A Comparison of Longwall & Continuous Mining Safety In US Coal Mines 1988 – 1997

Sean Gallagher
Research Physiologist
Mining Injury Prevention
Branch, Pittsburgh, NIOSH

Rhys Llewellyn
Chief
Office of Injury & Employment Information
Directorate of Program Evaluation and
Information Resources, MSHA

Jay Mattos
Program Analyst
Office of Program Policy Evaluation, Program Evaluation
And Information Resources, MSHA

Longwall Mining Safety

This paper contains the results of an examination of accident, injury, employment, and production information reported to the U.S. Department of Labor's Mine Safety and Health Administration (MSHA) and provides information on some of the measures longwall mine operators are using to prevent accidents

In all industries, technological advances play a key role in determining those who will survive as competitive participants in an increasingly global marketplace. While mining is among the most basic of industries, technological change is neither unfamiliar nor unwelcome to miners. Historically, technological advances in mining, particularly coal mining, have tracked closely with fluctuations in demand.

In the early 1900's, coal accounted for more than three quarters of all the fuel consumed in the U.S. To meet this tremendous demand, underground cutting machines were introduced, resulting in faster, more efficient coal extraction. Transporting coal to the surface, however, remained labor intensive. In the 1920's, nearly all underground coal was still being hand loaded. Demand for coal then declined as the price of oil, natural gas, and electricity became competitive. In the late 1930's and throughout the duration of World War II, coal demand and production was high. By 1940, more than half the coal mined was being mechanically conveyed to the surface.

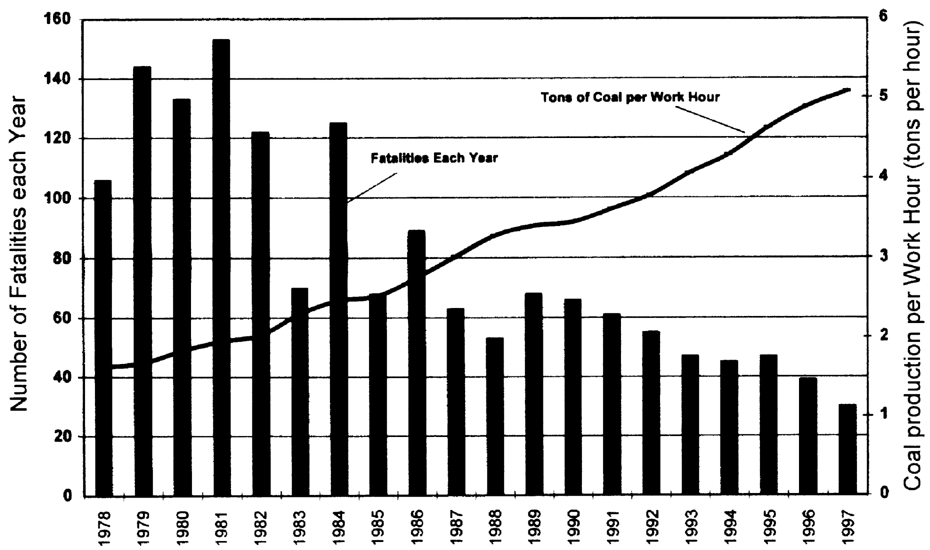
In 1948, the continuous mining method was introduced in the U.S., further accelerating the extraction process. By the 1950's and 1960's, however, coal production again declined as railroads converted to diesel fuel and gas and oil provided a larger share of the home heating market. Underground coal mines required even more mechanization to remain competitive as an energy source. The first longwall system was introduced in 1960. By 1995, longwalls were producing more than 189 million tons of clean coal annually, surpassing continuous mining production for the second straight year.

The mining of coal and other materials has not come without a huge loss of life and considerable human suffering. More than 103,000 workers died from injuries in U.S. mines in the last 85 years. Between two and three thousand miners died each year from the turn of the century until 1931, many from underground fires and explosions. The U.S. has witnessed a tremendous drop in fatalities in underground coal mines. Credit for that is due to safety inspections and enforcement activities, better safety awareness and practices among management and labor, improved ventilation, the use of safer equipment, and increased mechanization which removed many miners from the hazards at the face and also reduced the size of the mining work force.

There is little doubt that longwall mining has greatly increased underground coal mine productivity. The degree to which longwall mining has contributed to a safer work environment for underground miners is more difficult to ascertain.

Figure 1 shows the dramatic increase in coal mining productivity in the past 20 years, along with the equally dramatic decrease in coal mining fatalities[1].

Figure 1 - Coal Mining Productivity vs. Fatalities
1978-1997

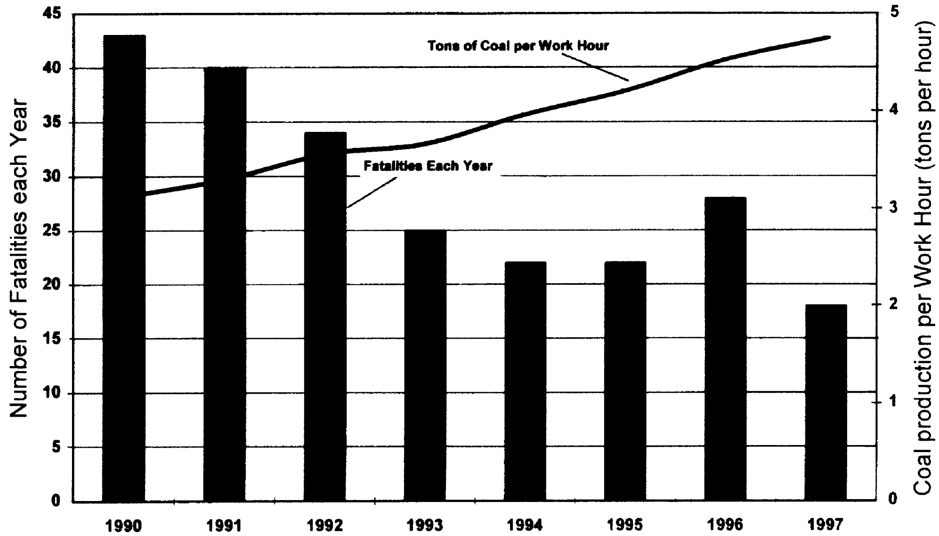


Much of the productivity gain is attributable to the significant increases in surface coal production in the Powder River Basin. Nevertheless, underground mining has separately exhibited similar productivity gains coupled with fewer fatalities. Figure 2 shows underground coal mining fatalities and productivity from 1990 to 1997.

---

[1] The statistics compiled in this paper are based on injury and work time reports required to be submitted by mine operators and contractors to MSHA.

Figure 2 - Coal Mining Productivity vs. Fatalities
Underground Mines



Despite the impressive decline in coal mining fatalities, longwall and continuous mining operations both continue to claim victims. On April 16, 1996 in Pennsylvania, a hydraulic prop ("duke jack") was being used to steer a stage loader assembly away from the left rib. The jack was not positioned correctly and it sprang free, striking a member of the maintenance crew and causing fatal injuries. The victim was 41 and had 20 years of mining experience. Almost a year later and only a few miles north, a 44-year-old mechanic with 23 years of mining experience died of asphyxiation when a continuous mining machine he was troubleshooting suddenly pivoted and pinned him against the coal rib.

Most injuries are not fatal and by analyzing the less serious occurrences, we may devise measures to reduce the incidence of similar occurrences.

The MSHA accident, injury, and illness report form includes an item for the underground mining method used at the site of the injury. Corresponding hours identified by mining method are not obtained. Consequently, incidence rates cannot be generated to make valid comparisons between longwall and, for example, continuous mining sections. The statistics do indicate that, in general, mines in which a longwall is installed experience lower injury incidence rates than those without longwall sections.

Table 1 compares the 1995-1997 incidence rates calculated from the total lost-time injuries reported by mines having a longwall section, compared to all other bituminous underground operations.

Table 1 - Lost-time Injury Incidence Rate for Underground Areas of Bituminous Coal Mines

	Number of Injuries per 200,000 Work Hours		
Year	Longwall Mines	Mines without Longwalls	Total Underground Mines
1995	10.8	11.3	11.1
1996	8.5	10.2	9.5
1997	8.0	9.9	9.2
1995-1997	9.1	10.5	9.9

Operations identified as "longwall" also utilize other extraction methods. These results provide only a rough measure of relative safety performances. Given the inability to normalize injury data using exposure hours by type of section, one alternative is to compare certain characteristics of the injuries and accident victims in the different environments.

From 1988 through 1997, nearly 42,000 disabling injuries were reported for continuous mining sections compared to 7,300 injuries associated with longwall sections.

A comparison of accident type, accident classification, source of injury, nature of injury, part of body injured, average severity, and age and experience of the employee revealed no significant differences between longwall and continuous mining sections. Percentage distributions within a particular characteristic seldom varied more than two points between the two mining method groups. For example, 16% of the longwall injuries and 18% of the continuous mining injuries resulted from the victim being struck by a falling object. Grouping data based on reported "underground mining method" covers too broad an area and fails to provide appropriate comparison measures.

Nevertheless, the accident and injury data provide some useful indicators of where we might identify "best practices" for preventing hazardous conditions or activities. Table 2 shows the number of disabling injuries reported on longwall sections between 1990 and 1997, by accident classification and the activity of the accident victim when injured.

Table 2 - Disabling Injuries on Longwall Sections - 1990-1997

	Activity						
Classification	Handling Supplies/ Materials	Walking/ Running	Machine Maintenance/ Repair	Non-Power Hand Tools	Advance Longwall Support	Other	Total
Handling Materials	**964**	31	**221**	3	28	827	2,074
Slip/Fall	204	**427**	64	3	16	363	1,077
Machinery	18	15	51	2	**200**	361	647
Non-Power Handtools	9	1	58	**328**	6	63	465
Other	121	225	93	13	75	817	1,344
Total	1,316	699	487	349	325	2,431	5,607

Less than 10% of accidents reported on longwall sections are directly related to operating the longwall shear/plow or advancing longwall roof support. Most of the injuries which occur on longwall sections occur while a victim is handling supplies or other materials, using non-powered handtools, performing equipment maintenance and repair, or engaged in other activities not directly related to coal production.

There are many similarities in the types of accidents that occur in underground mines regardless of the type of mining. For example, "handling materials" is by far the leading accident classification and activity in both longwall and continuous mining sections. There are, however, a number of health and safety issues unique to longwall mining. Some issues are common to all longwall operations while others, such as geological conditions, might be mine specific. Following are descriptions of some health and safety issues specific to longwall mining with information on practices that can be used to reduce or minimize the health and safety issues that confront the longwall face worker.

Pre-Longwall Setup

Best practices in longwall operation begin prior to installation. Compatibility testing of the system can provide an excellent opportunity to inspect the three main components of the system (shearer, supports and pan line) and to observe the clearances and tolerances of the system. Some mines have made effective use of providing hands-on training to the crew by setting up the longwall in a safe and controlled environment in the mine prior to actual implementation of the system in an operational setting. This approach provides the opportunity for the crew to gain experience in the operation of the equipment without disrupting the start-up and production processes. This procedure can be extremely helpful in establishing and reinforcing safe working habits prior to actual operation and maintenance of the equipment in the production setting.

Crew training is always an important aspect in the introduction of a new system, particularly if a mine is implementing its first longwall system and the miners are unfamiliar with the technology. Successful training is usually composed of a combination of formal classroom instruction, hands-on work to reinforce the classroom material and on-the-job training where new skills are applied. Some longwall equipment manufacturers have begun to provide customers with computerized multimedia modules that allow training to be performed in a self-paced manner. These modules assist the learning process by reducing complex technical knowledge into simpler knowledge sets (Chadwick, 1997).

Longwall Installation

The actual process of setting up a longwall is a complicated logistics exercise, involving transport and installation of massive components, often in difficult environmental settings. As a result, this process is often time consuming and results in many situations where accidents seem almost inevitable. Unfortunately, the coordination of this exercise is frequently not well thought out and leads to situations where needed parts or tools are unavailable or where equipment may be brought into the mine in a less than optimal fashion to facilitate safe and efficient set-up.

One mine in Australia sought to improve the safety and efficiency of its longwall setup and hired a consulting firm to perform a thorough hazard analysis and logistical evaluation of this exercise. The consulting firm developed a plan to optimize the setup process. The planning reached the detail of making sure that each shipment that went underground not only provided the materials in a logical fashion to facilitate the setup, but ensured that the tools required to put components together were shipped along with the actual material. If specific materials handling equipment was required for handling certain components, it was assured that this equipment was in place ahead of time. The thought and detail put into the planning of this process not only reduced the risk of injury to the workers, but allowed the mine to start coal production 12 days after the initiation of the longwall setup process. Obviously, the logistical planning and risk analysis used to improve the process of longwall setups also can -- and should -- be applied to longwall moves, as well.

Operator Workstations

The longwall operator often works in difficult situations. Some of the main problems include awkward postures, control layout or accessibility, dust, noise, visibility and communications. In response to some of these issues, work has been done on the development of a suitable workstation that would afford easy access to the controls and information required by the operator, while providing a comfortable workstation. Analysis of a prototypical workstation indicated that working conditions for these operators can be improved significantly. Some of the improvements include better accessibility and layout of controls, fewer awkward postures, better visibility, decreased physiological stress, less dust exposure and better illumination. Operators provided with such a workstation also felt that it increased their status in the operation.

Materials Handling

Materials handling remains a significant issue on longwall sections. Some companies have developed methods for facilitating the handling of materials on these sections. One innovation used by Twentymile Coal Company in the tailgate is the use of mechanically installed concrete "donuts" for roof support. These concrete cylinders replace the traditional wooden cribs, improve ventilation and provide superior support and efficient installation (Chadwick, 1997).

The movement of supplies along the longwall face can be quite difficult as a result of having to negotiate the mobile roof supports while handling heavy and awkward loads. An innovation by CONSOL was to develop a materials-handling cart that rides on the handrails of the conveyor. Materials can be loaded onto this cart and it can be rolled along the face with considerably less effort than it would take to manually carry these materials under the roof supports (Anderson, 1997).

Another materials handling method that has been used with some success on longwall sections is the utilization of a winch attached to the mobile roof support to help with the handling of heavy items on the longwall face. Use of such mechanical assist devices can significantly reduce the exposure of workers to the hazards associated with manual lifting of some very heavy objects.

Design for Maintainability

Maintainability of the equipment at the face is another significant challenge in longwall mining. Maintenance of the relatively inflexible longwall system is often complicated by environmental conditions. In some cases, severe conditions have necessitated development of a shearer which required minimum component changes during the mining of a panel. Studies have suggested that electrical checks and oiling and greasing equipment accounted for the bulk of the maintenance workload for shearers. In some equipment, it was found that the location of filling points was on the face side of the shearer, which made maintenance difficult. Obviously, such filling points should be easily accessible to facilitate maintenance needs. Analysis of the shearer system has also led some to recommend that remote fluid level sensors should be provided whenever possible and that powered pumps will facilitate the transfer of fluids to the shearer (Coleman, 1994).

Illumination

Proper illumination of the face area is an important part of maintaining a safe working environment. Lighting requirements vary in accordance to the thickness of the coal seam being extracted. In mines where the face is less than 1.5 meters in height, for example, it is much more important to focus on the uniformity of the illumination rather than the intensity in order to reduce glare. Selection of low output luminaires will help minimize the risks associated with discomfort or disability glare. In general, the higher the seam, the higher the output of the luminaires that can be used. Installing luminaires on the powered supports has shown to be an effective method of properly illuminating the longwall face (Mentre, 1994).

Personal Protective Equipment

Longwall face workers are exposed to high doses of noise and dust. Such exposures demand properly designed personal protective equipment. A study of hearing protectors performed in Great Britain recently suggested the following design principles for hearing protection.

First, researchers recommended that hearing protectors be mounted on the helmet. Second, the protectors should provide a flat attenuation profile resulting in a 15-18 dB attenuation across the range 250 - 6000Hz, and should be designed so that the earpieces assume a close profile to the wearer's head during use. In an effort to reduce the threat of hearing loss to the longwall face crew, three main factors are to be taken into consideration with hearing protection devices: proper fit, comfort and convenience (Graveling, 1994).

Future of Longwall Mining

It is expected that automation technology will continue to influence the design of longwall faces in the future. The goal of the completely manless face, however, appears to lie well into the future. Though they may assume more of a role of supporting and directing the technology in the future, highly skilled workers are expected to continue to be crucial to the success of longwall operations (Organiscak et al., 1996).

Because longwall face workers are expected to remain an integral part of the production process, health and safety are expected to remain a major concern. It is likely that increased automation of the longwall face will result in relocation of face workers to outby areas, exposing them to different health and safety risks. Those positioned in these areas will be subject to less noise and dust exposure, but could experience increased materials handling activity, will be increasingly exposed to movement of outby equipment, and might experience increased exposure to ground movements as well.

Those workers remaining in the face area could be exposed to increases in respirable dust exposure and higher noise levels associated with increasing production rates in the future. Elevations in methane gas liberation could also be a byproduct of faster production rates. The effects of changing longwall technology will require increased vigilance and perhaps new control technologies so that the health and safety of mine workers can be properly maintained (Chadwick, 1997).

References

Anderson, D., 1997. Presentation at Ergonomics: Effective Workplace Practices and Programs Conference, Chicago, IL, January 7-8, 1997.

Chadwick, J., 1997. Best longwall practice. MINING Magazine, December 1997, pp. 352-366.

Coleman, G.J., 1994. Ergonomic guidelines for the design of mining machinery to facilitate maintenance. Chapter in Ergonomics Action in Mining (Berchem-Simon, ed.), Commission of the European Communities: Luxemburg, pp. 47-55.

Graveling, R.A., 1994. Improved hearing protection in a mining environment. Chapter in Ergonomics Action in Mining (Berchem-Simon, ed.), Commission of the European Communities: Luxemburg, pp. 103-112.

Mentre, G., 1994. Improving face lighting: developing and testing new lighting installations. Chapter in Ergonomics Action in Mining (Berchem-Simon, ed.), Commission of the European Communities: Luxemburg, pp. 127-138.

Organiscak, J.A., Mark, C., Jankowski, R.A., and Thimons, E.D., 1996. Health and safety implications of U.S. semi-autonomous longwall operations, SME Annual Meeting, Phoenix, AZ, March 11-14, 1996.