FREQUENTLY ASKED QUESTIONS SERIES:

Reliability Engineering

This resource guide answers nine of the questions most frequently asked of LCE subject matter experts in reliability engineering.

QUESTION #1:

What is the role of a reliability engineer and how are they different from other engineers?

ANSWER #1:

Even though the day-to-day activities of the reliability engineer will not be the same for all industries, the general roles and responsibilities are common to all areas. The main responsibility for a reliability engineer is to identify and manage asset condition and mitigate risks that could negatively affect the company's value stream. This broad definition can be divided into three concerns:

- **Loss Elimination –** tracking high production losses, abnormally high maintenance costs, and repetitive failures to find ways to reduce or eliminate those losses, costs, or failures. These deficiencies are prioritized to focus efforts on the most critical or risky issues.
- **Risk Management –** managing risk to the achievement of an organization's strategic objectives in the areas of environmental, health and safety, asset capability, quality and production. Ownership of asset Preventive and Predictive Maintenance (PM & PdM) programs are a key area of implementing risk management to balance maintenance costs and equipment availability.
- **Life Cycle Asset Management –** management of all stages of projects for new assets and modification of existing assets. Studies show that as much as 95% of the Total Cost of Ownership (TCO) or Life Cycle Cost (LCC) of an asset is determined before it is put into use, so reliability engineers should be focused on the design and installation phases in particular.

Reliability engineering differs slightly from other engineering disciplines. Since it is a relatively new discipline and there are not many universities offering degrees in it, most reliability engineers come from other engineering backgrounds and find themselves with the title of reliability engineer without totally understanding what the role involves. The following are some of the ways that reliability engineers differentiate themselves from other engineers.

- **Education –** Reliability engineers are expected to have different skill sets that are gained through traditional education (universities, colleges, technical training, seminars, conferences, etc.) Reliability engineers also learn about new concepts or techniques through self-learning. These resources include textbooks, internet documents and discussion forums. Utilizing statistics in both operational and failure analysis is a key area of academic competency for reliability engineers.
- **Experience –** Reliability engineers typically are asked to be involved with improving the reliability of assets that are both electrical and mechanical. This means that having some level of experience or the ability to understand equipment and failure dynamics of both types is necessary. In addition, a reliability engineer needs to be able to understand how processes work and how to optimize them.
- **Relationships –** Reliability engineers often find themselves in a position where they have to bring different groups together to work toward a common goal or implement changes that require both groups to coordinate their efforts.

QUESTION #2:

What are some benefits a reliability engineer brings to the company?

ANSWER #2:

A reliability engineer can create value in all life cycle phases from design to decommissioning. It is often said that reliability engineering is one of the only engineering disciplines that pay for themselves. That is, a reliability engineer should save the company money in excess of what it costs to employ them. The following are a few examples.

- **Reducing the life cycle cost of equipment –** By focusing on true life cycle cost instead of initial cost, a reliability engineer can suggest equipment and component changes that may initially cost more, but can last longer and be easier to maintain. The overall effect is a reduction in the total cost of the asset over its life cycle.

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- **Extending equipment life through precision maintenance –** Equipment life can be severely reduced by improper installation. A reliability engineer understands the importance of precision maintenance and the ability for equipment installed with laser alignment tools or properly torqued fasteners. These techniques will extend the equipment life and decrease the frequency of replacement.
- **Decreasing the frequency of or eliminating time-based maintenance tasks –** Preventive Maintenance tasks are time-based activities that are aimed at increasing asset reliability. A drawback to preventive maintenance is that it can induce failures of its own, be time consuming and waste valuable equipment life. By looking for ways to replace preventive maintenance with predictive maintenance tasks (vibration, oil analysis, thermography, etc.), a reliability engineer will reduce or remove the potential for equipment downtime.

QUESTION #3:

What do I do when I cannot find a root cause after Root Cause Analysis (RCA)?

ANSWER #3:

Sometimes when you just can't find the exact root cause of an RCA, some might recommend finding an expert to help you solve the riddle or to help preparations to mitigate the consequence of the next occurrence, since it's likely to happen again. When the severity of the consequences dictates that preparing for the worst and hoping for the best is just not enough, here is one approach that can be used to systematically reduce the chances of the next failure. You can focus on the most probable cause or causes and either mitigate or eliminate them.

Here is how to find the most probable cause or causes given lack of complete data.

1. Construct a very detailed fault tree that details all the physically possible causes, regardless of how apparently improbable they are. This usually requires a good team of people. Creating a functional block diagram with all system and physical interactions of the system being investigated can aid in this process.
2. Systematically eliminate those pieces in each branch of the fault tree for which there is no concrete evidence of a break in the sequence. That is, first eliminate what you can PROVE the cause WAS NOT. From a Sherlock Holmes story: "…when you have eliminated the impossible, whatever remains, however improbable, must be the truth." Focus on using operational or test data to prove or disprove potential faults.

In addition, set up "data traps" (instruments or procedures to ensure that the critical determining information is not lost or destroyed) for the next time it happens, so that the real cause(s) can be verified.

QUESTION #4:

How much detail should I include in my job plans and maintenance procedures?

ANSWER #4:

The level of complexity in job plans and maintenance procedures depends on three factors:

- **The complexity of the task –** Tasks which have multiple steps that must be performed in specific sequence, or contain unusual operations, must be spelled out precisely.
- **The specific data needed to complete the task with repeatable results –** Critical numerical data, such as torque values and clearances, specific type of lubricant, or special tools, should always be spelled out and never left to memory. This information is subject to change, as is your craft person's memory.

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- **The criticality of the procedure's outcome or the importance that the job is done exactly right –** As the tolerance for poor outcome or any variation in the outcome decreases, the need for specific detail required to ensure a consistent outcome increases sharply. Check-off and inspection steps may be necessary. If your employees' lives depend on the procedure, write it as if your life depended upon it! But always strive for simplicity and clarity, using simple but precise words and short, unambiguous sentences. You are writing for your people's understanding, not to win the Pulitzer Prize.

Keep in mind, you do not offend your people's professional pride when you write procedures that will reinforce their memory and convey critical information. Always write your procedures so that a craftsperson competent with the tools and basic skills of their trade, but who has not done this procedure on this asset before, can use the information provided and perform the task to consistently achieve the desired outcome. Never assume that because the users of the procedure are skilled and experienced craftspeople they know all of the critical job-specific details. And don't assume that they will always remember the details accurately. With well-written procedures, the experience of the person executing the procedure may affect how quickly they can complete it, but the experience level of a qualified and competent person should never affect the quality of the results.

On the other hand, do not offend them by writing procedures that tell them in painful detail how to use the basic tools of their trade. Telling them to use a #2 Phillips to tighten the screws is not overkill, especially if the screws are located at the top of a long ladder climb and all the other units have slotted head screws. And if they were left-handed screws, including that in the procedure would be useful information. But if they are standard screws and you feel it is necessary to have to explain to them how to use that screwdriver, or multi-meter, or other simple tools to get the job done right, then you need to correct that problem at the basic skills training level, not in the procedure. You are writing procedures, not skills training materials.

QUESTION #5:

Can I count on the OEM recommendations for my job plans and maintenance procedures?

ANSWER #5:

The short answer is that it depends on the criticality of the asset in question. OEM recommendations are not enough for assets that fall in the medium to high criticality range. OEM recommendations come from sources such as the analysis of history from in-house and field tests by customers or output from very strict methodologies such as Reliability-Centered Maintenance (RCM). Depending on the mix of strategies employed by the OEM, the user and maintainer may have a valid concern about their credibility. It is quite often the case too, that it is next to impossible to get a true understanding of what their approach might have been.

Both the currently available PAS 55-1:2008 specification and the upcoming ISO 55000 standard recommend that every organization have a systematic and coordinated set of activities and practices that sustainably manages its assets' performance, risks and expenditures over their life cycles for achieving the organizational strategic plan. This suggests that the first consideration is to determine what the strategic objectives for the business are and then determine how each asset supports them. Obviously, the degree to which the objectives depend on a given asset will determine how valuable its asset management strategy will be to the organization. The process by which this is determined is known as criticality analysis.

The asset's criticality ranking should be one of the primary considerations used to determine how its control strategy is developed. Of all the approaches that are commonly used today, such as Reliability Centered Maintenance, Total Productive Maintenance and all the standard risk management plan development techniques, the blind acceptance and use of OEM recommendations has to be one of the least effective. All of the previously mentioned techniques require due diligence to be done by reviewing OEM recommendations, but total reliance on them is only reserved for the least critical of assets.

QUESTION #6:
How do I know if my maintenance procedures are effective?

ANSWER #6:
Here are some questions to answer to help maintain the health, welfare and safety of the products delivered:

- Is the PM procedure adequate for the equipment?
- Is the PM procedure adequate for the operating parameters (have the production rates been changed from design)?
- Is the existence of Standard Work Instructions (SWI) a requirement?
- Is the adherence to the SWI instructions a requirement for both operations and maintenance and the routine auditing of the SWI adherence a routine factor in the culture of the facility?
- Are the intervals of the PM inspections adequate to allow the procedures to functionally prevent failure maintenance in any manner, except planned and scheduled programmed and corrective maintenance that is accomplished in a controlled manner, with minimal impact on production?
- Are you routinely mining and refining the knowledge and expertise of the operators and crafts to enhance the reward of the specific PM procedure and tasking?
- Are your reliability engineers applying their talents to addressing less than functional PMs?
- Are your crafts capturing and coding the PM Work Orders appropriately to allow the reliability engineers the necessary forensic data to improve and tune the specific equipment PMs?
- Are your planners, in conjunction with Operations and Maintenance, ensuring the timely scheduling of Preventive Maintenance inspections for compliance completion?

Another way to evaluate effectiveness is to look at the distribution of maintenance work hours within your facility. Best practice benchmarks should be utilized to determine if you are performing effective maintenance, but the following can be used as general guidance:

- 60% Preventive & Predictive Work (predominantly predictive is preferable)
- 30% Corrective Work as follow-up work from PM/PdM activities
- 5% Proactive Work (e.g. implementing root cause analysis countermeasures)
- <5% Emergency Maintenance Work

QUESTION #7:
I have heard a lot about OEE and that I should be measuring it. What is OEE?

ANSWER #7:
Overall equipment effectiveness (OEE) can be an accurate representation of overall plant performance. Derived from Total Productive Maintenance (TPM) and the Toyota Production System (Lean), OEE is a single, calculated value that represents the plant's effectiveness in three key performance indicators: 1) availability or runtime; 2) production rate; and 3) quality rate. This straightforward value was intended to be the product of these three values, but has become a convoluted, almost infinite variation of calculations.

The correct calculation for OEE is the product of the availability, production and quality rates and should be calculated as follows:

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- **Availability Rate –** Availability rate is the actual production runtime for a specific time interval divided by the "planned" runtime for the same interval. Planned preventive maintenance, breaks, lunch or times where there is nothing to produce are examples of times that would not be included in the "planned" runtime. For example, an asset that is planned and scheduled to operation eight hours per day, five days per week has a total availability of 40 hours. If it has an actual runtime of 20 hours, the resultant availability rate is 50%.
- **Production Rate –** Production rate is the actual gross units produced for a specific time interval divided by the number of units that should have been produced. Technically, the denominator in this case should be the ideal rate as defined by the asset's design specifications, but in most cases assets are operating well above the original "nameplate" production rate. Therefore, the best demonstrated production rate should be used for this calculation. Best demonstrated is simply the best sustainable rate, based on asset history that your plant has been able to achieve. For example, when an asset produces 1,000 units per hour and its best demonstrated rate is 2,000 units per hour, the resultant production rate is 50%.
- **Quality Rate –** Quality rate should be straightforward. It is the total quality units produced divided by the total or gross units produced. Total quality units is defined as the total (gross) units produced minus all scrap, rejects, reworks and any other units that cannot be sold as prime. For example, if the asset produces 1,000 total units but 100 units are rejected, the numerator becomes 900 and the denominator is 1,000 or a quality rate of 90%.

Once these three values are determined, the final OEE calculation is simply the product of the three values, expressed as percentages, or 50% x 50% x 90% or 22.5%.

QUESTION #8:

Is the reliability engineer the only one responsible for asset reliability?

ANSWER #8:

No, everyone must take an active role. A viable reliability improvement program must start with corporate management. They must establish and support policies that create an environment that is conducive to maximum utilization of manufacturing and process systems. Without their active support, improvement is difficult to achieve. Unfortunately, lack of corporate leadership and support is the norm, and often contributes to poor equipment reliability.

Plant engineering, purchasing, production, operations, maintenance and training are the critical functions. Life cycle cost, ease of maintenance, and reliability must become their primary focus. They must work together with a common objective –to achieve the best performance from all plant equipment and systems. If you can improve the reliability of your equipment, product quality, increased capacity and profitability will follow.

Statistical analyses conducted by a number of industrial, trade and professional organizations conclusively point to the fact that maintenance is the primary source of less than 20% of availability losses. The majority is the result of deficiencies in other functional groups or functions within the plant or corporation. Therefore, the solution to availability problems should be clear–a holistic approach to standardized, value-added business and work practices that assure availability, best quality and lowest total cost of ownership. Single-focused approaches, such as maintenance improvements, simply will not generate enough benefits to warrant the effort–it cannot affect the majority of the factors that limit availability.

QUESTION #9:

How do I select the right Key Performance Indicators or Metrics?

ANSWER #9:

The framework of seven principles below is an example that attempts to incorporate basic, fundamental thinking into the creation of meaningful Key Performance Indicators (KPIs). Keeping the "End in Mind", KPIs should create value/full potential and help to establish competitive advantage. The seven principles of performance measurement really describe qualities that performance measures should have if they are honestly going to be useful:

1. **Have a clear purpose (End in Mind)** Use performance measures which provide objective evidence of the results that either define or lead to success for your business so your attention can effectively stay on what matters most in achieving, sustaining and elevating that success.
2. **Think systemically (Holistic Approach)** When you create, interpret or use a performance measure, think carefully about the unintended consequences that could result from using it, such as impacts on other areas of performance and especially for the success of your cross-functional business as a whole.
3. **Align with processes (From Independent to Interdependent)** Use your cross-functional, interdependent business processes as the framework for selecting and defining KPIs so they can translate targeted performance results into direct, actionable and appropriate action.
4. **Drive the right behavior (One Culture, One Team)** Create measures that will encourage and reward people to act in ways that achieve desired results, and sustain and elevate business success. People know that many business decisions are driven by performance measures.
5. **Build in integrity and trust (Ownership)** Ensure that your data, measures/ KPIs are valid and conform to accepted standards (both intuitively and statistically) by being unbiased, transparent and accurate enough to clearly define and fit their purpose.
6. **Understand variation (Technology, Processes, People)** Take account of levels of inherent variability in performance levels (predictability)when you interpret measures/ KPIs to decide if and when you need to do something about it,(mostly too late and a dollar short) as opposed to reacting to rapid changes and trends.
7. **Integrate with decision making (Change, Focus, Speed, Results)** Design the measurement/ KPI process so that it provides the most useful information in the most useful way so employees can engage to explore questions, assess options , make decisions and take actions to continuously improve (CI) processes measures/ KPIs by employing proven methodologies, i.e. PDCA, DMAIC, A3.

It's important not to pick too many KPIs. A best practice is to select a small number of business-focused KPIs for ongoing monitoring by management, and then have another set of more detailed KPIs at the maintenance department level. The management metrics should deal with maintenance budget trending, top 10 "bad actor" assets by cost, etc. The dept. level KPIs should be focused on specific areas of needed improvement such as: % work orders with time entry logged, % work orders with completion notes, etc.

Life Cycle Engineering offers classes and services to help you solve problems and improve performance (click on links or visit www.LCE.com to learn more):

- Reliability Engineering Excellence Course
- Root Cause Analysis Course
- Risk-Based Asset Management Course