Introduction
A cement plant has various stages in its lifecycle. Whatever stage a plant is at, it can be demonstrated that completing a mechanical integrity and reliability audit can have significant benefits when engaging with an experienced auditor who provides fresh observations.

A typical asset lifecycle is displayed within Figure 1, which illustrates that, when considering the condition of an asset, decisions are required on a cyclic basis about how best to maintain and operate that asset. Equipment could be patched, repaired or reconditioned, or components may need to be changed. This can be looked at in terms of minor or major items, depending on the time and cost to make the repairs. Areas of equipment that are repeatedly failing can be designed out or new technology can be introduced to try to stop disruptions to planned kiln campaigns. Depending on the availability of raw materials and market conditions, it is often possible for clinker production to be increased – utilising the original equipment design as much as possible – by undertaking a de-bottlenecking study. The scope to do this can also be based on how conservative the original design standards were and what safety margins were incorporated in order for the original equipment to meet contractual performance guarantees. Eventually, though, all cement plants will end up at the disposal stage, which can be for a variety of reasons. However, there is a considerable market for second hand equipment in the sector, so it would not be unusual to see the closure of a cement plant, with some equipment being dismantled and installed at another location and continuing its operating life cycle there.

What is a mechanical integrity and reliability audit?
Mechanical integrity within the cement industry can be defined as the process of ensuring that equipment is fabricated from the right materials and is properly installed, maintained and replaced to prevent unplanned failures.

Therefore, if a plant management team is to achieve the above, the entire lifecycle of an asset has to be assessed, which
involves understanding the design concepts and design life of the original equipment that was installed.

A **reliability audit** within the cement industry can be defined as a comparison between the existing cement plant reliability performance and the targeted reliability requirements from within the business plan. The reliability requirements are the standards to be used in a reliability audit to assess a cement plant’s performance. The difference between existing performance and the reliability requirements is the ‘gap’. A good reliability audit report shows a cement plant’s gaps and provides solutions to bridge those gaps.

A reliability review would not be considered the same as an audit, the main difference being that a reliability audit has a standard or set of requirements to measure existing reliability performance against.

The term audit stems from the Latin word ‘audire’, which means to ‘hear’. This is a very important aspect of a skilled auditor’s role: to ask questions and then listen to the answers and explanations for a cement plant’s existing reliability performance.

**Why combine mechanical integrity and reliability together as part of the same audit?**

Without focusing and understanding the design standards a cement plant was originally built to at the beginning of its operating life, many issues are overlooked later on when reviewing a plant’s reliability performance and the decisions tree of whether to repair or replace components. Therefore, assessing the mechanical integrity of equipment is an essential foundation for improving reliability performance. For items such as pressure vessels, inspections are mandatory. However, for much of the equipment that makes up a cement plant, there are no such compulsory inspections. As part of a reliability audit, strategies and improvements can be developed for maintenance planning, maintenance inspecting, measuring and monitoring, in addition to actually implementing maintenance activities. However, consideration to the original design standards and factory acceptance test information is often overlooked. The result generally always leads to some form of catastrophic failure to a major component within a cement plant. Really looking at the original design standards for materials, welding standards, stress calculations and finite element analysis can reveal vital clues to improve an area of equipment that has just experienced a catastrophic failure or can even prevent a major catastrophic failure from taking place. The original design standards are an area often overlooked when completing ‘Root Cause Analysis’ of failures by plant personnel.

Many cement companies use the independent knowledge and skills of an auditor to support their reliability objectives and to assist in predicting what issues are around the corner. Consultants can offer assistance with putting plans in place to monitor, measure and prepare to execute major maintenance issues, which the plant personnel may not have experienced before. Of course, looking at the original design in isolation does not always provide the solution, but the combination of understanding the original design and then having the experience and understanding of modern designs, trials of new equipment modifications, different standards and materials, provides a unique capability to improve reliability.

The ability to understand the various different international standards that equipment is now built to is of obvious increasing relevance as the cement industry becomes more globalised and more and more long-term equipment suppliers look to outsource the manufacture of equipment to different regions of the world with varying legal requirements, capabilities, and foundry and metallurgical standards. Sometimes, when assessing the commercial feasibility of a new cement plant, the viewpoint of investors and the financial state of the owners in terms of their strategy (short-term, mid-term or long-term) in relation to gaining payback from their original investment in projects can affect the overall profitability of a plant and its capability to operate for a long period without significant major equipment replacement. Basically: buy cheap, buy twice. If equipment is built to indeterminate standards, do not be surprised if it fails early and damages a cement plant’s ability to reliably achieve its business goals.

Specialist auditors have experience of specifying crucial design criteria when ordering a new cement plant, completing factory acceptance test visits, as well as the experience of building new plants from different international suppliers, alongside the experience of maintaining cement plants of various vintages. The skill sets required for each activity are different and this broader experience base offers cement plant owners something extra...
to help them achieve successful results from a mechanical integrity and reliability audit.

How to start a mechanical integrity and reliability audit

When completing a mechanical integrity and reliability audit, a good starting point is for the auditor to provide independent shutdown support for a cement plant’s major maintenance period. During this period, access to the major components for more thorough inspections is possible, compared to when the plant is operational. The shutdown can be likened to academic examinations in some ways and offers a great opportunity to make a first assessment. To build a relationship between an auditor and the plant engineers and technicians, offering support for some inspections, execution methods and planning support for the following shutdown allows an auditor to gain a good understanding of the existing maintenance standards, philosophies, tools, resources and systems in place. This experience provides a fair understanding of the actual situation at a plant in order to start looking at solutions to improve performance or to prepare to maintain standards for equipment as it increases in age. Being part of the shutdown allows an auditor to assess the plant management’s approach towards reducing the risks of unplanned failure and their attitudes towards designing out defects or any trials/ modifications to improve equipment performance.

These first experiences allow an auditor to be part of a cement plant’s journey over the next few years to achieve the balancing act of safe, environmentally friendly production whilst maximising the production of consistent quality cement, trying to reduce production costs and increase plant reliability.

From this first snapshot, experience has shown that whatever a plant is doing, there are always some aspects in terms of achieving reliability targets that can be improved. The challenge is to then work with the management team by identifying the tools, techniques, resources and approach that best suits management’s aims and experience. Such technical discussions lead to a greater depth of understanding of cement plant equipment and great possibilities to implement new systems, maintenance and monitoring techniques and to plan accordingly to prevent major catastrophes.

When to carry out a mechanical integrity and reliability audit

Based on practical experiences, evidence has shown that such an audit is suitable for all of the following situations:

- After a change in ownership.
- After a change in the senior management team.
- After a significant reduction in workforce.
- Rehabilitation of a previously mothballed kiln.
- A significant change in raw materials or fuel types.
- A poorly performing plant.
- Within the first year of operation of a new greenfield site.
- Within the first year of operation of an upgraded existing kiln expansion project.
- For a 5 – 10 year old plant.
- For a 10 – 15 year old plant.
- For a 15 – 20 year old plant.
- For a 20 – 30 year old plant.
- For a 30 – 40 year old plant.
- For a 40 – 50 year old plant.

If an auditor uncovers just one major area that a plant had overlooked and was obviously going to be a catastrophic failure at a cement plant then the return on investment for an auditor is immediate.

Each plant should be treated individually by utilising knowledge of design lifecycles to help predict the types of maintenance issues that are on the horizon. Many such major activities may be the first time components have been changed or refurbished since they were installed. Different equipments have different life expectancies, ranging from less than a month to decades.

What are the benefits?

Over the years, in various companies and different size organisations, results have shown that the combination of skills offered by an auditor provides cement companies with something additional that they do not have in-house and avoids the office politics that can be an issue for plant personnel. External auditors are also independent of the historical activities and decisions that have taken place over the years at a cement plant and thus can offer a fresh view when dealing with an existing plant and its performance.

Typical feedback and benefits of completing a mechanical integrity and reliability audit have included:

- Improved reliability and business performance.
- Greater training and understanding of the cement plant workforce in the design criteria of their equipment.
- Improved maintenance; planning, budgeting, inspecting and executing.
- Improved team working.
- Improved safety performance.
- A reduction in unplanned and breakdown maintenance activities.
- Improved spare parts management.
- Reduced operational costs.
- Process stability, which leads to reduced clinker and cement quality variation.
- Energy efficiency improvements.

Conclusion

This is one approach of many, but considering and understanding the original design standards of equipment that management have to operate and maintain is important. Combine this capability with the knowledge of how to build and maintain major equipment, alongside an understanding of how and why design standards have changed can only support a quality decision-making process in terms of managing an asset’s lifecycle and achieving reliable business outcomes.