental consequence and / or collateral damage
Reactive Condition Based Maintenance	Employs condition monitoring to detect early stages of failures. Replacement or repair is scheduled on-condition (eg. Wear debris analysis, vibration analysis, thermography, motor current analysis)	Asset fails randomly. Critical nature justifies early detection techniques
Proactive Condition based Maintenance	Condition monitoring detects the presence of failure root causes, enabling preemptive correction (eg. contaminant monitoring, balancing, alignment, viscosity etc)	Objective is to reduce the failure rate for a given time period
Precision Maintenance	Precision methods used to install and/or adjust machines	Reduce early life failures
Redesign	Changes in hardware, loading, design and/or procedures	Enhance inherent reliability
Redundancy	Deploy active shared-load or stand-by redundant system	Mission critical assets for which no other approach is acceptable

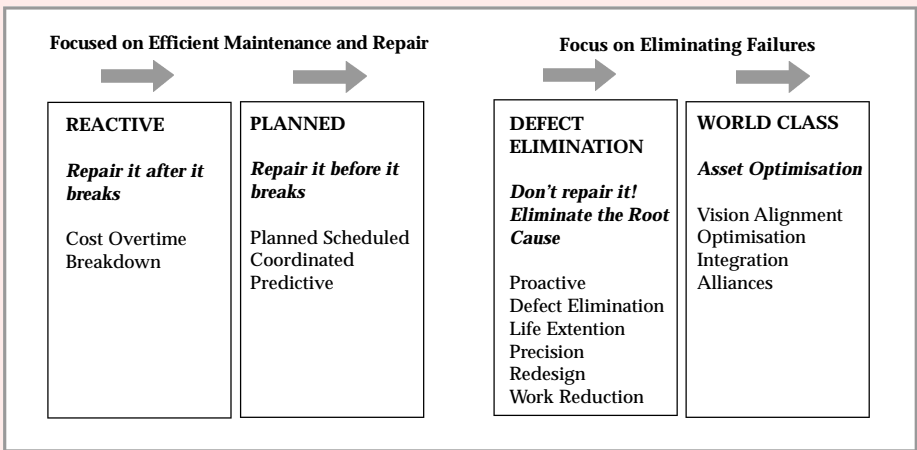


Figure 3: Journey to a world class maintenance

on the selected assets before appropriate maintenance strategies are formed.

- Define asset functions
- Define functional failures
- Identify failure modes
- Identify failure effects
- Identify failure consequences
- Prediction and prevention of failures
- Select appropriate maintenance strategy

Maintenance Strategy can be run to failure, scheduled rebuild/replacement, condition-based maintenance, redesign or redundant system as in Table 1. The success of condition monitoring depends on the proper of setting the limits. Limits enable additional exception-based analysis. It provides advance warning and alerts you to the abnormal data or trends and facilitate planning, scheduling and

substantially reduce the amount of data one sees. Targets are limits that define goals of performance and not impending failure. It gives you advance warning.

CONCLUSION

In order to achieve the business goals of a reliable plant, the organisation must transform by integrating optimised and engineered business processes, technology integration, provide training and education, and document the best practices into the cultural transformation.

Hence to achieve world-classreliability, it takes more than maintenance alone, it requires:

- Strong leadership focus and business-aligned reliability mission, vision and strategic plan
- Reliability culture management
- Vision centric rewards system
- Targeted leading and lagging metrics
- Procedure, document and knowledge support systems
- Reliability data collection and analysis systems
- Strategic customer and supplier relationships
- Effective talent management
- Effective inter functional and inter plant communications
- Focus on design for reliability, operability, maintainability, safety and inspectability
- Reliability focused operations
- Reliability focused maintenance ■