Table 45.—Number of fire injuries per number of fires causing injuries and total fires for surface stone mines by year, ignition source, equipment involved, and location, 1990–2001

Year	No. total fires	No. fires causing injuries	No. fire injuries	Ignition source	Equipment	Location
1990	6	4	2	Heat source	Heater	Refuse pile area.
			2	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
1991	6	5	2	Heat source	Heater	Maintenance area.
			1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
			1	Flammable gas explosion	Product treatment pot	Product treatment areas.
			1	Hydraulic fluid/fuel on equipment hot surfaces	Loader	Loading area.
1992	10	7	5	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
			1	Heat source	Heater	Maintenance area.
			1	Overheated oil	Air compressor	Drilling area.
1993[2]	14	12	5	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
			3	Heat source	Heater	Beltline/refuse pile areas.
			2	Hydraulic fluid/fuel on equipment hot surfaces	Truck/dozer	Crusher/mining areas.
			1	Refueling fuel on hot surfaces	Truck	Maintenance area.
1994	9	6	3	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
			2	Heat source	Heater	Maintenance area.
			1	Hydraulic fluid/fuel on equipment hot surfaces	Loader	Loading area.
1995	11	9	4	Heat source	Heater	Hopper belt/maintenance areas.
			2	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
			2	Flammable liquid on hot surfaces	Truck/loader	Maintenance area.
			1	Electrical short/arcing	Dozer cab	Mining area.
1996	12	9	2	Heat source	Heater	Maintenance area.
			2	Electrical short/arcing	Generator/truck	Generator housing/haulage area.
			1	Flame cutting/welding spark/slag	Oxyfuel torch	Flame cutting/welding areas.[1]
			3	Hydraulic fluid/fuel on equipment hot surfaces	Dozer/truck	Mining/haulage areas.
			1	Oil on hot surfaces	Truck	—
1997	7	6	1	Mechanical friction	Loader	Loading area.
			2	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
			2	Heat source	Heater	Maintenance/working areas.
			1	Hot material	Hopper belt	Hopper area.
1998	4	4	1	Heat source	Heater	Maintenance area.
			1	Flammable liquid on hot surfaces	Truck	Preheat tower.
			1	Hot material	Kiln	Kiln area.
			1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
1999	6	1	1	Fuel on hot surfaces	—	Storage shed.
2000	4	3	1	Hydraulic fluid/fuel on equipment hot surfaces	Truck	Haulage area.
			1	Flame cutting/welding spark/slag/flame	Shovel	Flame cutting/welding areas.[1]
			1	Electrical short/arcing	Loader	Loading area.
2001	8	2	1	Flame cutting/welding spark/slag/flame	Oxyfuel/torch	Flame cutting/welding areas.[1]
			1	Heat source	Gas heater	Screen deck.
Total	97	68	67			

[1]Includes crusher, ball chain, bin feeder, screen shaft, stamper breaker and beltline areas, and mobile equipment maintenance areas.
[2]In 1993, there was 1 fire fatality, which was caused by a hydraulic fluid/fuel fire involving a truck.

METAL/NONMETAL MILL FIRES

Table 46 and figure 16 show the number of fires and fire injuries for metal/nonmetal mills by state during 1990–2001. Table 46 also shows the injury risk rates, employees' working hours, and lost workdays. In all, 77 fires occurred in 26 states. Thirty-seven of the fires caused 41 injuries and 1 fatality (including 5 fires and 3 injuries involving contractors). The yearly average was 6.4 fires and 3.4 injuries. Fifty-four fires with 26 injuries and 1 fatality occurred at metal mills; 23 fires with 15 injuries occurred at nonmetal mills. The Ewhr value was 845×10^6 hr (Irr = 0.01), and the LWD value was 6,681.

Minnesota had the most fires (16 fires and 5 injuries), followed by Arizona (9 fires and 3 injuries), Wyoming (8 fires and 3 injuries), Nevada (7 fires, 4 injuries, and 1 fatality), and Texas (4 fires and 7 injuries). Of these states, Texas had the highest injury risk rate value (Irr = 0.033).

Table 47, partly illustrated in figure 17, shows the number of fires, fire injuries, fire fatalities, risk rates, employees' working hours, and lost workdays by time period. The number of fires increased slightly during the second period, then decreased during the remaining periods. The number of fire injuries show a decrease during most of the periods (an increase is seen during the third period), accompanied by a decline in employees' working hours during most of the periods. The Irr values follow patterns similar to those shown by the injury values.

Tables 48–53 show the number of fires by ignition source, method of detection and suppression, equipment involved, location, and burning material by time period. Figure 18 shows the major variables related to fires for 1990–2001. Table 54 shows the number of fire injuries per number of fires causing injuries and total fires by year, ignition source, equipment involved, and location.

Ignition Source

Table 48 shows the number of fires and injuries by ignition source for each time period. The leading sources were flame cutting/welding spark/slag/flame (29 fires or 38%), hot material (12 fires or 16%), and flammable liquid/oil/refueling fuel on hot surfaces/explosion (9 fires or 11%). Other ignition sources were electrical short/arcing, conveyor belt friction, overheated oil, surface vaporized oil on hot surface, chemical explosion/ ignition, hydraulic fluid/fuel sprayed onto equipment hot surfaces, and heat source. Two sources were unknown. At least one of the three mobile equipment hydraulic fluid/fuel fires became a large fire because of continuous flow of fluids from the pump due to engine shutoff failure. In this instance, the cab was suddenly engulfed in flames, probably due to the ignition of flammable vapors and mists that penetrated the cab.

During the first, third, fourth, and fifth periods, the largest number of fires were caused by flame cutting/welding spark/ slag/flame. During the second period, the largest number of fires were caused by flammable liquid/oil/refueling fuel on hot surfaces/explosion. During the sixth period, the largest number of fires were caused by flame cutting/welding spark/slag/flame, conveyor belt friction, and overheated oil.

Method of Detection

Table 49 shows the number of fires by method of detection for each time period. The most frequent methods were workers who saw smoke long after the fires had started, followed by welders who saw sparks and operators who saw the fires when they started as flames/flash fires. Other methods of detection were workers who saw smoke shortly after the fires had started, workers who heard an electric trip warning or an explosion, workers who saw a smoldering fire, and an operator who saw white smoke. Four fires were undetected.

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

Suppression Method

Table 50 shows the number of fires by suppression method for each time period. The most common methods were water or portable fire extinguishers alone and manual techniques with or without portable fire extinguishers. None of the equipment involved in fires had machine fire suppression systems. Other suppression methods were portable fire extinguishers with foam, dry chemical powder, and water. On at least five occasions, including one mobile equipment fire, fire brigades and fire departments fought the fires with portable fire extinguishers together with foam, dry chemical, and water. However, six 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 period, the largest number of fires were suppressed with water or portable fire extinguishers alone and manually with or without portable fire extinguishers. During the second period, the largest number of fires were suppressed with portable fire extinguishers alone. During the third through fifth periods, the largest number of fires were extinguished with water alone. During the sixth period, the largest number of fires were extinguished with water or portable fire extinguishers.

Equipment Involved

Table 51 shows the number of fires by equipment involved for each time period. The equipment most often involved was oxyfuel torches (at times electrical arc welding equipment was used). This was followed by dust collectors, air compressors, chutes, dryers, crushers, liquor and refueling pumps, and oil vaporizers. Other equipment included mobile equipment (trucks, dozers, loaders, shovels, and forklifts), beltlines, and electrical breakers, cathodes, and fixtures. Also involved in fires were facilities (considered equipment in this report), heaters, sample and chemical containers, a hydroprecipitator, kilns, product cooling systems, and maintenance equipment.

During the first, third, fourth, and fifth periods, the largest number of fires involved oxyfuel torches. During the second period, the largest number of fires involved oxyfuel torches, mobile equipment, dust collectors, air compressors, chutes, crushers, and dryers. During the sixth period, the largest number of fires involved oxyfuel torches and dust collectors.

Location

Table 52 shows the number of fires by location for each time period. The most common locations were flame cutting/welding areas, beltline areas, and maintenance areas. Other fire locations included dust collectors, air compressors, chutes, crushers, dryers, pelletizer building, baghouse, refinery, liquor pump areas, storage silos, product cooling areas, boiler rooms, power houses, and chemical storage areas. Mobile equipment working areas (haulage, loading, and mining areas), facility and elevator shaft, and a lab and shop were also affected by the fires. During the first through fifth periods, the largest number of fires occurred at flame cutting/welding areas. During the sixth period, the largest number of fires occurred at flame cutting/welding areas, dust collectors, and maintenance areas.

Burning Materials

Table 53 shows the number of fires by burning material for each time period. The materials most often involved were oxyfuel/clothing/grease and other materials (including liquor pumps, belt material, pipelines, dust collector and chute liners, flammable liquids, wood pallets, crusher and screen panel). This

was followed by belt and hot materials, flammable liquids, refueling fuel, and vaporized oil. Other burning materials included electrical wires and cables, facilities and their contents, and oil, chemicals, refuse, and core samples. Dust collector and chute liners, pipeline and crusher materials, equipment mechanical components, and hydraulic fluid/fuel were also involved in the fires.

During the first, third, fourth, and fifth periods, the largest number of fires involved oxyfuel/clothing/grease and other materials. During the second period, the largest number of fires involved oxyfuel and flammable liquids, refueling fuel, and vaporized oil. During the sixth period, the largest number of fires involved oxyfuel, flammable liquids, and facilities and their content.

Fire Injuries

Table 54 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 were 41 injuries and 1 fatality caused by 37 fires.

The greatest number of fire injuries occurred in 1990 (eight injuries caused by eight fires) and 1994 (seven injuries and one fatality caused by six fires). The ignition sources that caused the injuries were flame cutting/welding spark/slag/flame, flammable liquid/refueling fuel on hot surfaces/explosion, and hot material. Other ignition sources were chemical ignition, electrical short/arcing, overheated oil, conveyor belt friction, heat source, and hydraulic fluid/fuel sprayed onto equipment hot surfaces. The equipment involved in fire injuries included oxyfuel torches, maintenance equipment, refueling and liquor pumps, and product cooling systems. Other equipment included chemical containers, electrical systems, air compressors, mobile equipment, heaters, and beltline. The location where most of the fire injuries occurred were the flame cutting/welding areas, maintenance areas, pump housing, liquor pump and refinery areas, and product cooling area. Other fire locations were lab and storage areas, crusher and pelletizer building, beltline, maintenance areas, and mobile equipment working areas.

A fatality occurred in Nevada [MSHA 1994e]. The victim, equipped with firefighting gear and self-contained breathing apparatus, was fighting a refinery electrical fire. The victim was found unconscious on the floor.

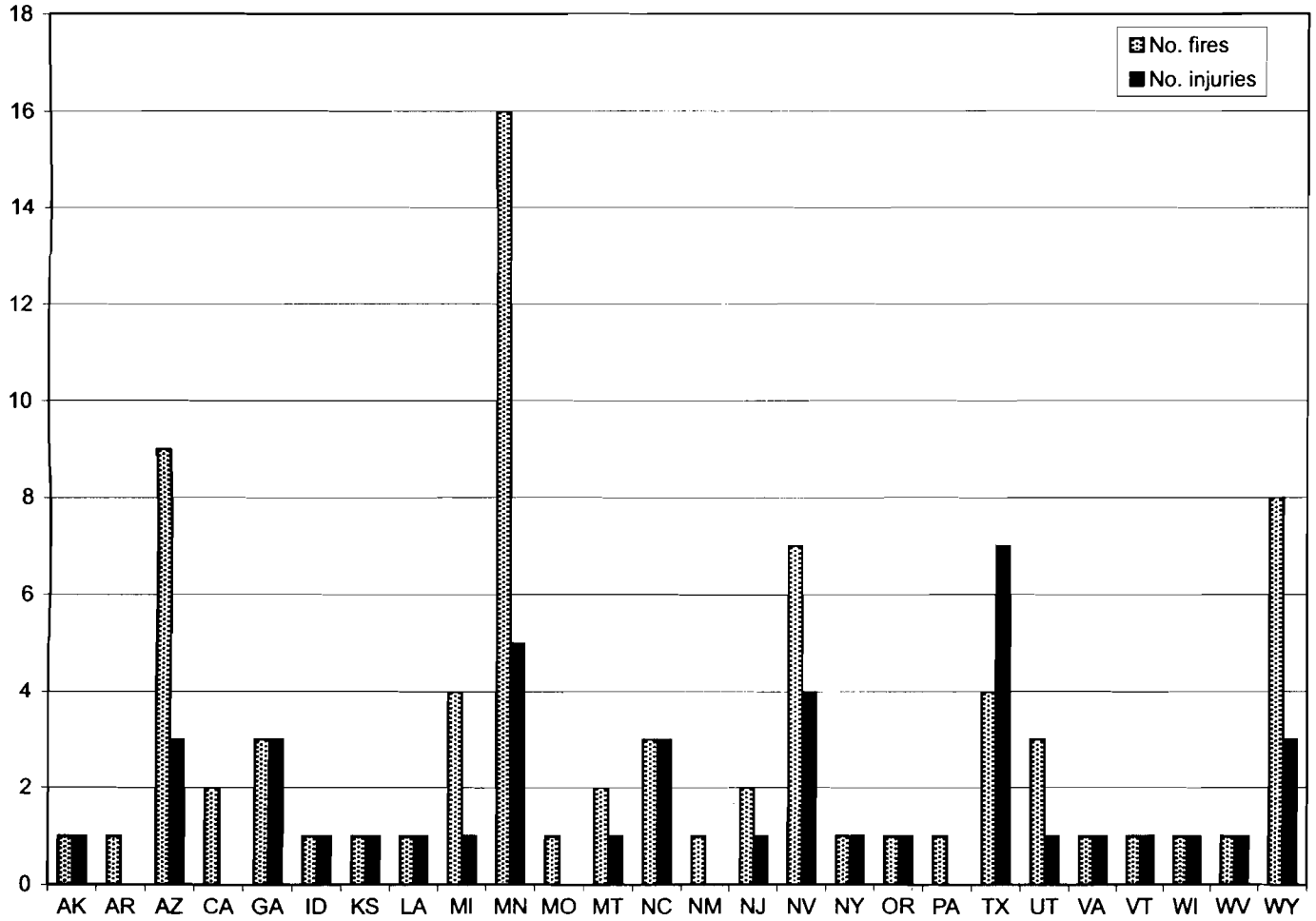

Figure 16.—Number of fires and fire injuries for metal/nonmetal mills by state, 1990–2001.

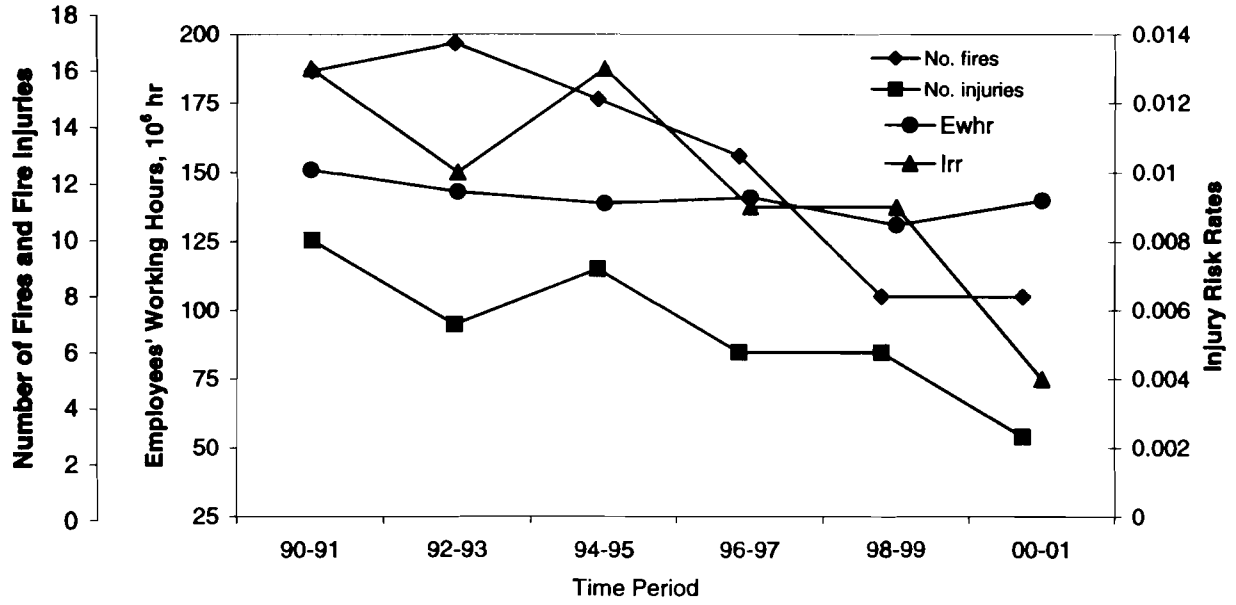

Figure 17.—Number of fires, fire injuries, risk rates, and employees' working hours for metal/nonmetal mills by time period, 1990–2001.

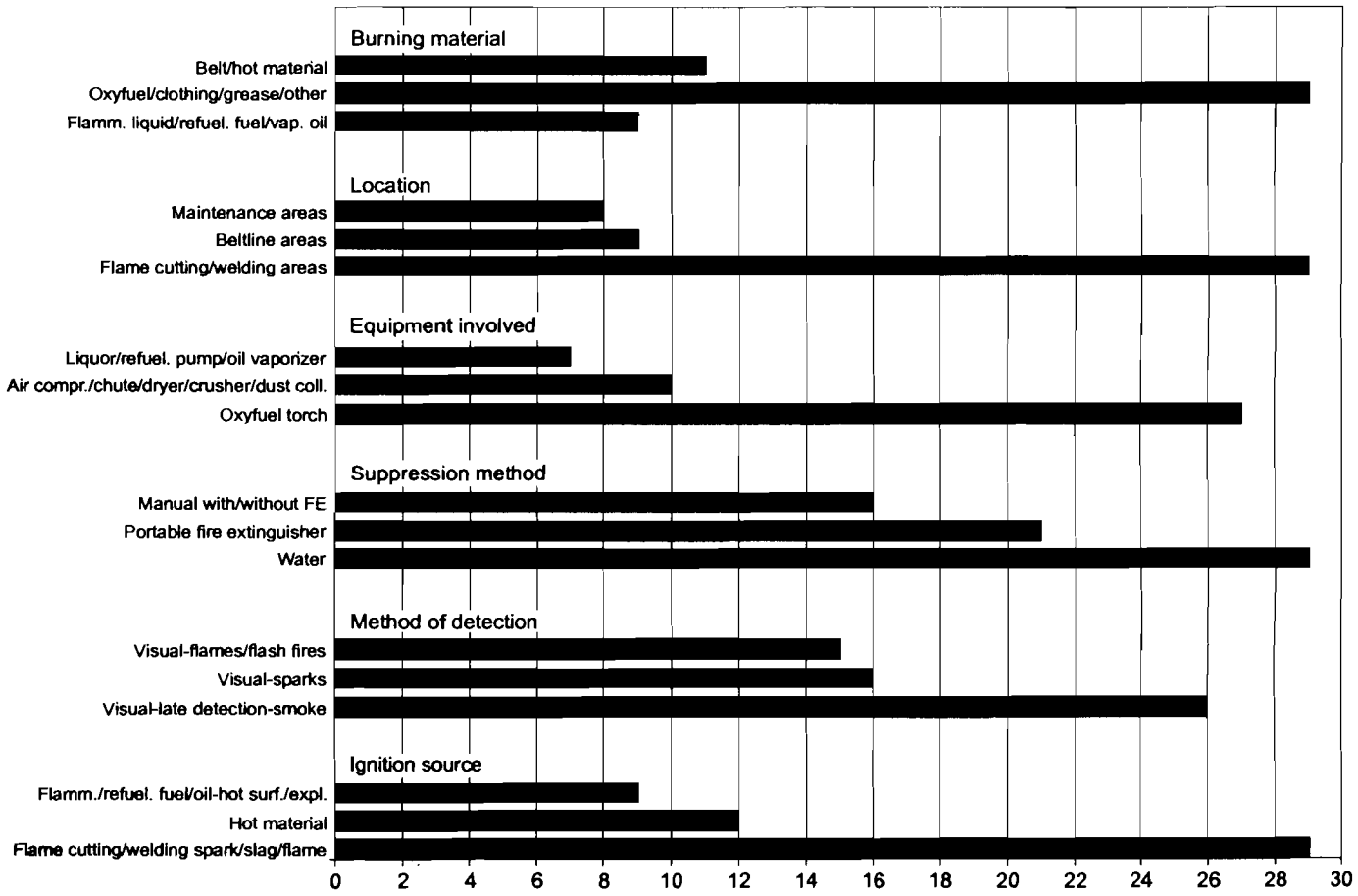

Figure 18.—Major variables for metal/nonmetal mill fires, 1990–2001. (FE = portable fire extinguisher)

Table 46.—Number of fires, fire injuries, and risk rates for metal/nonmetal 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]
Alaska	1	1	7	7.1	0.028
Arizona	9	3	56	78.5	0.008
Arkansas	1	—	—	18.5	—
California	2	—	—	44.72	—
Georgia	3	3	6	102	0.006
Idaho	1	1	—	7	0.029
Kansas	1	1	33	4.5	0.044
Louisiana	1	1	50	16.5	0.012
Michigan	4	1	11	27	0.007
Minnesota	16	5	26	75	0.013
Missouri	1	—	—	4.8	—
Montana	2	1	—	33.5	0.006
Nevada[4]	7	4	6,058	86	0.009
New Jersey	2	1	—	0.65	0.308
New Mexico	1	—	—	11.4	—
New York	1	1	18	1.2	0.17
North Carolina	3	3	—	16.4	0.037
Oregon	1	1	—	1.84	0.109
Pennsylvania	1	—	—	2	—
Texas	4	7	385	42	0.033
Utah	3	1	—	26.4	0.008
Vermont	1	1	9	1.63	0.123
Virginia	1	1	—	7.9	0.025
West Virginia	1	1	—	0.6	0.333
Wisconsin	1	—	—	0.2	—
Wyoming	8	3	22	46.1	0.013
All other states	—	—	—	182	—
Total	77	41	6,681	845	[3]0.01

[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.
[4]Nevada had 1 fire fatality.

Table 47.—Number of fires, fire injuries, fire fatalities, and risk rates for metal/nonmetal 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]	16	17	15	13	8	8	77
Number of fire injuries[1]	10	7	9	6	6	3	41
Number of fire fatalities[1]	—	—	1	—	—	—	1
LWD[2]	58	78	6,033	50	411	51	6,681
Ewhr,[2] 10^6 hr	151	143	139	141	131	140	845
Irr[3]	0.013	0.010	0.013	0.009	0.009	0.004	[3]0.01

[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 48.—Number of fires for metal/nonmetal 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	7	4	8	5	3	2	29
Hot material	1	3	3	3	2	—	12
Flammable liquid/refueling fuel/oil on hot surfaces/ explosion	3	5	—	—	—	1	9
Electrical short/arcing	3	1	1	1	2	—	8
Conveyor belt friction	1	2	—	2	—	2	7
Overheated/vaporized oil on hot surface	1	1	—	—	—	2	4
Hydraulic fluid/fuel on equipment hot surfaces	—	1	—	1	—	—	2
Chemical explosion/ignition	—	—	1	—	1	—	2
Heat source	—	—	1	—	—	1	2
Unknown	—	—	1	1	—	—	2
Total	16	17	15	13	8	8	77

Table 49.—Number of fires for metal/nonmetal 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:							
Late smoke detection	5	7	3	5	3	3	26
Sparks	5	3	3	2	2	1	16
Flames/flash fires	5	3	4	2	1	—	15
Smoke	—	1	1	2	1	4	9
White smoke	1	—	—	—	—	—	1
Smoldering fire	—	—	—	1	—	—	1
Heard an electrical trip warning	—	2	2	—	—	—	4
Heard an explosion	—	1	—	—	—	—	1
Undetected	—	—	2	1	1	—	4
Total	16	17	15	13	8	8	77

Table 50.—Number of fires for metal/nonmetal 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
Water	5	5	6	7	3	3	29
FE	5	8	2	1	2	3	21
Manual with or without FE[1]	5	2	3	3	2	1	16
FE-DCP-foam-water	—	2	2	1	—	—	5
Destroyed/HD[2]	1	—	2	1	1	1	6
Total	16	17	15	13	8	8	77

DCP Dry chemical powder.
FE Portable fire extinguisher.
HD Heavily damaged.
[1]Method used by welders to extinguish clothing and oxyfuel/grease fires.
[2]Usually due to failure of firefighting methods, late fire detection, undetected fires, or fire size.

Table 51.—Number of fires for metal/nonmetal 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]	6	4	7	5	3	2	27
Dust collector/air compressor/chute/dryer/crusher	2	4	1	1	—	2	10
Liquor/refueling pump/oil vaporizer	2	3	1	—	1	—	7
Electrical cathode/breaker/fixture	2	—	1	1	2	—	6
Beltline	1	1	—	2	1	1	6
Mobile equipment[2]	—	4	—	1	—	1	6
Facility[3]	—	—	2	2	1	—	5
Heater	—	1	1	—	—	1	3
Sample/chemical containers/hydroprecipitator	1	—	2	—	—	—	3
Maintenance equipment	2	—	—	—	—	—	2
Kiln/product cooling system	—	—	—	1	—	1	2
Total	16	17	15	13	8	8	77

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

Table 52.—Number of fires for metal/nonmetal 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]	7	4	8	5	3	2	29
Beltline areas	1	3	—	3	1	1	9
Dust collector/air compressor/chute/crusher/dryer areas	2	3	1	—	—	2	8
Maintenance areas	3	3	—	—	—	2	8
Pelletizer/baghouse/refinery/liquor pump areas	2	2	1	1	—	—	6
Storage silos	—	—	2	2	—	—	4
Product cooling area/boiler room/power house/chemical storage	—	—	1	—	2	1	4
Mobile equipment working areas[2]	—	2	—	1	—	—	3
Facility/elevator shaft	—	—	1	1	1	—	3
Laboratory/shop	—	—	1	—	1	—	2
Other	1	—	—	—	—	—	1
Total	16	17	15	13	8	8	77

[1]Includes dust collector, chute and hopper areas, bin feeder, baghouse, pelletizer building, pipeline, elevator shaft, liquor pump, shops, beltline area, and maintenance areas.
[2]Includes haulage, loading, and mining areas.

Table 53.—Number of fires for metal/nonmetal 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]	7	4	8	5	3	2	29
Belt/hot material	1	3	1	3	2	1	11
Flammable liquid/refueling fuel/vaporized oil	3	4	—	—	—	2	9
Electrical wires/cables	3	1	1	1	2	—	8
Oil/chemicals/refuse/core samples	1	1	2	1	—	—	5
Facility/content	—	—	2	1	1	2	6
Dust collector/chute liners/pipeline/crusher material	1	1	1	1	—	—	4
Hydraulic fluid/fuel	—	1	—	1	—	—	2
Equipment mechanical components	—	2	—	—	—	1	3
Total	16	17	15	13	8	8	77

[1]Includes liquor pumps, belt material, pipelines, flammable liquids, dust collector and chute liners, wood pallets, crusher, and screen panel.

Table 54.—Number of fire injuries per number of fires causing injuries and total fires for metal/nonmetal mills by year, ignition source, equipment involved, and location, 1990–2001

Year	No. total fires	No. fires causing injuries	No. fire injuries	Ignition source	Equipment	Location
1990	12	8	4	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
			2	Electrical short/arcing	Electrical system	Crusher/pelletizer building.
			2	Flammable liquid on hot surfaces	Maintenance equipment	Maintenance area.
1991	4	2	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
			1	Refueling fuel on hot surfaces	Refueling pump	Pump housing.
1992	8	2	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
			1	Overheated oil	Air compressor	Mining area.
1993	9	5	2	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
			3	Flammable liquid/refueling fuel on hot surfaces/explosion.	Liquor pump/heater/forklift	Maintenance area/liquor pump area.
1994[1]	10	6	3	Chemical ignition	Chemical samples	Storage/laboratory.
			1	Electrical short/arcing	Electrical system	Refinery building.
			3	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
1995	5	2	2	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
1996	8	3	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
			1	Conveyor belt friction	Beltline	Beltline areas.
			1	Hydraulic fluid/fuel on equipment hot surfaces	Loader	Loading area.
1997	5	3	3	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
1998	5	1	1	Chemical ignition	Chemical samples container	Laboratory.
1999	3	2	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
			4	Hot material	Cooling system	Product cooling area.
2000	4	1	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.
2001	4	2	1	Oil on hot surfaces	Oil cooler	Power house.
			1	Heat source	Heater	Working area.
Total	77	37	41			

[1]In 1994, there was 1 fire fatality, which was caused by a refinery electrical fire.