

## METHODOLOGIES

For all coal mining categories, data on coal mine fires during 1990–1999 have been reported as actual numbers and calculated values.

1. For each mining category, actual numbers include the total number of fires, fire injuries, employees' working hours, lost workdays, and coal production (for underground and surface mines only) for a 10-year period (1990–1999) and for five successive 2-year periods within the 10-year period. These numbers have also been reported by state (10-year period). The actual number of fire fatalities has been reported by time period. Furthermore, actual numbers of fires for the five 2-year periods have been reported by ignition source, method of detection and suppression, equipment involved, location, and burning material. Actual numbers of fire injuries per number of fires causing injuries and total fires have been reported by year, ignition source, equipment involved, and location.

2. For each mining category, the calculated values include the fire and injury risk rates during the 10-year period and the five 2-year periods. The fire risk rate (Frr) values were

calculated according to the USBM formula [Pomroy and Carigiet 1995]. The injury risk rate (Irr) values were calculated according to the MSHA formula [MSHA 1991a, 1992, 1993, 1994a, 1995a, 1996, 1997, 1998b, 1999c, 2000]. Also, risk rate values for individual states (10-year period) were calculated according to the above-mentioned formulas.

Of note is that only the risk rate values for the 10-year and five 2-year periods and risk rate values for individual states with the highest number of fires and fire injuries were considered for comparison purposes. The fatality risk rate values were not calculated because of the extremely small number of fire fatalities during the 10-year period.

3. Calculations of risk rate values are as follows:

- a. Fire risk rate (Frr) value: Number of fires per million tons of coal produced [Pomroy and Carigiet 1995].
- b. Injury risk rate (Irr) value: Number of fire injuries multiplied by 200,000 working hours per total employees' working hours [MSHA 1991a, 1992, 1993, 1994a, 1995a, 1996, 1997, 1998b, 1999c, 2000]. The Irr value is the average risk rate value for the number of fire injuries per 200,000 working hours for a given time period.

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<sup>2</sup>*Code of Federal Regulations*. See CFR in references.

- c. Total employees' working hours (Ewhr) value during 1990–1999: Sum of 10 yearly Ewhr values for all of the states involved in fires. This value also includes the Ewhr value reported for all other states not involved in fires. The Ewhr value for each state (10-year time period) is the sum of 10 yearly Ewhr values for that state.
- d. Total employees' working hours (Ewhr) value for five 2-year time periods: Sum of two yearly Ewhr values for all of the states, involved and not involved in fires, within the 2-year period.
- e. The coal production (CP) values in short tons were calculated similarly.
- f. The lost workday (LWD) values were reported by state and time period.
- g. An LWD value of 6,000, assigned by MSHA to each fatality, was reported.

## FIRE DATA ANALYSIS FOR ALL COAL MINING CATEGORIES

### UNDERGROUND COAL MINE FIRES

Table 1 and figure 1 show the number of fires and fire injuries that occurred in underground coal mines by state during 1990–1999. Table 1 also shows by state the risk rates, employees' working hours, lost workdays, and coal production. Overall, 87 fires occurred in 12 states. Twenty-seven of those fires caused 34 injuries (the yearly average was 8.7 fires and 3.4 injuries). One fire and one injury involved a contractor. The underground mine fires required 25 mine rescue team interventions and 30 mine/section evacuations followed by 13 mine/section sealing/flooding/ $\text{CO}_2/\text{N}_2$  gas injections. The Ewhr value was  $1,003 \times 10^6$  hr (Irr = 0.007), the CP value was  $4,008 \times 10^6$  st (Frr = 0.022), and the LWD value was 208.

Virginia had the most fires (15 fires and 7 injuries). Pennsylvania had the most fire injuries (12 fires and 9 injuries), followed by Kentucky (12 fires and 6 injuries), and Alabama (12 fires and 4 injuries). Among these states, Alabama had the highest fire risk rate value (Frr = 0.073), whereas Pennsylvania had the highest injury risk rate value (Irr = 0.016).

Table 2, partly illustrated in figure 2, shows by time period the number of fires, fire injuries, risk rates, employees' working

hours, lost workdays, and coal production. The number of fires and fire injuries show a decrease followed by an increase during the five time periods (see table 2 and figure 2). This was accompanied by a decline in employees' working hours throughout the periods and an overall small decrease in coal production. The Irr and Frr values follow patterns similar to those shown by the fire and injury values.

By comparison, data from Pomroy and Carigiet [1995] show that during 1978–1992 a total of 11 states were involved in 164 underground coal mine fires (yearly average, 10.8) with 43 injuries (yearly average, 2.9) and 27 fatalities (yearly average, 2; however, the 27 deaths occurred during a single fire caused by an overheated air compressor [MSHA 1984]). The CP value was  $5,340 \times 10^6$  st (yearly average,  $356 \times 10^6$  st) (Frr = 0.031). Data on employees' working hours and injury risk rates were not available.

Tables 3–8 show the number of fires by ignition source, method of detection and suppression, equipment involved, location, and burning material by time period. Figure 3 shows the major variables during 1990–1999. Table 9 shows the number of fire injuries per number of fires causing injuries and total fires by year, ignition source, equipment involved, and location.

**Table 1.—Number of fires, fire injuries, and risk rates for underground coal mines by state, employees' working hours, lost workdays, and coal production, 1990–1999**

State <sup>1</sup>	No. fires <sup>1</sup>	No. injuries <sup>1</sup>	LWD <sup>2</sup>	Ewhr, <sup>2</sup> 10 <sup>6</sup> hr	CP, <sup>2</sup> 10 <sup>6</sup> st	Frr <sup>3</sup>	Irr <sup>3</sup>
Alabama .....	12	4	6	67	165	0.073	0.012
Colorado .....	7	1	4	20	148	0.047	0.01
Illinois .....	12	1	6	96	403	0.03	0.002
Indiana .....	1	1	—	5	24	0.042	0.04
Kentucky .....	12	6	1	245	948	0.013	0.005
Ohio .....	1	—	—	32	133	0.0075	—
Pennsylvania .....	12	9	14	116	456	0.026	0.016
Tennessee .....	2	—	—	9	21	0.095	—
Utah .....	1	—	—	34	252	0.004	—
Virginia .....	15	7	140	96	291	0.052	0.015
West Virginia .....	9	5	37	271	1,131	0.008	0.004
Wyoming .....	3	—	—	3	23	0.13	—
All other states .....	—	—	—	9	13	—	—
Total .....	87	34	208	1,003	4,008	<sup>3</sup> 0.022	<sup>3</sup> 0.007

<sup>1</sup>Derived from MSHA "Fire Accident Abstract" and "Fire Accident Report" publications.

<sup>2</sup>Derived from MSHA "Injury Experience in Coal Mining" publications.

<sup>3</sup>Calculated according to USBM and MSHA formulas reported in the "Methodologies" section.