STONE MILL FIRES

Table 55 and figure 19 show the number of fires and fire injuries for stone mills by state during 1990–2001. Table 55 also shows the injury risk rates, employees' working hours, and lost workdays. In all, 118 fires occurred in 33 states. Seventy-six of the fires caused 82 injuries (including 8 fires and 6 injuries involving contractors). The yearly average was 9.8 fires and 6.8 injuries. The Ewhr value was 873×10^6 hr (Irr = 0.019), and the LWD value was 1,911. Missouri had the most fires (16 fires and 9 injuries), followed by Pennsylvania (15 fires and 14 injuries), Michigan (9 fires and 5 injuries), and Virginia (7 fires and 5 injuries). Of these states, Virginia had the highest injury risk rate value (Irr = 0.091).

Table 56, partly illustrated in figure 20, shows the number of fires, fire injuries, risk rates, employees' working hours, and lost workdays by time period. The number of fires and fire injuries decreased during most of the periods, with a sharp increase during the last period. The number of employees' working hours increased throughout the periods. The Irr values follow patterns similar to those shown by the injury values.

Tables 57–63 show the number of fires by ignition source, method of detection and suppression, equipment involved, location, and burning material by time period. Figure 21 shows the major variables related to fires for 1990–2001. Table 63 shows the fire injuries per number of fires causing injuries and total fires by year, ignition source, equipment involved, and location.

Ignition Source

Table 57 shows the number of fires and fire injuries by ignition source for each time period. The leading sources were flame cutting/welding spark/slag/flame (53 fires or 45%), hot material (24 fires or 20%), and electrical short/arcing (11 fires or 9%). Other ignition sources were refueling fuel/flammable liquid/gas on hot surfaces/collision, heat source, hydraulic fluid/fuel sprayed onto equipment hot surfaces, conveyor belt friction, and overheated oil. One ignition source was unknown. At least four of the five mobile equipment hydraulic fluid/fuel fires became large fires because of the continuous flow of fluids from the pumps due to engine shutoff failure, difficulty in activating available emergency systems at ground level, lack of an emergency line drainage system, or lack of effective and rapid local firefighting response capabilities. In at least one instance, the cab was suddenly engulfed in flames, probably due to the ignition of flammable vapors and mists that penetrated the cab. Of note is that the hydraulic fluid fires subsequently involved the fuel system.

During the first, second, and fourth periods, the largest number of fires were caused by flame cutting/welding spark/slag/flame. During the third and sixth periods, the largest number of fires were caused by hot material. During the fifth period, the largest number of fires were caused by hot material and electrical short/arcing.

Method of Detection

Table 58 shows the number of fires by method of detection for each time period. The most frequent methods were welders who saw sparks, workers who saw smoke shortly and long after the fires had started, and operators who saw the fires when they started as flames/flash fires. Other methods of detection were workers who heard an explosion and workers who saw a glow or a smoldering fire. Six fires were undetected. The hot material fires were detected long after they had started due to lack of combustion smoke/gas detection systems.

During the first, second, and fourth periods, the largest number of fires were detected by welders as sparks. During the third and fifth periods, the largest number of fires were detected by workers as smoke long after the fires had started. During the sixth period, the largest number of fires were detected by operators as flames/flash fires.

Suppression Method

Table 59 shows the number of fires by suppression method for each time period. The most common methods were manual techniques with or without portable fire extinguishers, followed by water or portable fire extinguishers alone. Other suppression methods were portable fire extinguishers with foam, dry chemical powder, and water. One piece of mobile equipment involved in a fire had a machine fire suppression system, whose activation together with the engine shutoff system succeeded in temporarily abating the fire.

In at least 11 instances, including 2 mobiles equipment fires, fire brigades and fire departments fought the fires with portable fire extinguishers together with foam, dry chemical powder, and water. However, seven fires destroyed or heavily damaged equipment (including one piece of mobile equipment) because of failure of firefighting methods, late fire detection, undetected fires, or fire size.

During the first, second, and fourth periods, the largest number of fires were suppressed manually with or without portable fire extinguishers. During the third period, the largest number of fires were suppressed manually with or without portable fire extinguishers or water alone. During the fifth period, the largest number of fires were extinguished with water alone. During the sixth period, the largest number of fires were extinguished with water alone and portable fire extinguishers with foam, dry chemical powder, and water.

Equipment Involved

Table 60 shows the number of fires by equipment involved for each time period. The equipment most often involved were oxyfuel torches (at times electrical arc welding equipment was used), followed by kilns, preheat and cooling systems, and mobile equipment (loaders, trucks, drills, and locomotives). Other equipment included electrical systems, heaters, barrels, refueling pumps, beltlines, chutes, crushers, waste fuel tanks,

dust collectors, and storage bins. Maintenance equipment and facilities (considered equipment in this report) were also involved in the fires.

During the first through fourth periods, the largest number of fires involved oxyfuel torches. During the fifth period, the largest number of fires involved electrical systems. During the sixth period, the largest number of fires involved oxyfuel torches, kilns, and preheat and cooling systems.

Location

Table 61 shows the number of fires by location for each time period. The most common locations were flame cutting/welding areas (at hopper, crusher, elevator shaft, chute and kiln areas, and maintenance areas). This was followed by kilns, hoppers, chutes, storage silo areas, mobile equipment working areas (shop and crusher areas, drilling, loading, haulage, transportation, and fuel preparation room), and beltline areas. Other fire locations included maintenance areas, pump and bagging stations, preheat and cooling areas, pit and bin areas, waste fuel areas, electrical control rooms, shops, and substation areas. Dust collector, crusher, chute, and facility areas were also affected by the fires.

During the first, second, and fourth periods, the largest number of fires occurred at flame cutting/welding areas. During the third period, the largest number of fires occurred at flame cutting/welding areas, kilns, chutes, hoppers, and storage silo areas. During the fifth period, the largest number of fires occurred at beltline areas. During the sixth period, the largest number of fires occurred at kiln areas.

Burning Materials

Table 62 shows the number of fires by burning material for each time period. The materials most often involved were oxyfuels/ clothing/grease and other materials (including rubber hoses, pipelines, dust collector and chute liners, and shaft and kiln materials). This was followed by belt and kiln/clinker hot materials, flammable liquids/oil/refueling fuel, electrical wires/ cables/ transformers/ batteries, and rubber tires/refuse/waste fuel. Other materials involved in fires were hydraulic fluid/fuel, chute and dust collector liners and hoppers, and facilities and their content.

During the first, second, and fourth periods, the largest number of fires involved oxyfuel/clothing/grease and other materials. During the third period, the largest number of fires involved oxyfuel and belt and kiln/clinker hot materials. During the sixth period, the largest number of fires involved oxyfuel and flammable liquids, oil, and refueling fuel.

Fire Injuries

Table 63 shows the number of fire injuries per number of fires causing injuries and total fires by year, ignition source, equipment involved, and location for 1990–2001. Overall, there

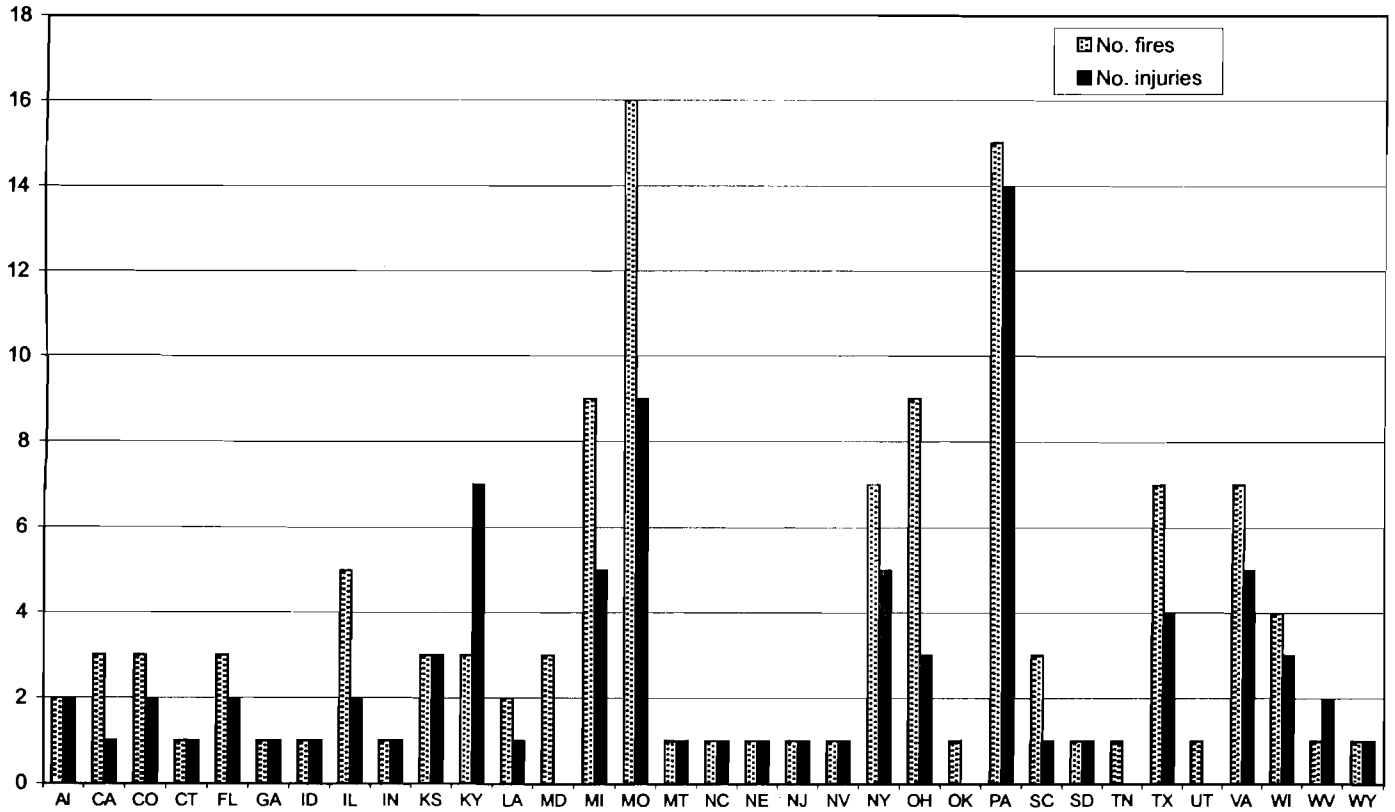

Figure 19.—Number of fires and fire injuries for stone mills by state, 1990–2001.

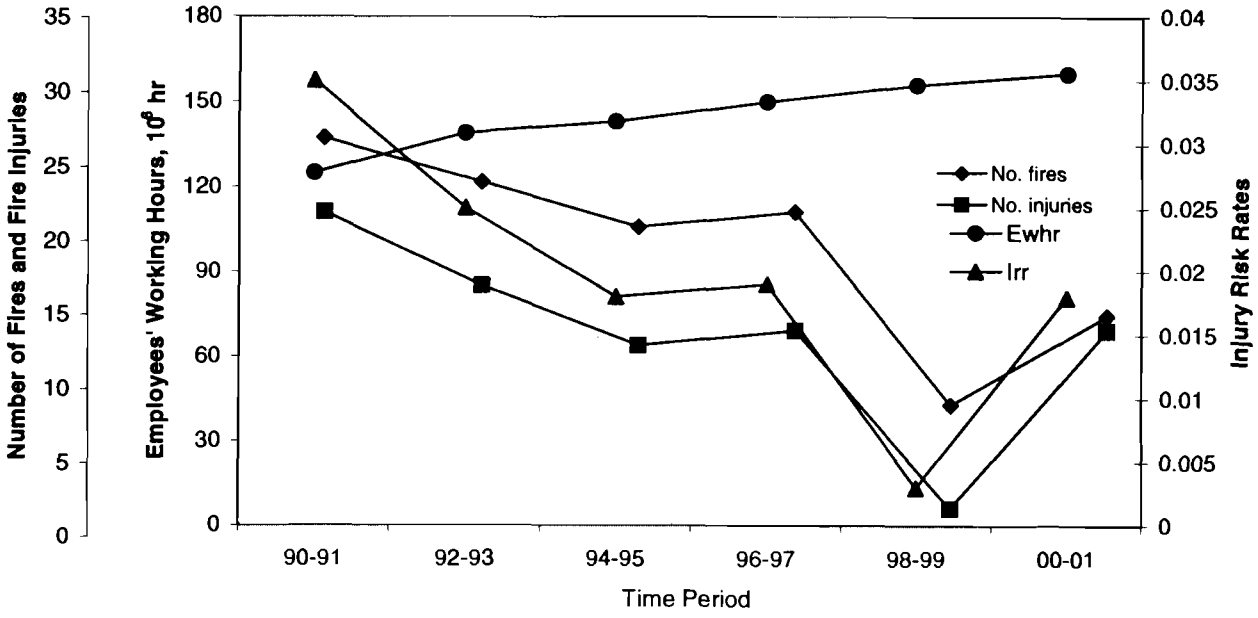

Figure 20.—Number of fires, fire injuries, risk rates, and employees' working hours for stone mills by time period, 1990–2001.

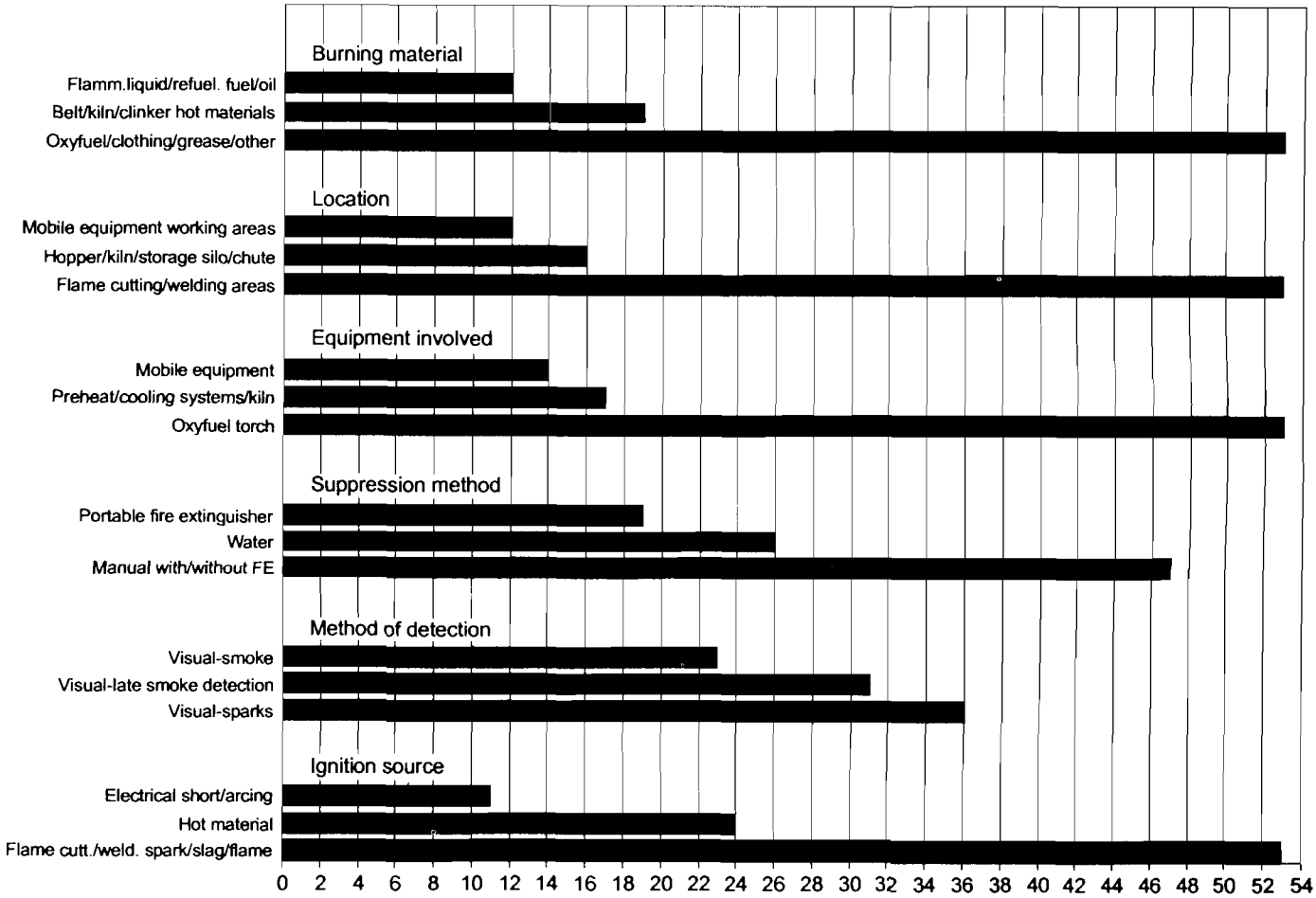

Figure 21.—Major variables for stone mill fires, 1990–2001. (FE = portable fire extinguisher)

were 82 injuries caused by 76 fires. The greatest number of fire injuries occurred in 1990 (15 injuries caused by 15 fires). The ignition sources that caused most of the fire injuries were flame cutting/welding spark/slag/flame, hot material, and flammable liquid/refueling fuel on hot surfaces. Other ignition sources were heat source, hydraulic fluid/fuel sprayed onto equipment hot surfaces, mechanical friction, and electrical short/arcing. The equipment involved in fire injuries included oxyfuel torches, kilns, beltlines, chutes, refueling pumps, and maintenance equipment. Other equipment included heaters, mobile equipment, maintenance equipment, kiln, and electrical systems. The locations where the fire injuries occurred were flame cutting/welding areas, beltlines, kiln and chute areas, and maintenance areas, followed by mobile equipment working areas and transportation areas. Other fire locations were pump stations and beltline areas.

Table 55.—Number of fires, fire injuries, and risk rates for stone mills by state, employees' working hours, and lost workdays, 1990–2001

State[1]	No. fires[1]	No. fire injuries[1]	LWD[2]	Ewhr,[2] 10^6 hr	Irr[3]
Alabama	2	2	249	38.4	0.01
California	3	1	10	38.6	0.005
Colorado	3	2	58	8.5	0.047
Connecticut	1	1	4	5.2	0.039
Florida	2	2	56	28.6	0.014
Georgia	1	1	10	31.2	0.006
Idaho	1	1	13	2.2	0.091
Illinois	5	2	63	36.5	0.011
Indiana	1	1	—	27.6	0.007
Kansas	3	3	104	13.5	0.044
Kentucky	3	7	158	24	0.058
Louisiana	2	1	102	1.1	0.182
Maryland	3	—	—	17	—
Michigan	9	5	95	20.2	0.05
Missouri	16	9	155	56	0.032
Montana	1	1	16	3.7	0.054
Nebraska	1	1	39	5.9	0.034
Nevada	1	1	20	6	0.033
New Jersey	1	1	27	8	0.025
New York	7	5	4	25.5	0.039
North Carolina	1	1	48	23.7	0.008
Ohio	9	3	58	35	0.017
Oklahoma	1	—	—	15.6	—
Pennsylvania	15	14	218	67	0.042
South Carolina	3	1	14	16.2	0.012
South Dakota	1	1	16	5.7	0.035
Tennessee	1	—	66	21.4	—
Texas	7	4	24	54	0.015
Utah	1	—	—	5.2	0.03
Virginia	7	5	153	11	0.091
West Virginia	1	2	90	13.1	0.031
Wisconsin	4	3	41	11	0.055
Wyoming	1	1	—	10	0.02
All other states	—	—	—	186	—
Total	118	82	1,911	873	[3]0.019

[1]Derived from MSHA "Fire Accident Abstract" internal publications.
[2]Derived from MSHA "Injury Experience in Mining" publications.
[3]Calculated according to MSHA formula reported in the "Methodologies" section.

Table 56.—Number of fires, fire injuries, and risk rates for stone mills by time period, employees' working hours, and lost workdays, 1990–2001

	Time period						
	90-91	92-93	94-95	96-97	98-99	00-01	1990-2001
Number of fires[1]	27	24	21	22	9	15	118
Number of fire injuries[1]	22	17	13	14	2	14	82
LWD[2]	377	298	310	388	280	258	1,911
Ewhr,[2] 10^6 hr	125	139	143	150	156	160	873
Irr[3]	0.035	0.024	0.018	0.019	0.003	0.018	[3]0.019

[1]Derived from MSHA "Fire Accident Abstract" internal publications.
[2]Derived from MSHA "Injury Experience in Mining" publications.
[3]Calculated according to MSHA formula reported in the "Methodologies" section.

Table 57.—Number of fires for stone mills by ignition source and time period, 1990–2001

Ignition source	Time period						
	90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	00-01 No. fires	1990-2001 No. fires
Flame cutting/welding spark/slag/flame[1]	14	13	6	14	2	4	53
Hot material	1	5	7	3	3	5	24
Electrical short/arcing	4	2	2	—	3	—	11
Heat source	3	2	1	1	—	2	9
Refueling fuel/flammable liquid/gas on hot surfaces/ collision	2	2	1	1	1	2	9
Hydraulic fluid/fuel on equipment hot surfaces	3	—	1	1	—	1	6
Conveyor belt friction	—	—	1	1	—	—	3
Overheated oil	—	—	1	1	—	—	2
Unknown	—	—	1	—	—	—	1
Total	27	24	21	22	9	15	118

[1]This source caused explosions of pressurized cans and oxyfuel.

Table 58.—Number of fires for stone mills by method of detection and time period, 1990–2001

Method of detection	Time period						
	90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	00-01 No. fires	1990-2001 No. fires
Visual:							
Sparks	9	9	4	10	1	3	36
Smoke	5	2	4	6	2	4	23
Late smoke detection	3	8	7	5	6	2	31
Flames/flash fires	7	2	2	1	—	5	17
Smoldering fire/glow	—	—	1	—	—	1	1
Heard an explosion	2	1	—	—	—	—	3
Undetected	1	2	3	—	—	—	6
Total	27	24	21	22	9	15	118

Table 59.—Number of fires for stone mills by suppression method and time period, 1990–2001

Suppression method	Time period						
	90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	00-01 No. fires	1990-2001 No. fires
Manual with or without FE[1]	12	12	6	12	2	3	47
Water	3	5	6	5	3	4	26
FE	6	3	3	2	2	3	19
FE-foam-DCP-water[2]	4	3	3	3	1	4	18
FSS-foam-water	1	—	—	—	—	—	1
Destroyed/HD[3]	1	1	3	—	1	1	7
Total	27	24	21	22	9	15	118

DCP Dry chemical powder.
FE Portable fire extinguisher.
FSS Machine fire suppression system.
HD Heavily damaged.
[1]Method used by welders to extinguish clothing and oxyfuel/grease fires.
[2]In two instances, fire emergency foam suppression systems were used.
[3]Usually due to failure of firefighting methods, late fire detection, undetected fires, or fire size.

Table 60.—Number of fires for stone mills by equipment involved and time period, 1990–2001

Equipment	Time period						
	90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	00-01 No. fires	1990-2001 No. fires
Oxyfuel torch[1]	14	13	6	14	2	4	53
Kiln/preheat/cooling systems	—	4	5	2	2	4	17
Mobile equipment[2]	5	1	3	3	—	2	14
Electrical system	3	2	2	—	3	—	10
Heater/barrel/refueling pump	3	1	1	1	—	1	7
Beltline	—	1	1	2	1	1	6
Chute/crusher/waste fuel tank/bin feeder/dust collector	1	1	2	—	1	1	6
Facility[3]	—	—	1	—	—	—	1
Maintenance equipment	1	1	—	—	—	—	2
Other	—	—	—	—	—	2	2
Total	27	24	21	22	9	15	118

[1]At times, electrical arc welding equipment was used.
[2]Includes loaders, trucks, drills, and locomotives.
[3]Considered equipment in this report.

Table 61.—Number of fires for stone mills by location and time period, 1990–2001

Location	Time period						
	90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	00-01 No. fires	1990-2001 No. fires
Flame cutting/welding areas[1]	14	13	6	14	2	4	53
Kiln/chute/hopper/silo areas	—	3	6	1	1	5	16
Mobile equipment working areas[2]	4	—	3	3	1	1	12
Beltline areas	—	2	1	2	3	2	10
Maintenance areas/pump station	3	3	1	—	—	1	8
Preheat/cooling areas/bagging station/pit/bin/waste fuel areas	—	2	2	1	1	1	7
Electrical control room/shop/substation	4	—	1	—	1	—	6
Dust collector/chute/crusher areas	1	1	—	1	—	1	4
Facility areas	1	—	1	—	—	—	2
Total	27	24	21	22	9	15	118

[1]Includes hopper, crusher, elevator shaft, chute and kiln areas, and maintenance areas.
[2]Includes pumping station, shop and crusher areas, drilling, loading, haulage, transportation, and fuel preparation areas.

Table 62.—Number of fires for stone mills by burning material and time period, 1990–2001

Burning material	Time period						
	90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	00-01 No. fires	1990-2001 No. fires
Oxyfuel/clothing/grease/other[1]	14	13	6	14	2	4	53
Belt/kiln/clinker hot materials	—	4	6	3	3	3	19
Flammable liquid/oil/refueling fuel	3	3	1	1	—	4	12
Rubber tires/refuse/waste fuel	2	1	3	3	1	1	11
Electrical wires/cables/transformer/battery	4	2	1	—	3	1	11
Hydraulic fluid/fuel	3	—	1	1	—	1	6
Chute/dust collector liners/hopper	—	1	2	—	—	1	4
Facility/content	1	—	1	—	—	—	2
Total	27	24	21	22	9	15	118

[1]Includes rubber hoses, pipelines, dust collector and chute liners, and kiln and shaft materials.

SUMMARY OF MAJOR FIRE AND FIRE INJURY FINDINGS FOR ALL METAL/NONMETAL MINING CATEGORIES

The major fire and fire injury findings for all metal/nonmetal mining categories for 1990–2001 are shown in tables 64–65. Table 66, partly illustrated in figure 22, shows the number of fires, fire injuries, fire fatalities, risk rates, employees' working hours, and lost workdays for all metal/nonmetal mining categories by time period.

For all metal/nonmetal operations (including stone and sand and gravel), a total of 518 fires occurred during 1990–2001; 296 of those fires caused 308 injuries and 4 fatalities (Ewhr = 4,012 × 10^6 hr, Irr = 0.015, LWD = 36,204). Thirty fires and 26 injuries involved contractors. The greatest number of fires and fire injuries occurred at surface operations; the highest risk rate values were also calculated for surface operations. The number of fires increased during the first four 2-year time periods (1990–1991, 1992–1993, 1994–1995, and 1996–1997), then decreased during the last two periods (1998–1999 and 2000–2001). The number of injuries showed a decrease throughout the periods, accompanied by an increase in employees' working hours.

Twenty-five firefighting interventions by mine rescue teams in underground mines and at least 30 interventions at surface operations were required to combat these fires. However, 45 fires destroyed or heavily damaged facilities and equipment (including 19 pieces of mobile equipment) because of failure of firefighting methods, late fire detection, undetected fires, or fire size. Ninety-seven fires were detected late, and 30 fires were undetected.

The ignition sources that caused the greatest number of fires were flame cutting/welding spark/slag/flame (169 fires or 33% with 137 injuries), hydraulic fluid/fuel sprayed onto equipment hot surfaces (89 fires or 17% with 46 injuries and 3 fatalities), heat source/explosion and flammable liquids/ gas/refueling fuel on hot surfaces (98 fires or 19% with 73 injuries), electrical short/arcing (51 fires or 10% with 16 injuries), and spontaneous combustion/hot material (46 fires or 9% with 17 injuries).

The flame cutting/welding spark/slag/flame source caused fires usually involving welders' clothing or oxyfuel/grease and other materials (including chute and dust collector liners, flammable liquids, belt material, crusher, hopper and shaker deck materials, washer plants, equipment mechanical components, stampler breaker, hydraulic fluid, rubber tires and hoses, gear boxes, bin feeder, dump rope cables, screen liner and screen panel, kiln and shaft material, pipelines, liquor pumps, wood pallets, electrical junction boxes, handrails, grease, refuse, shop and wood). The spontaneous combustion/hot material and electrical fires were usually detected late due to lack of combustion gas/smoke detection systems. At least 55 of the 89 mobile equipment hydraulic fluid/fuel fires became large fires (requiring 12 mine rescue team interventions in underground