CONCLUSIONS

During 1990–1999, a total of 458 fires occurred in all coal mining categories; 157 of those fires caused 164 injuries and 2 fatalities. The greatest number of fires and fire injuries occurred at surface mines, which also had the highest risk rate values. A total of 66 firefighting interventions were required. Of these, there were 25 mine rescue team interventions in underground mines, including 5 mobile equipment firefighting interventions, and 41 fire brigade and fire department interventions at all surface operations, including 19 mobile equipment interventions. In all, 50 fires destroyed or heavily damaged equipment (including 16 pieces of mobile equipment) because of failure of other firefighting methods, late fire detection, undetected fires, or fire size. A total of 114 fires were detected late by smoke, and 42 fires were not detected.

In the future, coal mine fires might be prevented or detected and extinguished at their earliest stage by adopting existing/improved technologies and/or by developing new technologies. Several strategies for reducing the number of fires and fire injuries follow.

1. *Adopt existing/improved safety procedures and develop new technologies for flame cutting/welding operations. Require safety training for welders (including contractors) working in gaseous environments.*

At all coal operations during 1990–1999, flame cutting/welding operations caused 102 fires (22% of total fires with 69 injuries). These fires usually involved welders' clothing or oxyfuel/grease (grease embedded in the equipment's mechanical components). However, in two instances sparks/hot slag/flames caused methane ignitions followed by large fires (one of these fires required firefighting interventions and mine/section/facility evacuation and sealing), in six cases undetected hot slag caused coal belt fires, in one instance undetected hot slag caused a storage facility fire, in another instance undetected hot slag caused a large coal fire that required firefighting intervention and mine evacuation and sealing followed by a methane explosion, and in another instance undetected hot slag caused a coal chute smoldering fire, which, upon water application,

produced a flashback accompanied by a gas explosion (causing one fatality), which required firefighting interventions and mine/section evacuations. By adopting existing/improved safety procedures, the flame cutting/welding fires due to the ignition of oxyfuel/grease might be prevented. By developing new technologies to contain sparks/slag, the flame cutting/welding fires due to sparks and hot slag might also be prevented.

2. *Adopt existing/improved inspection programs for mobile equipment hydraulic, electrical, and fuel systems. Adopt an optimal ground level location for the activation of emergency systems. Develop new emergency technologies for engine/pump shutoff, hydraulic line drainage, line safeguards, and fire barriers. Develop rapid equipment/cab fire detection and effective fire prevention/suppression systems. Develop effective and rapid local firefighting capabilities. Schedule more frequent fire emergency preparedness training for equipment operators.*

At all coal operations during 1990–1999, there were 98 (21% of total fires with 29 injuries) mobile equipment hydraulic fluid/fuel fires (mostly at surface operations) and 12 equipment electrical fires in underground mines, which in at least one instance affected the hydraulic lines. Most of the hydraulic fluid/fuel fires became large fires because of the continuous flow of fluid/fuel from the pumps due to engine shutoff failure, flow of pressurized fluids entrapped in the hydraulic lines (not affected by the engine shutoff operation), difficulty in activating emergency systems at ground level, or lack of effective and rapid local firefighting capabilities. Of note is that most of the hydraulic fluid/fuel fires were caused when hydraulic fluids sprayed onto equipment hot surfaces; subsequently, these fires involved the fuel lines. In at least seven instances the cab was suddenly engulfed in flames, probably due to the ignition of flammable vapors and mists that penetrate the cab during the spraying of pressurized hydraulic fluid onto equipment hot surfaces. Also, most of the mobile equipment electrical fires became large fires because of unavailability of effective machine fire suppression systems, lack of an emergency hydraulic line drainage system, or lack of effective and rapid local firefighting capabilities. In all, 10 pieces of mobile equipment involved in fires had machine fire suppression systems. Dual activation (six activations) of machine fire suppression and engine shutoff systems succeeded in abating the fires, but the flames reignited, fueled by the flow of fluids entrapped in the lines (not affected by the engine, or motor, shutoff operation).

By adopting existing/improved mobile equipment inspection programs, hydraulic line and electrical cable wear and tear might be detected early, thereby preventing hydraulic fluid/fuel and electrical cable fires. By adopting an optimal location for ground level activation of machine fire suppression and engine shutoff systems, these emergency operations might be performed safely and in a timely manner, thus stopping the continuous flow of fluid/fuel from the pumps. By developing new technologies for the emergency draining of pressurized fluids entrapped in lines, the hydraulic fluid fires might not reignite, thus allowing the operators to exit the cab safely. By developing/adopting cab fire detection and cab fire inerting/suppression systems, the cab fires might not occur. By preparing local miners to fight mobile equipment fires, when detected, with large, contained quantities of suppressant agents on vehicles for ease of deployment to the fire site, these fires might be extinguished in their early stage.

3. *Adopt existing/improved continuous and early combustion gas/smoke detection systems.*

At all coal operations during 1990–1999, there were 71 (16% of total fires) spontaneous combustion/hot coal fires involving goblines, sealed and abandoned areas, coal silos, coal chutes, dust collectors, and beltlines. The spontaneous combustion/hot coal fires were usually detected late due to lack of continuous and early combustion gas/smoke detection systems; however, twice they were accompanied by methane explosions. By adopting existing continuous and early combustion gas/smoke detection systems, the spontaneous combustion/hot coal fires might be detected and suppressed at their earliest stage.

4. *Adopt existing/improved technologies to monitor equipment operations.*

At all coal mining operations during 1990–1999, there were 30 fires (7% of total fires with 6 injuries) caused by the operational failure of beltlines, drives, and pulleys. By adopting existing/improved technologies to monitor equipment operations, failures might be detected early, thereby preventing these types of equipment fires.

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