Property Risk Consulting Guidelines

A Publication of AXA XL Risk Consulting

PRC.17.13.1

ALUMINUM ROLLING MILLS

INTRODUCTION

An aluminum rolling mill receives aluminum as a large ingot that must be reduced in thickness. Combinations of mills then roll the ingot into sheet and strip.

The rolling process requires considerable amounts of energy. High horsepower motors turn the rolls, and high pressure hydraulic systems control the rolls and other mill equipment.

Rolling fluids on aluminum mills include water, water-oil emulsions, kerosene and mineral oil. Heat from hot-rolled aluminum and frictional heat generated by the rolling process cause the rolling fluid to evaporate. Some also splashes off the moving rolls. If the rolling fluid contains oil, it will collect on cooler building and equipment surfaces and inside fume exhaust systems, where it can be ignited.

Hydraulic fluids, lubricating oils and greases are also possible fuel sources. Leaks from lubrication and hydraulic systems create sprays, which hot aluminum, sparks or electrical equipment can ignite. Mechanical breakdown of rotating mill parts and electrical breakdown of large electric motors also present large dollar loss exposures.

Fire protection systems for an aluminum rolling mill should cover the building, the mill itself, mill motors and gears, oil cellars, pits, hydraulic systems, fume hoods, exhaust ducts, scrubbers and precipitators. Protection should also cover rolling fluid filtering operations. The design of the fire protection systems depends on the fluids used.

Protection against mechanical and electrical breakdown should be provided for gears, rolls, motors and all ancillary equipment necessary for running the mill. The protection required depends on the type of mill.

POSITION

This PRC Guideline covers protection for the rolling mill and immediate building area only. It assumes the facility has good management programs, noncombustible construction, adequate water supplies and proper protection for other operations. Follow PRC.17.13.0 in these areas.

Management Programs

Implement management programs for loss prevention and control as follows:

Housekeeping

Clean all mill areas, including cellars and fume systems, as often as necessary to control residue buildup. For the average aluminum mill, this will be monthly but it could be less often. Clean more frequently if residue buildup occurs between monthly cleanings. Also keep the mill free of ordinary combustible clutter. The following housekeeping standards apply to residue buildup:

- Roof: No visible accumulations.
- Upper levels of the mill: No measurable accumulations.
- Mill and immediate vicinity: No measurable accumulations outside the stands. Peripheral equipment diked with no measurable accumulations outside diked areas. Slight pooling acceptable within diked areas. No clogging of grated walkways.
- Pits and cellars: No measurable accumulations outside diked areas, slight pooling acceptable within diked areas. No measurable accumulations on ledges or cable trays or on any horizontal surface.
- Fume and exhaust systems: No excessive buildup in any part of the system not designed for residue collection. No buildup on sprinklers or nozzles that would prevent them from operating properly.

Maintenance

Implement preventive maintenance programs for the following equipment:

- Motors and electrical equipment, in accordance with PRC.1.3.0;
- Transformers, in accordance with PRC.5.4.5 and PRC.5.9.1;
- Gear sets and other mechanical equipment, including screwdown gears, rolls and in-line shears. Maintain these in accordance manufacturers' instruction;
- Hydraulic, lubricating and cooling oil systems, in accordance with PRC.9.2.4.

In addition to following the guidance in these sections, perform nondestructive testing of gears, shafts, frames and couplings. Use dye penetrant or magnetic particle techniques for accessible, highly stressed areas. Use ultrasonic techniques for inaccessible areas, such as keyways—particularly those located under shrink-fit couplings.

Use written lockout/tagout procedures for conducting mill maintenance. When working on any pressurized mill system containing combustible fluids, isolate the systems by one of the following procedures:

- Two manual isolation valves locked shut and tagged;
- One manual isolation valve locked shut and tagged and system pressure-capable blinds (caps, blank flanges, etc.) on all openings;
- One manual isolation valve locked shut and tagged and leads lifted or fuses pulled from all pressure sources;
- System pressure-capable blinds on all openings and leads lifted or fuses pulled from all pressure sources.

Also follow written procedures for isolation of stored energy sources, such as charged accumulators or capacitors.

Pre-Emergency Planning

Analyze the effect on production if each mill were down for an extended time. Designate a mill critical if it generates a substantial portion of a facility's profits and if its production cannot be handled by other mills. Consider the excess capacity that would normally be available when determining whether other mills can make up the production.

Provide spares for critical equipment, for equipment that is obsolete or otherwise hard to replace, or for equipment with long replacement time. This equipment should include screwdown gears, rolls, in-line shears, large motors or armatures, gear sets and rectifiers.

Employee Training

Include the following in training programs for mill operators:

- Minimum acceptable temperature for the aluminum entering a hot mill;
- Limits on mill reduction, speed, motor current draw and motor winding temperature;
- Maximum acceptable motor starts or reversals per hour;
- Actions to take when a mill trips.

Process Hazard Analysis

Thoroughly analyze all modifications to a mill for their effect on all parts of the mill. Determine changes in acceptable mill loading based on age and wear, as well as any modifications that have been made to the mill.

Roof Fire Protection

Roof protection is not required over a rolling mill in a building of noncombustible construction if the mill is protected in accordance with this section and meets all the criteria in one of the categories in Table 1.

Protect the roof over all other mills as follows:

- Provide noncombustible draft curtains extending at least 20 ft (6.1 m) beyond the mill and subdividing the roof into areas of 10,000 ft^2 (930 m^2) or less. The curtains should extend from the top of the craneway to the roof and should be at least 6 ft (1.8 m) deep.
- Provide automatic heat and smoke venting of 300 cfm (8.5 m^3/min) per 75 ft^2 (7.0 m^2) of roof area in accordance with PRC.2.1.4. Actuate the vents upon detection of sprinkler water flow in the curtained area. A credit of 300 cfm per ft^2 of opening (91.5 m^3/min per m^2 of opening) may be given for natural ventilation through roof monitors.
- Install a closed head sprinkler system using 286°F (74°C) old style heads listed by a nationally recognized testing laboratory. Design the system in accordance with NFPA 13 and PRC.12.1.1.0 to deliver 0.30 gpm/ft^2 (12.2 L/min/m^3) over the most hydraulically remote 3000 ft^2 (279 m^2) area and 0.20 gpm/ft^2 (8.1 L/min/m^2) over the most hydraulically remote draft-curtained area. Extend the sprinklered area 50 ft (15 m) beyond the footprint of the mill and its support equipment. Increase the area of application by 30% for a dry system.

TABLE 1

Mill Categories Not Requiring Roof Protection

Category	Rolling Fluid	Hydraulic and Lubricating Fluids	Mill Arrangement and Protection
1	Water only	Less flammable as defined in PRC.9.2.4	Hydraulic systems provided with the interlocks specified in PRC.9.2.4
2	Water only	One or more fluids not less flammable	Hydraulic systems fully protected per PRC.9.2.4
3	Water-based	N/A	Mill enclosed or sufficiently ventilated to prevent any accumulation of combustible residue on the roof Hydraulic systems fully protected per PRC.9.2.4

Mill Fire Protection

Protect mills in accordance with the decision tree in Figure 1. Refer to the following sections for protective system design criteria for each type of mill.

Provide water supplies for the entire facility in accordance with PRC.14.0.1. Each supply should be capable of meeting the mill's fire protection water demand for 4 hr.

Provide manual emergency stop switches for all mills. Locate the switches near key exits, and arrange them to stop all mill motors and all pumps handling combustible fluids.

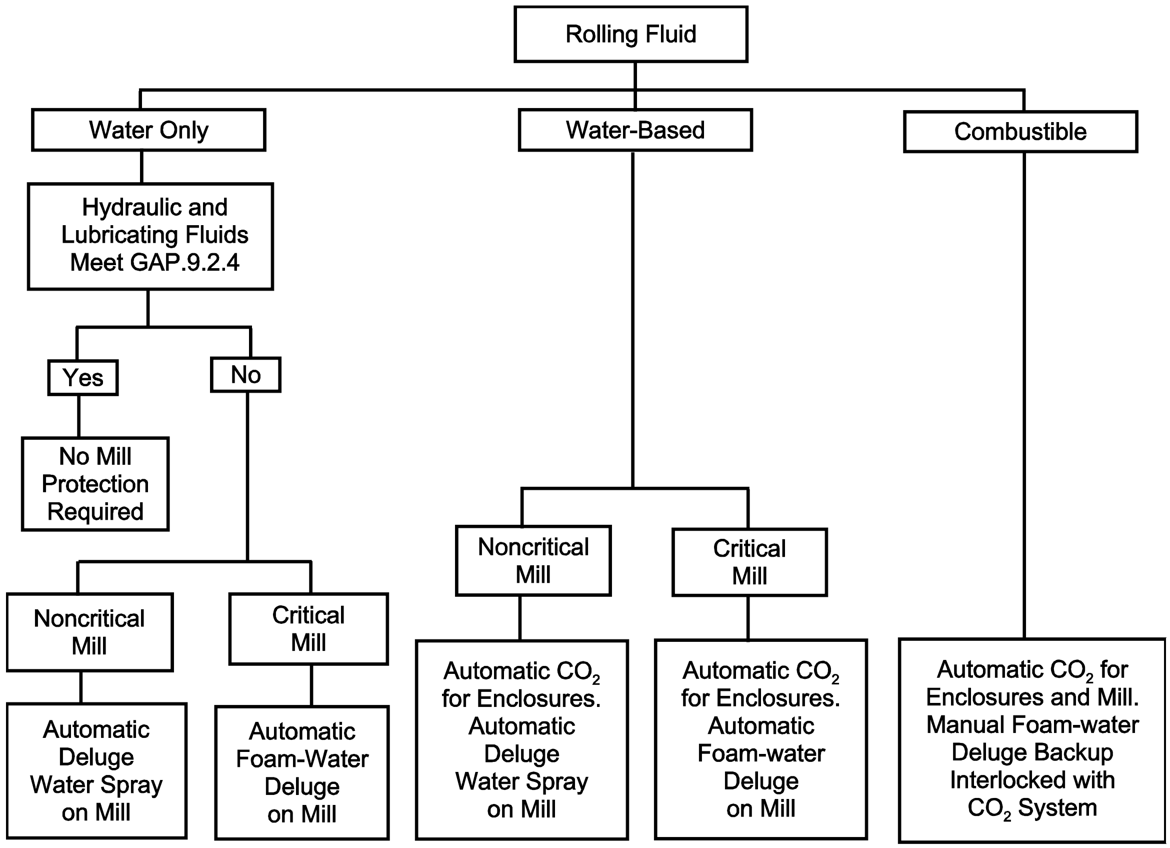

Figure 1. Decision Tree For Aluminum Rolling Mills.

Mills Using Water Only As Rolling Fluid

Provide an automatic, foam-water deluge system for the mill rolls and stands, including the top side, motors and gears on the mill side of the partition, fume hoods, exhaust ducts, scrubbers, precipitators and floor-mounted roll coolant and hydraulic equipment. Design the system in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft^2 (6.5 L/min/m^2) over the protected areas.

Deluge water spray systems are acceptable in lieu of foam-water deluge systems on noncritical mills. Design water spray systems in accordance with NFPA 15 to provide 0.25 gpm/ft^2 (10.2 L/min/m^2) over the protected areas.

Actuate the deluge system with automatic, fixed temperature detectors. Interlock the mill permissive system to prevent mill startup unless the deluge system is in service and to shut down the mill on deluge system actuation. Use detector wiring capable of withstanding an open flame temperature of 2000°F (1093°C) for a minimum of 10 min, such as that listed in the UL Online Certifications Directory under category PPKV.

No mill protection is needed above the floor if both the hydraulic fluid and lubricating oil are “less flammable” as defined in PRC.9.2.4, and if the water rolling spray remains in service with local mill power off.

Provide automatic, closed head foam-water sprinkler systems in oil cellars and pits. Design the systems in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft^2 (6.5 L/min/m^2) over the most hydraulically remote 3000 ft^2 (279 m^2).

Install hose stations in the mill area and locate them so that two stations can reach any area. Supply hose stations from the foam-water sprinkler system.

Mills Using Water-Based Rolling Fluid

Provide an automatic, low-pressure CO_2 system with manual release at each operator station for the fume hoods, exhaust ducts, scrubbers and precipitators. Design the system in accordance with NFPA 12 and PRC.13.3.1. Use total flooding design for enclosed equipment and local application, rate-by-volume design for open equipment. Design the system to provide liquid CO_2 at the hydraulically most remote nozzle in 10 s. Size the CO_2 storage tank for at least two system discharges plus an additional amount for hand hoses.

Actuate the CO_2 system with fixed temperature detectors. Use wiring capable of withstanding an open flame temperature of 2000°F (1093°C) for a minimum of 10 min, such as that listed in the UL Online Certifications Directory under category PPKV.

Provide an automatic foam-water deluge system for mill rolls and stands, including the top side, motors and gears on the mill side of the partition, pits under the mill, and floor-mounted roll coolant and hydraulic equipment. Extend this protection to the fume system on critical mills. Design the system in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft^2 (6.5 L/min/m^2) over the protected areas.

Deluge water spray systems are acceptable in lieu of foam-water deluge systems on noncritical mills or mills rolling aluminum for food products. Design water spray systems in accordance with NFPA 15 to provide 0.25 gpm/ft^2 (10.2 L/min/m^2) over the protected areas.

Actuate the deluge system with automatic, fixed temperature detectors. Interlock the mill permissive system to prevent mill startup unless the deluge system is in service and to shut down the mill on deluge system actuation. Use detector wiring capable of withstanding an open flame temperature of 2000°F (1093°C) for a minimum of 10 min, such as that listed in the UL Online Certifications Directory under category PPKV.

Provide automatic, foam-water closed head sprinkler systems for oil cellars and pits separate from the mill. Design these systems in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft^2 (6.5 L/min/m^2) for the most hydraulically remote 3000 ft^2 (279 m^2).

Install hose stations in the mill area and locate them so that two hose stations can reach any area. Supply hose stations from the foam-water sprinkler system.

Mills Using Combustible Rolling Fluid

Provide an automatic, low-pressure CO_2 system with manual control at each operator station for the mill rolls and stands, including the top side, motors and gears on the mill side of the partition, fume hoods, exhaust ducts, scrubbers, precipitators, pits and floor-mounted roll coolant and hydraulic equipment. Design the system in accordance with NFPA 12 and PRC.13.3.1. Use total flooding design for pits, fume hoods, exhaust ducts, scrubbers and precipitators and local application, rate-by-volume design for the mill and other equipment. Design the system to provide liquid CO_2 at the hydraulically most remote nozzle in 10 s.

Provide "spurt" capability either at the rolls only or for the whole system. Activate the spurt manually, from UV or IR detectors, from loss of web tension on the mill, or from any combination of these. Size the CO_2 storage tank for at least three system discharges plus an additional amount for hand hoses, if provided.

Actuate the CO_2 system with automatic, fixed temperature detectors. Use detector wiring capable of withstanding an open flame temperature of 2000°F (1093°C) for a minimum of 10 min, such as that listed in the UL Online Certifications Directory under category PPKV. Interlock CO_2 system detectors to actuate the deluge system when the CO_2 system is not on automatic operation.

Provide a manual, foam-water deluge system for the mill, fume hood, exhaust ducts, pits and floor-mounted hydraulic equipment. The deluge system should also be capable of automatic operation from CO_2 system detectors when the CO_2 system is not on automatic operation. Design the deluge system in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft^2 (6.5 L/min/m^2) for the protected areas.

Interlock the mill permissive system to prevent mill startup unless either the CO_2 or deluge system is in automatic service and to shut down the mill if either system actuates.

Provide automatic, foam-water closed head sprinkler systems for oil cellars and pits separated from the mill. Design these systems in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft^2 (6.5 L/min/m^2) for the entire cellar or pit. If curbs and drains are provided, it is acceptable to reduce the design area to the most hydraulically remote curbed or drained area or 3000 ft^2 (279 m^2), whichever is greater.

Install hose stations in the mill area and locate them so that two hose stations can reach any area. Supply hose stations from the foam-water sprinkler system. CO_2 hose stations are an acceptable option.

Protection From Mechanical Breakdown

Limit stresses on a rolling mill by the following means:

- Monitor the temperature of aluminum entering a hot mill to confirm it is sufficiently heated for rolling.
- Monitor the mechanical load on each roll of a rolling mill. Limit the load by properly setting screwdown gears and by not exceeding the maximum permitted thickness reduction.
- Install vibration monitoring systems on roll shafts and set them to stop the mill upon detecting unacceptable vibration.

Protection From Electrical Breakdown

Protect mills from electrical breakdown as follows:

- Monitor the current draw of the motors.
- Protect motors from overcurrent.
- Install protective devices on transformers in accordance with PRC.5.9.3.

Mill Motors & Motor Control Centers

Separate mill motors and motor control centers from the mill by a 1 h rated fire partition. Firestop cable and shaft penetrations, and protect doorways with single fire doors rated for 1 h with a maximum temperature rise of 250°F (139°C) in 30 min.

Provide automatic sprinkler protection or CO_2 flooding for motor rooms and motor control centers when combustible rolling fluid is located in the same area. Design sprinkler systems in accordance with NFPA 13 and PRC.12.1.1.0 to deliver 0.20 gpm/ft^2 (8.1 L/min/m^2) over the most hydraulically remote 3000 ft.^{2} Design CO_2 systems in accordance with NFPA 12 and PRC.13.3.1. Provide wheeled CO_2 extinguishers to protect the electrical hazard.

Run as many cable trays as possible on the motor room side of the partition. Protect all cable trays in accordance with PRC.17.12.1. Surround gears on the motor side of the partition with a drained dike.

Protect transformers in accordance with PRC.5.9.2.

Filters

Put kerosene or mineral oil filters in a separate room with a 2 hr rated fire partition. Protect doorways with single fire doors rated for 1½ hr with a maximum temperature rise of 250°F (139°C) in 30 min.

Design filter rooms to contain the expected spill or drain them to a catch tank. If a catch tank is used, size it to contain a volume equivalent to the maximum anticipated flow for a 5 min period.

Protect filter rooms with automatic foam-water deluge sprinkler systems. Design these systems in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft^2 (6.5 L/min/m^2) over the room area.

Equip the dirty coolant inlet line with an automatic valve actuated by the deluge foam-water sprinkler detection system and by remote manual stations located at the operator consoles. Arrange the valve to fail in the closed position.

Use only hoses and clamps that are designed specifically for the filter system. Close filter side panels over the hoses whenever the filter is running. Ground filter housings. Immediately remove dirty filters from the room when replacing them.

Fire Protection Water Demand

The total fire protection water demand for a rolling mill includes the demand for the mill itself, for the roof over the mill, and for the oil cellar. The rolling mill's fire protection water demand should consider all protective systems that would be expected to operate during a fire starting anywhere on or near the mill. In most cases, this should include the roof system, the mill system, the separate systems protecting oil hazards (if provided), and one or more cellar systems.

Whether or not protection is required at the roof, the water demand of any roof system provided should be included in the fire protection water demand if a fire on or near the mill might cause roof sprinklers to operate. This would usually be the case for mills using any combustible or water-based fluids.

For cellars protected by closed head systems, the system with the highest demand should be included. For cellars with open head systems, the largest system and one or more systems adjacent to it should be considered. For cellars offset horizontally from the mill that are completely cut off with all pipe openings totally sealed, the demand would not have to be included.

DISCUSSION

During the rolling process, coolant is sprayed on the rolls, collected and recycled back to the mill. Mill hydraulic and lubricating fluids can be either combustible or listed less flammable types. Coolant, lubrication and hydraulic equipment is usually located below the mill in a pit or separate cellar. Some mill installations can have coolant and hydraulic equipment alongside the mill. These areas require fixed automatic fire protection.

Rolling mills are either primary or finishing. Usually, primary mills are hot mills and finishing mills are cold mills.

Rolling mills are categorized by the product produced, such as plate, sheet or foil. Plate is any material with a thickness 0.25 in. (6.3 mm) or greater. Sheet is any material with a thickness between 0.006 in. (0.15 mm) and 0.25 in. (6.3 mm). Foil is any material with a thickness less than 0.006 in. (0.15 mm).

Mills are often described by the number of stands and the width of the stock rolled. A stand is one or more pairs of horizontal rolls stacked one above the other. A mill may have a single stand or as many as six or seven stands. The number depends on the type of product and the thickness of the feedstock. Spacing between the stands is fairly close, normally in the range of 2 ft – 5 ft (0.6 m – 1.5 m).

Hot Mills

Hot mills receive a preheated ingot from a furnace or soaking pit. These mills are usually the single stand reversing type and are usually cooled with water-based rolling fluid containing animal fat or vegetable oil. Hot mills can also be multiple stand mills.

A reversing mill is one which rolls the ingot through the mill in one direction, reduces the roll clearance, and rolls the ingot in the other direction. This repeats until the ingot reaches the desired thickness. Because the ingot elongates as its thickness is reduced, run-out tables support the material on both sides of the mill. These tables can be several hundred feet (a few hundred meters) long.

Roll coolant for aluminum hot mills is usually a noncombustible water-oil emulsion. However, the residue remaining after the water in the coolant evaporates is combustible. Coolant mist sprayed from the mill collects throughout the mill area and inside fume exhaust systems, leaving behind this combustible residue.

Cold Mills

The feedstock for cold mills is not heated and is in the form of plate or coiled sheet. Aluminum cold mills are usually multiple stand and may or may not be the reversing type.

Even though the mill is called a cold mill, the rolling process creates considerable frictional heat with operating temperatures of about 250°F (121°C). The coolant for aluminum cold mills is usually kerosene or a mineral oil about the consistency of kerosene. This coolant is a combustible liquid that produces a high frequency of fires on cold mills. The source of ignition can be mill electrical components, hot bearings, electrostatic sparks, tail ends or strip breaks. When the sheet breaks, sparks are created which can ignite the coolant. Strip breaks are caused by loss of tension control, edge cracks and imperfections. The thinner aluminum products are more susceptible to strip breaks.

Due to the frequency of fires on aluminum cold mills, an automatic, low-pressure carbon dioxide system with manual foam-water deluge system as backup is considered the best protection scheme. Low pressure carbon dioxide systems have the advantage of partial discharge through the spurt system and ease of refill. The three-discharge capacity in the CO_2 tank allows mill operation to continue after a single discharge or spurt system use with protection and a reserve still available. A manual deluge system is recommended because sprinkler discharge causes considerable downtime for cleaning the coolant system. The switchover of the detection system from the CO_2 system to the deluge system provides automatic protection when the CO_2 system must be shut off. The CO_2 system impairment is required whenever workers enter the pit below the mill or are working at the mill.

Management Programs

Well implemented management programs are essential in aluminum rolling mills. Any facility with rolling operations should follow AXA XL Risk Consulting's *OVERVIEW*, paying particular attention to housekeeping, preventive maintenance programs, maintenance procedures and pre-emergency planning.

Allowing residues from the fluids used in rolling operations to accumulate can expose a facility to very large losses. Meticulous housekeeping in rolling mill areas is very important in preventing these losses. Maintaining adequate housekeeping as described in this section is a constant challenge.

Programs for lockout/tagout and pre-emergency planning are also important to preventing losses. Having critical equipment spares on hand can reduce the facility's downtime in the event of a loss.

Mill Fire Protection

Table 1 specifies that some properly protected mills do not require sprinkler protection at the roof. This does not mean that roof protection is an alternative to mill protection. Mills must have fire protection systems. Roof sprinkler systems are only intended to protect the roof in the event that the mill fire protection systems do not control a fire.

TABLE 2
Aluminum Rolling Mill Loss Breakdown

	Type of Loss		Amount of Loss in U.S. dollars (000)		
	Fire	B/M	<10	10-500	>500
Number of Losses	12	1	2	6	5
Percent of Losses	92	8	15	46	39

Loss History

There were thirteen aluminum rolling mill losses reported to AXA XL Risk Consulting between May 1989 and January 1993, a period of approximately 3½ yr. The most frequent loss scenario is a fire causing between $50,000 and $2M damage. Table 2 shows a breakdown of these losses by type and amount.

Losses were smallest in facilities with good housekeeping, properly designed protection that remained in service, and well implemented management programs. Losses were largest when facilities exhibited two or more such deficiencies.