



Property Risk Consulting Guidelines

XL Risk Consulting

A Publication of AXA XL Risk Consulting

PRC.17.4.2

STEEL ROLLING MILLS

INTRODUCTION

Molten steel is either poured into large ingots or continuously cast to produce slabs, billets or blooms. Rolling mills reduce the ingots or other cast material in size, and shape them into usable products.

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 steel mills include water, water-oil emulsions, water-glycol solutions and petroleum-based products. Heat from hot-rolled steel 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 or glycol, these materials will collect on cooler building and equipment surfaces and inside fume exhaust systems, where they can be ignited.

Hydraulic fluids, lubricating oils and greases are also possible fuel sources. Leaks from lubrication and hydraulic systems create sprays, which hot steel, 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 a steel 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. 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.17.4.0 in these areas.

Treat all tandem mills, mills with 20% or more production through them and mills with more than two stands as critical mills. Designate a mill as a critical mill if it generates a substantial portion of a facility's profits and if other mills cannot handle production. Do not consider the excess capacity of other mills when determining whether other mills can make up the production.

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. Most steel mills require cleaning at least once a week. 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 is not acceptable within diked areas. No clogging of grated walkways.
- **Pits and cellars:** No measurable accumulations outside diked areas, slight pooling is not 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;
- Hydraulic, lubricating and cooling oil systems, in accordance with PRC.7.0.5.2 and 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 system by one of the following methods:

- 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.

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

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.

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 steel 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 m) beyond the mill and subdividing the roof into areas of 10,000 ft² (930 m²) or less. Extend curtains from the top of the craneway to the roof. These curtains should be at least 6 ft (2 m) deep.
- Provide automatic heat and smoke venting of 300 cfm (8.5 m³/min) per 75 ft² (7.0 m²) 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 ft² (91.5 m³/min per m²) 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. Design the system in accordance with NFPA 13 and PRC.12.1.1.0 to deliver 0.30 gpm/ft² (12.2 L/min/m³) over the most hydraulically remote 3000 ft² (279 m²) area and 0.20 gpm/ft² (8.1 L/min/m²) over the most hydraulically remote draft-curtained area. Extend the sprinklered area 30 ft (9.2 m) beyond the

footprint of the mill and its support equipment. Increase the area of application by 30% for a dry system.

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 h.

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.

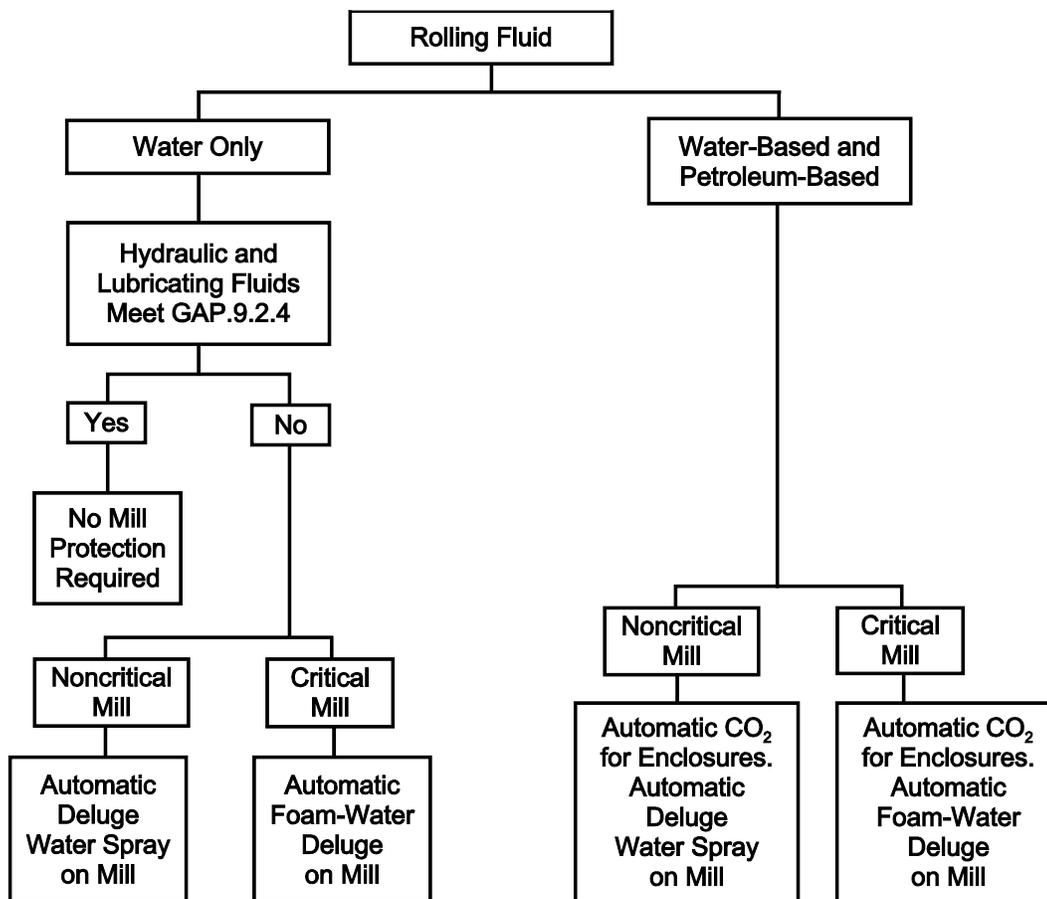


Figure 1. Decision Tree For Steel Rolling Mills.

Mills Using Water Only As Rolling Fluid

Critical Cold Mills

Protected all critical mills as follows:

- Provide an automatic, foam-water deluge system for the mill and an area of 30 ft (9.2 m) on all sides, including motors and gears on the mill side of the partition, entry and exit ends, between stands and any hydraulic reservoirs and pumps. Design the system in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft² (6.5 L/min/m²) over the protected areas.
- Provide automatic foam water deluge system inside the mill enclosure, if a fume box is present, to provide 0.16 gpm/ft² (6.5 L/min/m²) over the enclosed area.
- 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.

- Protect the oil cellars and pits with either of the following :
 1. Automatic, closed head foam-water sprinkler systems design in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft² (6.5 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).
 2. Automatic wet pipe, dry pipe or pre-action system design in accordance with NFPA 13 and PRC.12.1.1.0 to provide 0.38 gpm/ft² (6.5 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).
- Protect the fume hoods, exhaust ducts, scrubbers, precipitators, with any of the following:
 3. Automatic, closed head foam-water sprinkler systems design in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft² (6.5 L/min/m²) over the protected area.
 4. Automatic, low-pressure CO₂ system with a connected reserve and manual release at each operator station and manual water deluge back-up system. Design the CO₂ 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 CO₂ at the hydraulically most remote nozzle in 10 s. Size the CO₂ storage tank for at least two system discharges plus an additional amount for hand hoses.
- Provide 1½ in. (38 mm) hose connections with hoses and nozzles around the mill. 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.
- Install interlocks to shut the mill down in the event any of the following:
 5. Massive loss of pressure within hydraulic, lubrication oil, or mill solution systems
 6. Sudden reservoir level drop
 7. Low reservoir level conditions.
- Separate the mill motor room from the mill by either a masonry wall or metal wall protected by a water spray system.

Non-Critical Cold Mills

Protect all non-critical mill as follows:

- Provide either of the following over the mill.
 8. Automatic wet pipe, dry pipe or pre-action system design in accordance with NFPA 13 and PRC.12.1.1.0 to provide 0.38 gpm/ft² (6.5 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).
 9. Automatic deluge water spray system designed in accordance with NFPA 15 to provide 0.25 gpm/ft² (10.2 L/min/m²) over the protected areas.
 10. Protect the oil cellars and pits with either of the following :
 11. Automatic, closed head foam-water sprinkler systems design in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft² (6.5 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).
 12. Automatic wet pipe, dry pipe or pre-action system design in accordance with NFPA 13 and PRC.12.1.1.0 to provide 0.38 gpm/ft² (6.5 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).

Hot Mills

Protect all hot mill as follows:

- Protect the oil cellars and pits with either of the following :

13. Automatic, closed head foam-water sprinkler systems design in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft² (6.5 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).
 14. Automatic wet pipe, dry pipe or pre-action system design in accordance with NFPA 13 and PRC.12.1.1.0 to provide 0.38 gpm/ft² (6.5 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).
- Install interlocks to shut the mill down in the event any of the following:
 15. Massive loss of pressure within hydraulic, lubrication oil, or mill solution systems
 16. Sudden reservoir level drop
 17. Low reservoir level conditions.
 - Provide 1½ in. (38 mm) hose connections with hoses and nozzles around the mill. 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 And Petroleum-Based Rolling Fluid

Provide an automatic, low-pressure CO₂ 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 CO₂ at the hydraulically most remote nozzle in 10 s. Size the CO₂ storage tank for at least two system discharges plus an additional amount for hand hoses.

Actuate the CO₂ 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 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/ft² (6.5 L/min/m²) 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/ft² (10.2 L/min/m²) 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, closed head foam-water sprinkler systems in oil cellars and pits. Design these systems in accordance with NFPA 16 and PRC.12.3.1.1 to provide 0.16 gpm/ft² (6.5 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).

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.

Protection From Mechanical Breakdown

Limit stresses on a rolling mill by the following means:

- Monitor the temperature of steel 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.
- 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 or a barrier wall with automatic waterspray. Firestop cable 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 CO₂ flooding for small 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/ft² (8.1 L/min/m²) over the most hydraulically remote 3000 ft.² Design CO₂ systems in accordance with NFPA 12 and PRC.13.3.1. Provide wheeled CO₂ 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.

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 in 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

Steel ingots vary in shape and can weigh from several hundred pounds to over 300 tons (a few hundred kilograms to over 270 metric tons). Slabs have a rectangular cross section and vary in size from 2 in. – 9 in. (50 mm – 230 mm) thick and 24 in. – 59 in. (610 mm – 1510 mm) wide. Blooms and billets usually have square cross sections. Blooms have 6 in. – 12 in. (150 mm – 300 mm) sides and billets have 2 in. – 5 in. (50 mm – 125 mm) sides. Blooms are often short and may be called blocks or blanks. Billets are usually longer and are sometimes called tube rounds when they have a circular cross section.

Cast material goes either to preheat furnaces, which feed the finishing mills, or directly to the finishing mills. Ingots are sent to soaking pits where they are kept hot until they are sent to a primary rolling mill and reduced to slabs, blooms or billets.

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. Primary mills are hot mills. These mills are designated by the name of the shape that they produce; that is, slabbing mill, blooming mill or billet mill.

Finishing mills further reduce the slabs, blooms and billets. These mills can be either hot or cold mills, depending upon the product thickness. They are usually named for the product that they produce. Finishing mills include structural shape mills, rod mills, bar mills, plate mills, strip mills, sheet mills, and pipe or tube mills.

Finishing mills have numerous configurations. They usually consist of multiple stands or multiple mills arranged in series to achieve the desired final product shape and finish.

Mills are often described by the number of stands. A stand consists of one or more horizontal rolls stacked one above the other. Spacing between the stands is relatively close, ranging from 2 ft–5 ft (0.6 m–1.5 m). Mills stands can be described as two-high, three-high, four-high or cluster type.

Two-high mill stands are a simple pair of rolls through which the steel passes. Three-high mill stands consist of three rolls stacked one above the other. In the three-high stand, steel passes between the bottom pair of rolls and, after being raised and repositioned on a table, passes through the top pair of rolls in the opposite direction. This process repeats as necessary, depending upon the roll design.

Four-high mill stands are a variation of two-high mill stands. In these stands, top and bottom backing rolls are used to reduce the deflection of the center pair of working rolls. Cluster stands have multiple backing rolls—some up to nine backing rolls—for each working roll. The rolls are arranged like bowling pins and are held together by a cast steel housing.

Hot Mills

Hot mills receive preheated material from a continuous caster, furnace or soaking pit. These mills are usually the single stand reversing type and use water only as coolant. Hot mills can also be multiple stand mills.

A reversing mill rolls the ingot through the mill in one direction, reduces the 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 steel hot mills is usually water only. Although the water does not present a hazard, these mills still require protection for the hazards presented by the other mill fluids.

Cold Mills

The feedstock for cold mills is not heated and is often a semifinished steel product. Cold mills are not usually the reversing type and are more apt to use a combustible rolling fluid. Even though a mill is called a cold mill, the rolling process creates enough frictional heat to vaporize some of the rolling fluid.

Finishing mill roll coolant can be either a water-oil emulsion or a water-glycol solution, which are both noncombustible. 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.

Due to the severity of fires on steel cold mills, automatic, low-pressure carbon dioxide systems for enclosed equipment with automatic foam-water deluge systems on mills is considered the best protection scheme.

Management Programs

Well implemented management programs are essential in steel 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 weekly 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

Rolling mills meeting the criteria in Table 1 do not require sprinkler protection at the roof. However, 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.

Loss History

Fourteen steel rolling mill losses were reported to AXA XL Risk Consulting between January 1989 and April 1994, a period of approximately 5 yr. The most frequent loss scenario is a mechanical or electrical breakdown causing between \$10,000 and \$500,000 damage. Table 2 shows a breakdown of these losses by type and amount.

TABLE 2
Steel Rolling Mill Loss Breakdown

	Type of Loss			Amount of Loss in U.S. dollars (000)		
	Fire	B/M	Flood	<10	10-500	>500
Number of Losses	03	10	1	1	10	03
Percent of Losses	21	72	7	7	72	21

Losses were smallest in facilities with rigorous preventive maintenance programs and ample spare parts. Losses were largest when deficiencies existed in these areas. Loss of production contributed substantially to loss amounts. One facility was down for three weeks at a cost of approximately \$4M.

The largest loss, a \$138M fire, exhibited major deficiencies in three areas: housekeeping; lockout/tagout procedures; and protective system design.