Property Risk Consulting Guidelines

XL Risk Consulting

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PRC.17.15.0

CEMENT PRODUCTION

INTRODUCTION

The cement industry is a highly automated, continuous and a capital intensive operation. Large electric drive motors and heavy equipment intensifies the investment of capital in critical operations of the site operation which results in significant potential bottlenecks in the production process. Equipment involved in the process of making cement presents considerable fire protection concerns. The kilns are the heart of the entire operation. Fuel-fired rotary kilns operate at high temperatures to heat limestone. Like all fuel-fired equipment, kilns have fire and explosion hazards. Poor housekeeping and poor maintenance practices have led to unforeseen breakdowns. Overstressed kiln shells have been known to crack and require expensive replacement or repair. Fatigue cracking, warping, drive failure, rotating tire failure, inadequate ignition, overheated chains and refractory failures have also led to substantial kiln losses.

Explosive hazards are associated with open pit or quarry mining equipment, such as drilling and blasting machinery, power shovels, loaders or draglines and ore transport vehicles. Heavy electrical usage can result in high stress and heavy loading on transformers and other electrical support equipment which typically contain combustible oil. Transport of raw and intermediate materials consists of multiple conveyor belts which are often made of combustible rubber and can be difficult to access for maintenance and fire fighting due to their location below grade or high above ground.

BASIC PROCESS (PROCESSES AND HAZARDS)

The main raw materials used in the cement manufacturing process are limestone, sand, shale, clay and iron ore. Limestone is the major, naturally occurring, raw stock used in the cement manufacturing process. It is mined, usually from a quarry located near or adjacent to the cement plant. Mining of limestone requires the use of drilling and blasting techniques. Blasting techniques use technology to insure vibration, dust and noise are kept to minimum levels. Materials are typically loaded at the quarry blasting face into large transport trucks to bring to the crushing plant. Raw limestone is processed through a succession of standard, mining industry, rotating and tumbling machinery. The raw stone is crushed and ground into increasingly smaller sizes. Vertical rotary crushers crush large pieces. Horizontal rotating drum grinding mills tumble steel rods or steel balls with the crushed limestone and gypsum to pulverize the material.

There are two basic production methods used in the cement manufacturing process, sometimes referred to as Portland Cement. These methods are:

Wet Process: The wet process involves adding water to the proportioned raw material mixture creating a slurry form to meet a desired chemical composition which is then sent to the rotating ball mill in a water slurry form. Raw materials are ground to size where the majority of the materials are less than 75 microns. Slurry is pumped to blending tanks and homogenized to insure the composition is correct. It is then stored in tanks until needed. The wet slurry process is usually associated with longer kilns.

Dry Process: The dry process consists of materials ground to a powder, blended and fed into the rotating ball mill or vertical roller mill in dry powder form. Typically raw material is pre heated using the kiln exhaust gases prior to entering the kiln. The dry method involves charging the dry pulverized limestone directly into the kiln.

Whether the process is wet or dry the same chemical reactions take place within the kiln. Evaporation of moisture, calcining the limestone under high heat conditions to produce free calcium oxide and reacting the calcium oxide with minor materials such as sand, shale, clay and iron. In this process the pulverized fine grained material is fed into the upper end of a rotary kiln to burn the limestone to lime. It passes through at a controlled rate by the slope and rotational speed of the kiln. Chemical reaction inside the kiln leads to the fusion of the raw materials to produce the final black nodular product called clinker. In the calcining process limestone ($CaCO_3$), the material is heated to 1000°F – 1100°F (538°C – 593°C), and CO_2 is driven off. The lime (CaO) calcium oxide remains.

When sufficiently pulverized, the fine grained material is passed through a rotary kiln to burn the limestone to lime. This process is called “calcining.” In calcining limestone ($CaCO_3$), the material is heated to 1000°F – 1100°F (538°C – 593°C), and CO_2 is driven off. The lime (CaO) remains.

The resulting clinker nodules are pulverized and mixed with additives, such as gypsum, sand, iron and clay. These are blended and mixed to make a distinctive and uniform product. Figure 1 is a simplified flow chart showing the basic process of cement manufacture.

Coarse Crushers

Primary and secondary crushers are used in the coarse crushing process. Primary crushing occurs as near to the ore source as possible and may be located within the mine itself. Raw limestone at the mine is irregular break size. Pieces, frequently larger than 12 in., (30 cm) are fed to the primary crusher through a steel grate called a “grizzly.” The primary crusher consists of a vertical, hard alloy surface, steel bowl in which an alloy surfaced, steel pestle is rotated to break up the stone. It crushes the limestone to 5 in. – 8 in. (13 cm – 20 cm) pieces. Uniform sized limestone is transferred to the secondary crusher where it is broken to 1½ in. (3.2 cm) stone size. Limestone is then stockpiled in storage bins or silos.

Coarse crushers undergo hard usage in severe environments. Their extensive hydraulic systems present potential machinery and fire losses. A hydraulic fluid leak could cause considerable damage if ignited by electrical controls. Explosion hazards exist where there is a “stick supply” box of dynamite near the grizzly. Recommendations for handling and use of explosives are found in NFPA 495 and PRC.17.20.0.

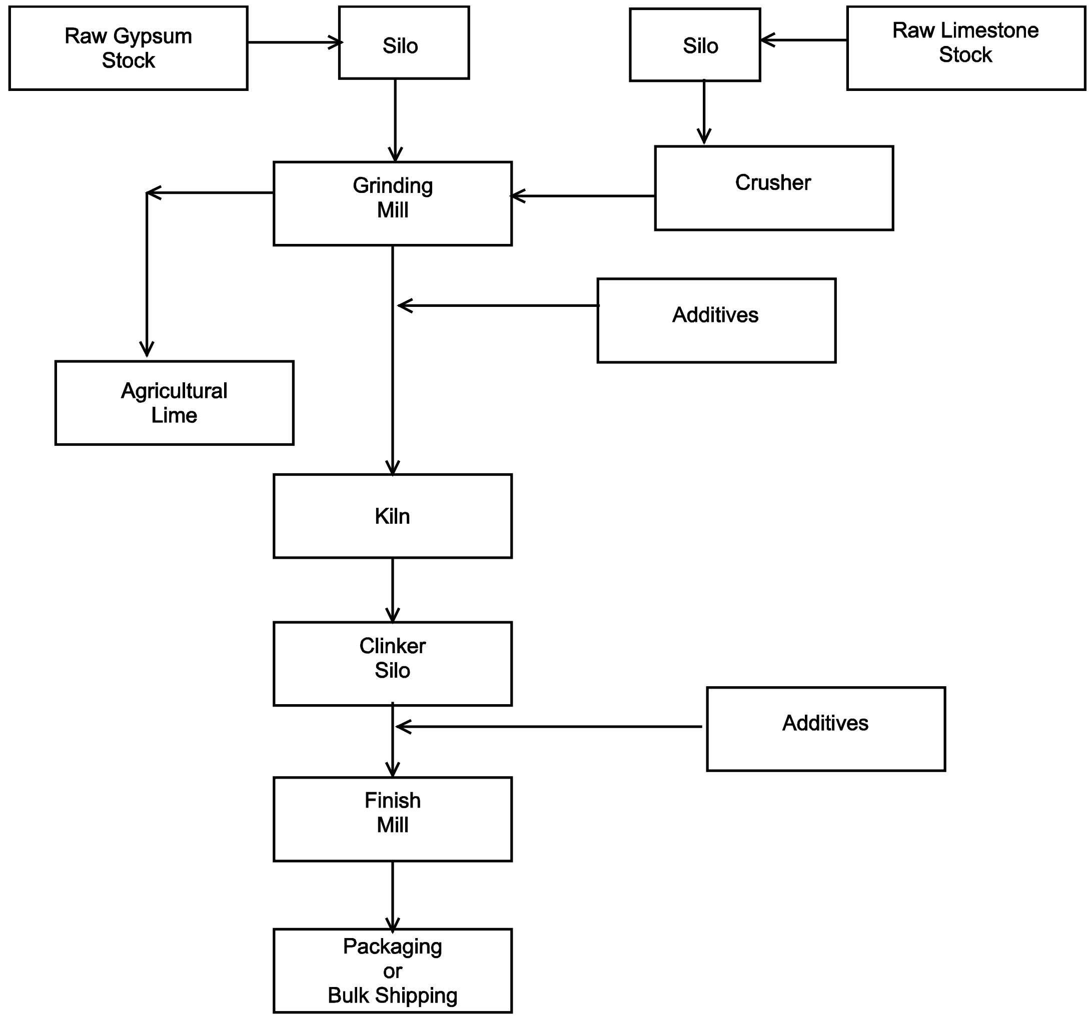

Figure 1. Simplified General Flow Chart.

Grinding Mills

Rotary grinding mills are horizontally mounted, rotating drums or barrels, which further reduce the stone to a size that can be made into a slurry or fed dry into the calcining kiln. A rod mill consists of steel alloy rods laid parallel in the drum. These tumble as the drum is rotated. A ball mill tumbles alloyed steel balls which pulverize the stone between the steel balls and against the sides of the rotating drum. A ball mill is used for the “finish mill.”

The large size of these mills requires high horsepower, 2500 hp – 5000 hp (1865 kW – 3739 kW), electric drive motors and large drive gear sets. Electrical and lubricating hazards are present.

Calcining Kilns

The calcining process takes place in a rotary kiln. The kiln is inclined from the loading “cold” end down to the firing end. When the limestone travels the length of the kiln, it will form clinkers as the CO_2 is driven off. The clinkers drop out of the kiln into a cooler where they are cooled to around 250°F – 300°F (107°C – 135°C).

Kilns are usually fired with pulverized coal or oil and may be dual fired. Safety controls for fuel firing are covered in PRC.4.0.1 and NFPA 86, for gas or oil fired units, and NFPA 85 for coal fired units.

Rotary kilns range from 12 ft – 20 ft (3.6 m – 6 m) in diameter and from 150 ft – 500 ft (46 m – 152 m) or more in length. They are typically constructed of steel with fire brick refractory linings. A zoned, direct-fired counterflow design has proven efficient for this process. The temperatures in the kiln during operation range from 500°F (246°C) at the cold end to 2700°F (1468°C) at the firing end.

Most kilns have chains at the cold end to agitate and expose incoming materials to the hot gases. The chains also help prevent unwieldy-sized clinkers from forming. To resist the extremely high temperatures in the kiln, the chains are often made of special steel alloys. Chains may not be easily replaced on a short term basis. If the flow of raw materials is interrupted or the kiln stops rotating, the chains can be seriously damaged because of overheating.

It is critical for the kiln to continue rotating even during a power outage, and for this reason, an emergency drive is normally provided. This engine for this drive may be diesel or gasoline fueled and is located directly adjacent to the drive kiln gear drive assembly. Upon loss of power this back up drive would automatically start and continue to spin the kiln at slow speed to prevent a potential warping condition. This warping condition can cause refractory and steel cracking damage which can result in prolonged down time. This situation can particularly be exaggerated when the loss of power to the kiln occurs and heavy rains also occur which can result in a quickly cooled exterior kiln on one side resulting in the above described warp condition. Therefore, preventative maintenance and weekly operation of these back up drive motors is essential to have a high confidence level this drive will start automatically.

Conveyors

Conveyors are critical to cement plant operation, because materials must be transferred through various production stages. Finished product conveyors, typical of general conveying systems, move product to packaging, shipping and storage areas.

The clinker belt transports the cooled clinker to the clinker storage building. This belt is usually a high temperature or “hot service” belt, rated to 400°F (190°C) because of the 250°F – 300°F (107°C – 135°C) temperature of the material it carries. The belt can range from 2 ft – 3 ft (0.6 m – 0.9 m) wide and several hundred feet long.

Belt conveyors, usually rubber, are one of the most serious loss exposures in the plant because of the size and location of the belts. The clinker reclaim belt, typically located in a concrete tunnel below the clinker storage building, is not accessible for manual firefighting because of its confinement within the tunnel. Loss of conveyor belts or support structures may lead to serious losses. A typical loss scenario is the over heating condition or seize of a bearing for the conveyor rollers which causes an over heating friction condition for the belt. Good preventative maintenance programs and inspections are critical on these rubber belts. In general cement maintenance departments are very savvy at repairing or “seaming” rubber belts together. Spare belts and a list of key belt suppliers can prevent a long business interruption situation.

Electrical Switchgear and Transformers

Because of the 2500 hp – 5000 hp (1865 kW – 3739 kW) electric drive motors, a high voltage and dependable electric power supply is necessary throughout the facility. Primary electric power is usually supplied from a public utility grid and may be a single line feed running for some distance. Plant-owned transformers, switchgear and distribution equipment supply electric power to motor control centers. Because of the size and distribution of equipment, there will be many motor control centers in various areas of the plant. In some instances, the transformers are located outside buildings with electrical switchgear inside. Transformers and switchgear could also be located inside, either adjacent to operations or in cut-off rooms.

Large switchgear rooms in unsupervised areas tend to accumulate combustible storage which increases fire exposure.

Shipping

Finished product is usually shipped in bulk or bagged. Bulk shipments are loaded from the storage bin to the loading hopper and are gravity fed into trucks or bulk rail haulers. Bins and silos must be vented to prevent a negative pressure from developing while cement is being withdrawn.

Bagging operations require a supply of bags. These bags are usually heavy kraft paper impregnated with some type of sealant to keep the cement dry. Quantity orders of empty bags are received on wood pallets and are stored in the storage building or a bag shed. Idle wood pallets, which are usually retained on site for reuse, are frequently stored with the bags. A nominal supply of empty bags may be piled in the bagging room.

Storage of combustible bags exposes the storage area to a possible total loss. Fire in wood pallets would be very difficult to control.

LOSS PREVENTION AND CONTROL

The loss prevention and control guidelines are not all inclusive and are provided with an “average” hazard level in mind. Increased hazard levels warrant additional loss prevention and control measures.

Misuse of heavy equipment and lack of maintenance are among the chief contributors to cement manufacturing losses. Well-trained operators are essential. Periodic inspections and scheduled maintenance procedures must be effectively used to detect wear and potential failure. Gears should be well-maintained, and provide a spare gear sets for critical equipment.

Poor housekeeping and accumulated combustibles can cause considerable losses in the switchgear rooms, transformer vaults, maintenance shops and general storage areas. Periodically clean all areas and remove combustibles and cement dust.

Facility construction should be noncombustible. Cut off pallet storage from finished storage and production machinery by a separate building or by a 3 h rated fire barrier walls and 3 h rated automatic closing fire doors.

Coarse Crushers

Loss prevention in crushing areas requires an awareness of electrical hazards, preventative maintenance procedures and good housekeeping practices. The machinery damage peril is moderate to high because of constant usage. Spare motors and gears should be available. Controls for newer model, rotating equipment may be hydraulic and include pressurized lines and an oil reservoir. Lubricating systems may also involve oil reservoirs and distribution systems. Gear lubrication for the large open gears is usually heavy grease.

Provide spot sprinklers, probably dry pipe, as needed over hydraulic reservoirs and lines. (See PRC.9.2.4.) Design the automatic sprinkler system or water spray fixed system in accordance with applicable NFPA 13 and 15 guidelines.

Grinding Mills

The machinery damage peril to grinding mills is moderate to high. An awareness of electrical hazards, preventative maintenance procedures and good housekeeping practices is important in grinding areas.

Controls for newer rotating equipment may be hydraulic and may include pressurized lines and oil reservoirs. Provide spot sprinklers as needed over these reservoirs and lines. Lubricating systems may also include oil reservoirs and distribution systems. Gear lubrication for the large open gears is usually heavy grease.

Calcining Kiln

The machinery damage peril is severe for kilns because of the adverse operating environment and constant usage. Hydraulic controls for newer rotating equipment may be in place. Spot sprinklers may be needed over oil reservoirs and pressurized lines. Knowledge of fuel storage, handling and combustion controls is necessary. Preventive maintenance procedures must be implemented and well documented. These programs should include vibration analysis and regular refractory rebuild programs based on manufacturers recommendations.

Special hazard protection for kilns should include:

- Combustion controls for kiln firing in accordance with PRC.4.0.1 and NFPA 86 for gas and oil fired units, NFPA 85 for coal fired units.
- An alarm to monitor drum rotation and loss of the slurry feed.
- Emergency cooling upon loss of slurry feed.
- Emergency drive with separate power supply for kiln rotation.
- Posted written procedures for emergency shutdown of the kiln.
- Good housekeeping in the environment to help prevent or control electrical and mechanical problems.

Conveyor Belts

Belt gallery enclosures should be noncombustible. The length of the raw material belt can range from a few hundred feet to several thousand feet. The width could be 2 ft – 4 ft (0.6 m – 1.2 m). In addition, this belt is typically elevated on trestle type supports and could be located as much as 150 ft (46 m) in the air which makes manual firefighting nearly impossible. If the belt and belt gallery were seriously damaged, the production downtime of the conveyor could result in a large loss. Belt replacement should include the use of fire resistive rubber belts which are slightly higher cost but will not ignite and burn as quickly or easily.

Provide water spray or closed head sprinklers protection for all conveyor belts in accordance with PRC.9.3.1 and NFPA 15. Additional protection for all belts includes zero-speed switches and alignment switches to shut down the belt if key pulleys stop rotating while the drive motor is running or if the belt becomes misaligned. In addition, the hot clinker conveyor should have heat sensors to detect abnormally hot clinker. Arrange these sensors to activate a cooling water spray or a shunt conveyor which would discharge the hot clinker to a safe location.

Electrical Switchgear and Transformers

Segregated electrical areas tend to be used to store electrical parts and large cable reels. Combustible storage increases the fire loss exposure. Removal of such accumulations is recommended.

Locate outside transformers containing combustible oil at least 30 ft (9 m) from buildings or equipment.

Switchgear Rooms

Maintain switchgear rooms free from combustibles and have good housekeeping, adequate fire extinguishers, automatic fire alarms activated by smoke detectors, and good preventative maintenance programs. In addition, switchgear rooms should have fixed fire protection. This may be a CO_2 system or sprinkler protection. (See PRC.17.12 for additional information.)

Cable trays are not generally a problem in single kiln plants or plants having a separate switchgear room for each kiln. However, evaluate the cable tray arrangement for each location.

Locate all inside transformers containing combustible oil in a cut-off vault.

Provide spot sprinklers, CO_2 protection or smoke detection where needed. Maintenance and testing should be provided in accordance with PRC.5.9.1.

Transformer Vaults

Cut off transformer vaults by 3 h rated fire barrier walls and 3 h rated automatic closing fire doors. Cut off switchgear rooms by 2 h rated fire barrier walls and 1½ h rated automatic closing fire doors.

Less-flammable liquid-insulated transformers or transformers which contain combustible oil may require a water spray system, 0.25 gpm/ft^2 (1.2 L/min/m^2), depending upon location, exposures and importance to continued operations. (See PRC.5.9.2 for additional protection recommendations.)

Transformer oil analysis gas chromatography, infrared surveys and electrical testing are essential to ensure electrical breakdowns do not occur. (See also PRC.5.2.1, PRC.5.2.2, and PRC.5.9.3 for electrical protection.)

Maintain and protected combustible oil-filled transformers or less-flammable liquid-insulated transformers in accordance with PRC.5.9.1 and PRC.5.9.2.

Unusual arrangements may require fixed pipe CO_2 or sprinklers at higher densities. (See PRC.17.12.)

Offices

Provide Ordinary hazard, Group 1 sprinklers for most areas of cement plants. Install sprinklers should in accordance with NFPA 13 and PRC.12.1.1.0.

Maintenance Shops

Install Ordinary hazard, Group 2 sprinklers in Maintenance Shops. Provide one inch (25 mm) hose connections spaced at approximately 100 ft (30 m) intervals and equipped with 100 ft (30 m) of 1½ in. (40 mm) woven-jacketed, lined fire hose and adjustable spray nozzles in areas of significant combustible loading. The hose connections can be supplied from the overhead sprinklers.

General Storage

Provide sprinklers in accordance with NFPA 13 and PRC.12.1.1.0, based on storage height and arrangement. Do not allow idle wood pallet storage in racks.

Housekeeping

Housekeeping practices include periodic cleaning and removal of cement dust. Particular attention is needed for structural members, such as beams and trusses. Moisture hardens cement dust. A buildup of hardened cement will add weight to the structure, and like snow and ice loading, can cause it to collapse.