fire because of the continuous flow of fluid 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.

In at least five instances, including one mobile equipment fire, fire brigades and fire department fought the fires with foam, dry chemical powder, 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. Twenty-six fires were detected late, and four were undetected.

The ignition sources that caused most of the fire injuries were flame cutting/welding spark/slag/flame, flammable liquids/refueling fuel on hot surfaces/explosion, and hot material. The equipment involved in fire injuries included oxyfuel torches, maintenance equipment, refueling and liquor pumps, and product cooling system. The locations where the fire injuries occurred were flame cutting/welding areas, maintenance areas, pump housing and liquor pump areas, and product cooling area.

7. At stone mills, 118 fires occurred; 76 of the fires caused 82 injuries (Ewhr = 873 × 10^6 hr, Irr = 0.019, LWD = 1,911). The leading ignition 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%).

The flame cutting/welding spark/slag/flame source caused fires involving oxyfuel/clothing/grease and other materials (including rubber hoses, pipelines, dust collector and chute liners, and shaft and kiln materials). Four of the five hydraulic fluid/fuel fires became large fires because of the continuous flow of fluids from the pumps due to engine shutoff failure, lack of an emergency line drainage system, difficulty in activating emergency systems at ground level, or lack of effective and rapid local firefighting response capabilities. In one instance the cab was suddenly engulfed in flames, probably due to the ignition of flammable vapors and mists that penetrated the cab. Of the six pieces of mobile equipment involved in fires, one had a machine fire suppression system, which, upon activation with the engine shutoff system, succeeded in temporarily abating the fire.

In at least 11 instances, including 2 mobile equipment fires, fire brigades and fire departments fought the fires with foam, dry chemical powder, and water. In two instances, emergency foam fire suppression systems were used. However, seven fires destroyed or heavily damaged equipment (including one piece of mobile equipment) because of failure of firefighting methods. Thirty-one fires were detected late, and six fires were undetected.

The ignition sources that caused most of the fire injuries were flame cutting/welding spark/slag/flame, hot material, and flammable liquid/gas/refueling fuel on hot surfaces. The equipment most often involved in fires included oxyfuel torches, kilns, beltlines, chute, preheat system, and maintenance equipment. Most of the fire injuries occurred at flame cutting/welding areas, kiln, beltline and chute areas, preheat areas, and maintenance areas.

CONCLUSIONS

During 1990–2001, a total of 518 fires occurred in all metal/nonmetal mining categories; 296 of those fires caused 308 injuries and 4 fatalities. Surface operations had the most fires and the highest injury risk rate values. Forty-five 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.

In the future, many of these fires and injuries might be prevented or detected and extinguished at their earliest stage by improving current fire safety procedures, adopting existing/improved fire detection and suppression technologies, and/or developing new technologies. Several strategies for reducing and/or preventing the number of fires and fire injuries follow.

1. Increase vigilance, improve safety procedures, and develop new technologies in order to prevent fires and injuries caused by flame cutting and welding operations.

2. Improve equipment hydraulic/fuel/electrical systems inspection programs; adopt fire-resistant hydraulic fluids and electrically powered motors for use in underground mines; develop new technologies (equipment/cab rapid fire detection/prevention/suppression systems, emergency line drainage systems, and fire barriers); adopt an optimal ground level location for the activation of emergency systems; improve operator's fire preparedness training programs; and develop effective and rapid local firefighting response capabilities.

3. Adopt existing/improved systems for continuous and early detection of combustion gases and smoke along beltlines.

4. Adopt existing/improved technologies for monitoring equipment (beltlines) operational functions.

5. Increase vigilance and adopt improved safety procedures for handling flammable liquids and refueling fuel in the vicinity of heat sources.

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