CONTENTS

Life Cycle Asset Management

Overview

Life Cycle Asset Management (LCAM) is an integrated approach to optimizing the life cycle of your assets beginning at conceptual design, continuing through shut down and decommissioning. Thorough planning, analysis and timely execution allow appropriate data-driven decision-making to occur and enable LCAM to deliver optimum:

- Operating and maintenance strategies
- Organizational structure
- Staffing requirements
- Optimized PM/PdM procedures
- Reliability engineering processes
- Work control/planning and scheduling processes
- Equipment criticality and hierarchy in the appropriate enterprise resource system format
- Purchasing and stores processes
- Maintenance inventory requirements with min./max. stocking levels
- Training plan
- Start up and commissioning plan
- Decommissioning plan
- Executive dashboards with performance baselines and targets

To ensure effective asset investment decision-making and to achieve sustainable results in business performance, companies must take a holistic approach that addresses not only infrastructure assets, but also the supporting resources, business processes, data and enabling technologies that are critical to success. This holistic approach to life cycle asset management enables vast amounts of asset data to be effectively managed and leveraged at a practical day-to-day business level. With this approach, companies can institutionalize asset management and make it a focus of the day-to-day business. Only by incorporating asset management into daily business routines can a company achieve optimum performance and full asset potential.

Foundational Elements

Three foundational elements must be in place to support life cycle asset management: management strategy, optimum organizational design and long term asset planning.

Management Strategy Development

A shared vision, strategy and action plan is the foundation for a successful life cycle asset management program. Developing a vision brings company stakeholders together to create a common understanding of asset management, reach consensus on business objectives and prepare a plan for successful program implementation. At the end of the vision development process, you will achieve:

- A common understanding of strategic asset management concepts and benefits
- Defined service level targets on which to base a life cycle asset management strategy
- An assessment of your current asset management activities and recommendations for improvement
- A structured plan, schedule and business case for improving your asset management capabilities

The final outcome of the visioning process is an asset management strategic plan that provides a plan, schedule, budget and business case for moving forward with a viable life cycle asset management process.

Deciding how to best invest limited capital and Operations and Maintenance (O&M) dollars requires an understanding of the current condition and capacity of the company's infrastructure, as well as future capacity and reliability requirements.

Organizational Design

Business success is based on the right people, processes, data, and information technology, coming together at the right time to form the foundation of a successful asset management program. It also requires the appropriate organizational structure with roles and responsibilities defined and qualified resources available at the right time to achieve program objectives.

Long-term Asset Planning

The ability to forecast where and when infrastructure investments should occur is critical to a company's product quality and performance reliability. Deciding how to best invest limited capital and Operations and Maintenance (O&M) dollars requires an understanding of the current condition and capacity of the company's infrastructure, as well as future capacity and reliability requirements. It also requires an understanding of the cost and risk associated with implementing or deferring system expansions and improvements. As a minimum, the planning process must:

- Prioritize capital projects over a five to ten year period based on strategic objectives
- Forecast capital renewal, replacement and expansion costs over a ten to fifteen year period
- Forecast infrastructure-funding requirements based on long-term revenue and cost.

Risk Management

Risks arise at all stages through the life cycle of a project. For the optimum outcome, risk management approaches need to be applied considering the entire duration of the project. This paper discusses the application of these approaches, and provides examples to illustrate the benefits available to operators who implement risk management throughout the entire life cycle of an asset. The major steps involved in the life cycle of a facility include the following stages:

- Concept and Design
- Construction
- Commissioning
- Certification
- Production
- Decommissioning
- Disposal

Risk management can be applied effectively across the entire life cycle of a facility. Figure 1 illustrates the various phases of a project and the application of some of the risk studies that can be implemented during the various stages of the life cycle. These approaches will minimize business management risk for the facility. This paper discusses the application of risk management principles and techniques through each of these stages, with reference to some examples that illustrate the benefits available to operators who apply these principles effectively.

Figure 1: Risk Management throughout the Life Cycle of a Project

Concept and Design

The most effective way to reduce the overall risk exposure for a facility is to eliminate factors that could result in risks during the conceptual and actual design phases. This approach can be referred to as "Front-end elimination" of risk, or at least, front-end minimization of risk. Eliminating or minimizing risk during these phases of a project will limit the overall risk exposure that a facility will carry for the remainder of its operating life. This can obviously be much more effective than attempting to manage in-built risks later during a facility's operating phase. Risk reduction during the operating phase may be restricted to implementing procedures and training, which have limited effectiveness, or retro-fitting of engineering solutions, which can be expensive.

The most effective way to reduce the overall risk exposure for a facility is to eliminate factors that could result in risks during the conceptual and actual design phases.

- Risk Studies during the Conceptual Design Phase: Risk studies undertaken during this phase should consider risk in a variety of areas, including project, safety and operational risk. These studies may include (but are not limited to) the following:

- Project Risk Assessment. Feasibility studies, financial risk assessments
- Safety Risk Assessment. Safety: hazard analysis, hazard and operability study (Hazop), quantified risk assessment
- Operational Risk Assessment. Critical machinery risk assessment, reliability and availability studies, simplified failure modes and effects analysis (SFMEA)

A significant factor in minimizing the risk over the life cycle of a facility is the provision of independent evaluation and reporting processes. Utilizing an "owner's representative" and correct implementation of these approaches should ensure that there is transparency of the risk decision-making processes. This would include a clear identification of all control measures put in place, together with the required procedural and asset integrity programs. This approach would also satisfy the requirements of corporate due diligence.

Selecting motors is an example of a mechanical decision that impacts operational risk, while selecting storage arrangements for hazardous materials provides an example of a decision that impacts safety.

- *Motor Size Selection*. The facility may require a series of motors for a range of applications, each having power requirements within a close range, although not necessarily identical. The cheap option for the project design team may be to specify individual motors for each application. However, during the operating life of the project, this may introduce a significant risk exposure, as a motor failure may require a long lead time for repair or replacement, resulting in significant downtime. To mitigate this risk, spare motors can be held. Selecting similar motors during the design phase mitigates the risk from a series of motor failures by having a single spare available. The considerably more expensive alternative for the case of individual motors would be for the facility to have spares for each item available, or accept the risk exposure to the operation that goes with not having a spare should a failure occur. Many other Total Cost of Ownership (TCO) decisions could be made regarding these motors, including where to store the motor, whether to pay extra for premium efficiency, and whether it's cost effective to have redundancy.

- *Hazardous Materials Storage Arrangements*. Chlorine, ammonia and LPG are common hazardous materials that are routinely stored in bulk. For many installations, the decision will need to be made during the concept stage between refrigerated or pressurized storage. In order to minimize the risk exposure, refrigerated storage is preferred. In the event of a failure releasing a significant amount of the stored material, the impact from a refrigerated storage will be dramatically less than that from a pressurized storage.

Construction

A variety of risks present themselves during the construction phase of a project. These range from occupational health and safety risks associated with injuries, to major financial risks that may have the potential to derail the project. In addition to managing the lower level risks, it is essential to identify and address risks that have the potential to seriously impact the viability of the project.

Industrial relations is an example of potential risks facing a project during construction.

- A major chemical company built two similar plants in different locations, with vastly different outcomes on the industrial relations front. The plant that commenced construction first was beset by industrial relations problems, whereas the sister plant encountered few such difficulties, enabling it to be completed on schedule and be operational prior to the first plant. Identifying potential risk exposures through a comprehensive risk assessment would enable such issues to be identified and appropriate measures put in place to limit the risk exposure. Measures that are commonly put in place to address these issues include bonus payments for strike-free periods and union/ project team agreements establishing union roles within a project.

Commissioning

During the commissioning phase, reviews are essential to ensure that the capital equipment and systems have been manufactured, installed and connected in a safe and reliable fashion.

During the commissioning phase, reviews are essential to ensure that the capital equipment and systems have been manufactured, installed and connected in a safe and reliable fashion. There is a need to conduct validation reviews to ensure that the installed design of the facility meets the specified performance parameters. This process is an extension of the "Owner's Representative" approach discussed earlier, and is most effective when implemented as a continuation of the same process.

Production / Operations

During the production phase of a facility, the scope for reducing risk is more limited. During the production or operational phase, implementation of additional risk control measures is restricted to procedures and the installation of improved control systems to manage safety-related hazards, or procedures and improved maintenance practices to manage operational risks.

Unfortunately for the operators of many facilities, the first time that risk approaches are implemented is often during the operational phase. Risk assessment can typically be triggered by regulatory requirements (e.g. statutory approvals) or unsatisfactory performance (e.g. in either safety or operational performance). These assessments may identify areas where the risk exposure can be reduced; however risk reduction measures that achieve a step-change in the risk exposure for a facility commonly require significant expenditure.

Experience has indicated that when considering operational risk exposures, the major risks are commonly associated with relatively frequent events that have a moderate consequence. This is illustrated in Figure 2, the Risk Diagram, and a plot of incident frequency against consequence.

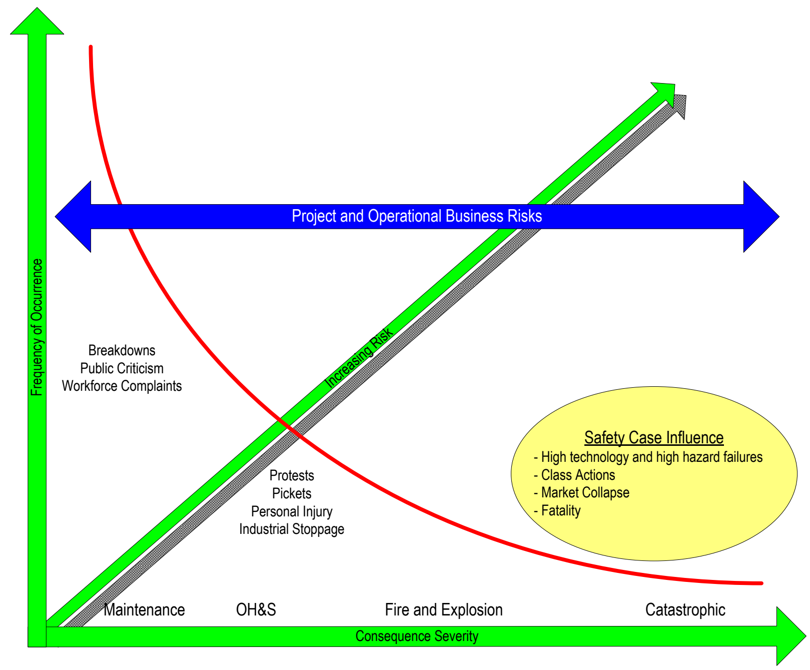

Figure 2: The Risk Diagram

As with the initial design of the facility, it is important to ensure that the risk exposures and operational requirements are taken into account during the design of upgrades, enhancements and modifications.

The cumulative impact of these events on the overall operation is commonly underestimated, resulting in them being neglected, with the status quo of poor operation continuing. A thorough risk assessment targeting events of this nature can identify the high-risk events and then also identify suitable controls for prevention and mitigation of the incident.

Although it is preferable that risk exposures be minimized in the front-end design of a facility, significant risk reduction can often be achieved once the facility is operational. As with the initial design of the facility, it is important to ensure that the risk exposures and operational requirements are taken into account during the design of upgrades, enhancements and modifications.

In many situations where upgrades and modifications are designed for a facility, they fail to take advantage of the opportunity to optimize the overall outcome. This can occur when external contractors are used, but can also easily occur when in-house project engineering groups are used. These groups often operate virtually independently of the operational arms of the organization, having their own goals and performance measures in place. Similar to the situation that can be encountered during the design phase, this situation can result in the installed facility having a greater risk exposure than is necessary. In order to minimize this potential, it is good practice to have representatives from the operational plant involved intimately with the design team, effectively fulfilling the role of an “owner’s representative”. This will ensure that the new items do not add unnecessary risk exposures to the original facility and will decrease risk where possible.

An example of a significant risk improvement achieved during the life of a facility was the replacement of particular equipment in a chlorine production plant. When the need arose to replace the refrigeration unit for the refrigerated liquid chlorine storage facility, the design choice was made to install the refrigeration unit within the secondary containment building housing the refrigerated storage vessels.

This option was selected to minimize the potential consequences of a release, by locating all pipelines that held liquid chlorine within the secondary containment building. A cheaper option of replacing the refrigeration system "like for like" would have missed this opportunity to increase the overall safety of the facility.

Decommissioning / Disposal

Selection of appropriate facility design can eliminate or reduce the issues associated with the decommissioning and disposal of facilities at the end of their useful life. Without such consideration, headaches easily present themselves for those left with the responsibility of decommissioning and disposing of the facility. Risk management can be put to good effect during the concept and design phases of a project to anticipate potential problems and take them into consideration in the initial design of the facility. This would enable potential clean-up issues to be avoided altogether, or at least appropriate risk reduction controls to be put into place in the initial design to minimize the impacts.

Site remediation is an issue that often raises itself during the final phases of the life of a facility. It is during this phase that major costs that have remained hidden for years will become evident. An example of this is major contamination of the facility site, caused by chemicals leaking into the ground. The extent of the contamination is commonly not known until the clean-up begins and many companies have faced potential financial ruin from the clean-up obligations that have been imposed on them following cessation of operations. To avoid this situation, it is important to identify potential risks early on and act accordingly, such as by providing appropriate leak prevention and spill containment systems.

Conclusion

The examples discussed above highlight the importance of considering the overall risk implications of decisions during the early phases of a project development. Decisions made during this time can have major implications for the risk exposure over the lifetime of the facility. Good decisions made early in the project will enable safety, operational and business risks to be eliminated or, at worst, minimized if elimination is not possible.

To find out how Life Cycle Engineering can help you reap the benefits of Life Cycle Asset Management for your company, please email us at **info@LCE.com** or call 843-744-7110.