# TECHNICAL SESSION I

## TRAINING

## "Human Factors and Training for Accident Reduction"

by

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## ABSTRACT

Bureau of Mines Human Factors Research aims at improving mine health and safety profiles through better work station and system design and through better methods and media for employee training. Investigations are of two types: (1) Ergonomics - seeks to establish permanent improvements in the organizational and physical design of the workplace; and (2) education and training - applies available learning technology to the specific training needs of the mining community.


## INTRODUCTION

Although efforts of industry, labor, and government to improve occupational safety in mining are considerable, the situation as a whole remains disturbing. For example, recent discussions of the impact of past health and safety legislation on coal mine safety profiles have commonly concluded that strict regulation and enforcement of mine safety standards over the past decade have had a positive impact on reducing disaster potential and have effected a substantial reduction in non-disaster-related fatalities. However, the significant decreases in nonfatal disabling (lost-time) injuries have not been maintained over the same time period. Supporting empirical data used as a base for these conclusions are presented in Tables 1, 2, 3, and 4.

Hypotheses have been presented that rigorous enforcement of physical mine safety standards may have reached a point where it no longer effects substantive reductions in nonfatal lost-time injuries. This is to say not

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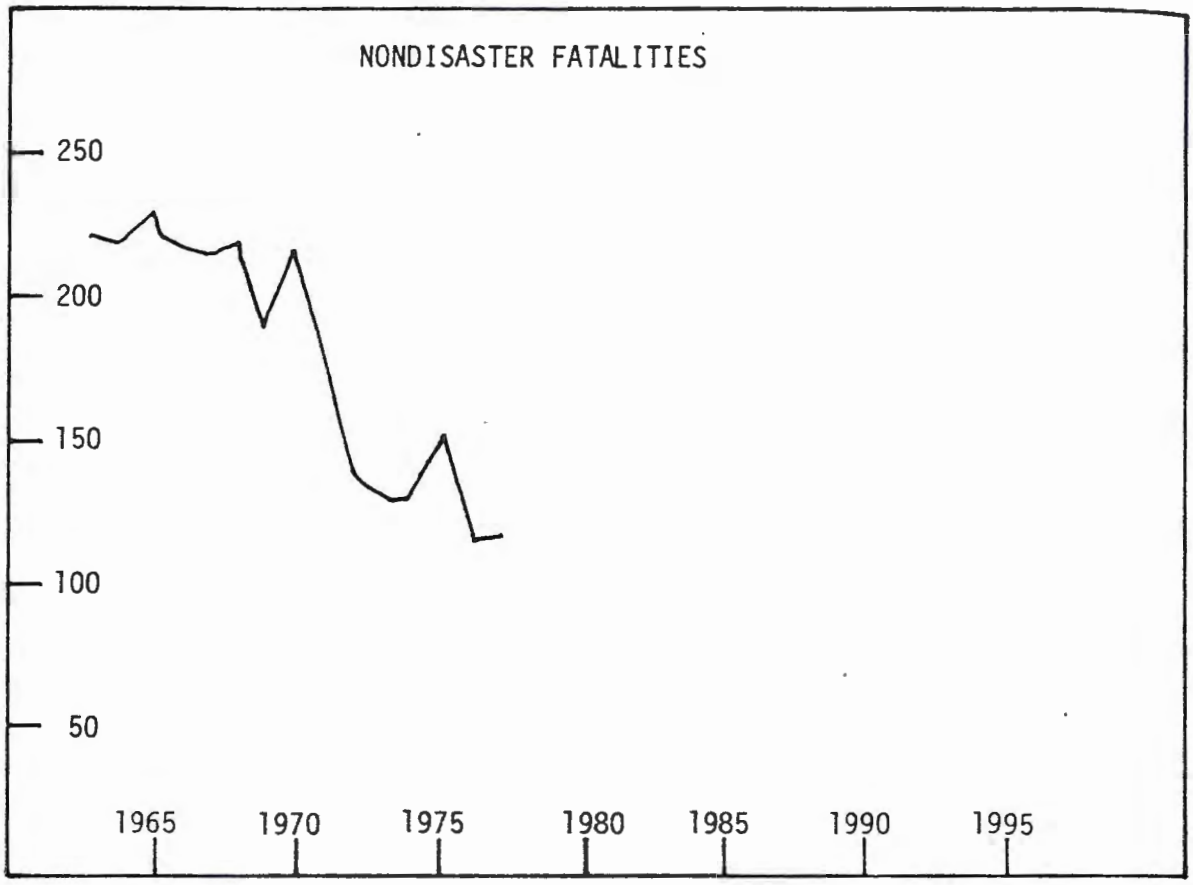
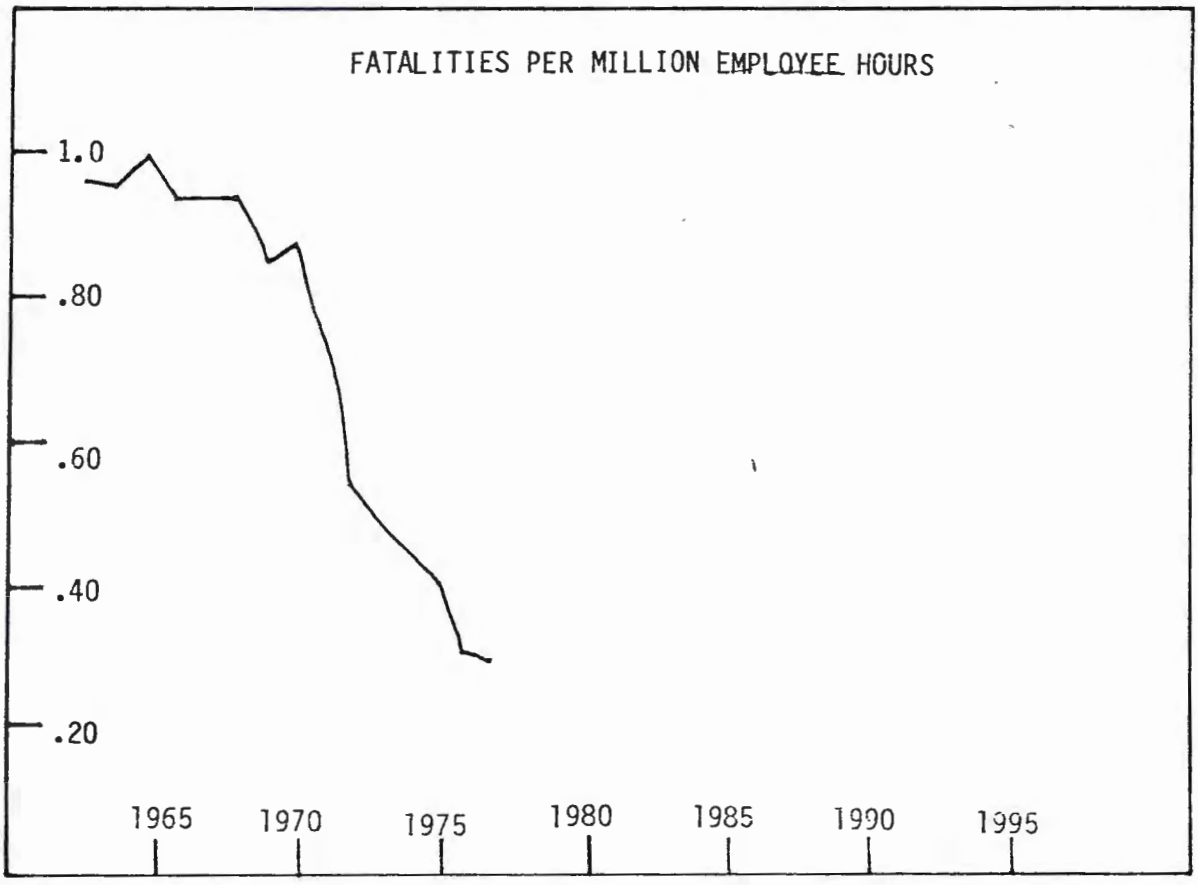
Table 1

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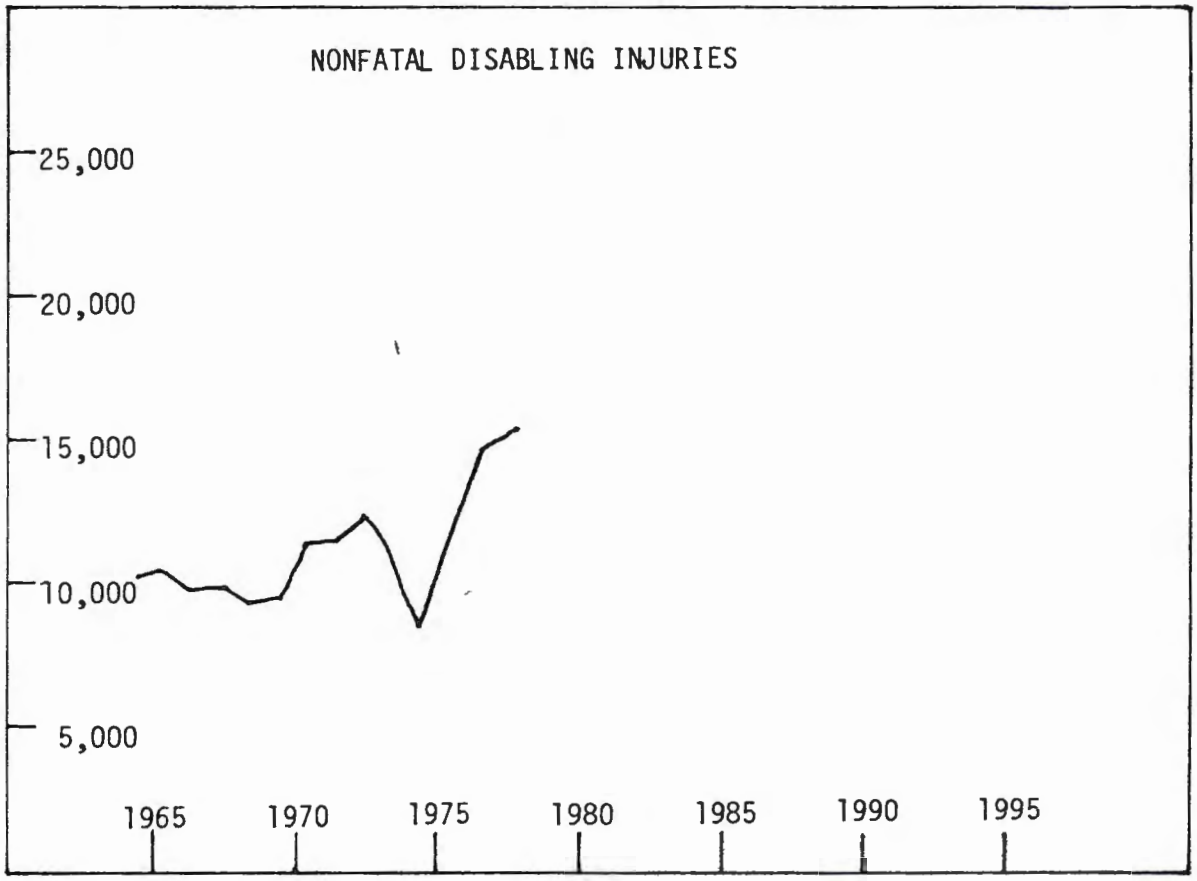


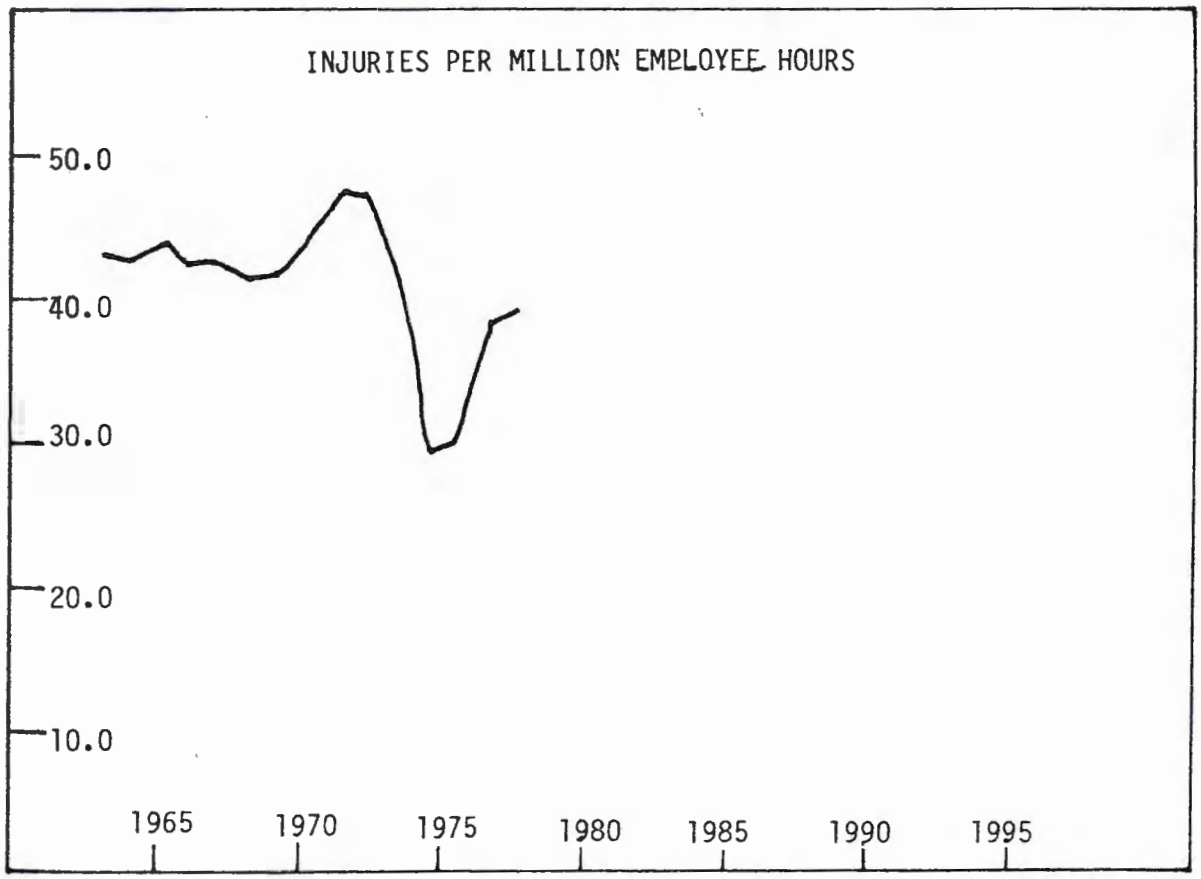


Table 4

that aggregate health and safety regulations are ineffective but that more emphasis may be needed on developing and maintaining proper work habits, and on engineering and technological advancements to improve the interface between the individual and the workplace (environment, machines, tools, etc.).

The Bureau of Mines Human Factors Research supports these hypotheses and addresses the broad categories of lost-time, disabling injuries through (1) ergonomic research, which seeks to develop permanent design improvements in work systems to prevent accidents, and (2) training research, in which current learning technology is applied to assist mine operators in the effective utilization of training resources.

The current program emphasizes training since this research element can be viewed as a short-term treatment for technology deficiencies in workplace and work system design.

## CONTRIBUTION OF ERGONOMICS

Ergonomics, or human engineering, is the study of man's relationship to his work. In practice, the main consideration is workplace design (machines, tools, tasks, procedures, etc.), taking into account human abilities and limitations. While it is true that people are highly adaptable and can modify their behavior patterns to accommodate most situations, ergonomics favors the concept that people should not be required to compensate for design deficiencies. Rather, human characteristics (anatomical, physiological, behavioral) should be a principal consideration in designing the work environment to assure a safe, healthful, and efficient operation.

The potential contribution of ergonomics to workplace design in mining is quite significant, although difficult to quantify. It has not been uncommon for accident analyses to show that at least 60% of all lost-time injuries are attributable to the "human element"; i.e., are due to the victim. In many cases, the causes of such accidents are classified as human error or unsafe acts. Although this conclusion may be correct, the optimum solution to the problem may be in providing a safer, more accident-proof working environment rather than in more training of the individual.

A principal hypothesis of ergonomics is that under critical, tense, and emergency conditions, human beings are most likely to react according to a "population stereotype"; that is, to react in the way that is most common to their given background of habits.

It may be assumed that many high-frequency, low-severity industrial-type accidents in coal mining (trips and falls, back sprains, etc.) are not unlike those occurring in other industries. The only discernible difference might be the relative frequency per exposure. From a human engineering and system safety standpoint, a reasonable explanation might be that, although the probability of human error for any given task may be the

same as in other industries, in mining there is a greater potential (higher risk per occurrence) for personal injury and/or property damage. This higher potential for injury can be intuitively associated with the unique demands of the work environment (large equipment and/or machines, confined and congested workplace, physical demands of the task, etc.).

Any work environment where human error frequently results in personal injury provides broad avenues for significant improvements in safety through human factors design of the workplace. A critical factor in making such designs effective is the ability to quantify the "human element" problem in real terms (detailed accident investigations), rather than relying on the myth that "human error" alone is responsible for most industrial accidents, as opposed to the design of equipment, machines, tools, and job procedures. Training can be used in many instances as a short-term solution to inefficient and poor work design but its high direct and indirect costs must be reckoned with along with its innate difficulty of assuring proper performance.

## ERGONOMICS RESEARCH

Ergonomic research currently conducted by the Bureau of Mines can be divided into three areas: (a) the miner, (b) machinery and equipment, and (c) the work environment.

### Miner

For the workplace and its equipment to be properly designed, considerable information is needed on the physical characteristics of the mining population and the physical demands of the various jobs.

A number of current studies are collecting relevant biomechanical, anthropometric, and work physiology data for various underground tasks. These data are being used to determine physical reach, work motion, energy expenditures, visibility, etc., and to develop information for possible task and workplace redesign.

It can be said that work is feasible because it is being done, but this assumes an extremely broad interpretation of feasibility. The ergonomic definition for adequate work is that job demands should closely match the skills and capabilities of the employee and not unduly expose personnel to health and safety risks.

### Machinery and Equipment

The ergonometric design of machines and equipment used in underground and surface mines represents a fertile area of research since accident investigations show machinery, materials handling, and equipment

to be a significant source of lost-time injuries. Based on human performance data, the objective here is to identify potential avenues for research expenditures in machine and work station redesign.

Current Bureau research is emphasizing the design of operator compartments of mining machinery used in thin coal seams since relatively little human engineering data and technology are available for man-machine combinations in confined or restrictive work space.

An additional activity entails the research support of the SAE Human Factors Working Group (Subcommittee 29) for the development of industry design guidelines for underground work stations. The end product will be a design manual utilizing available and developed human factors data for the design of underground mining equipment and machines.

This research area is an expansion of earlier research on the design of human engineered operator compartments for underground face equipment.

## Work Environment

A number of Bureau projects are seeking to improve the underground and surface work environment through noise and dust control, better illumination, etc. This area of ergonomics research is principally concerned with the study of organizational climate variables (morale, management policies, decision decentralization, etc.) so that safe employee performance can be enhanced.

This research area is an outgrowth of a study completed in 1976 assessing the impact of organizational climate and management policy on the safety profiles (accident frequencies) of underground coal mines. The results of this study strongly support the theory that climate and management practices have a direct effect on the incidence of disabling injuries. Current research applicable to coal, metal, and nonmetal mining involves assessing the feasibility of organizational development and supervisory training to introduce innovative methods that mine operators can use to solve problems related to the human element. Aspects to be considered relate to the organization and content of work to promote the general safety and well being of the mining work force.

In addition, an effort will be undertaken to assess the feasibility of improving the methods by which organizations deal with employees having severe performance problems. This employee assistance feasibility study will be a joint labor-management activity designed to effectively provide assistance to miners with personal problems adversely affecting their work performance.

## CONTRIBUTION OF EDUCATION AND TRAINING

The implementation of many permanent improvements in man-machine interaction through better ergonometric design of the workplace is a relatively long-term objective, and in any case such improvements cannot be expected to completely replace employee training needs. For any man-machine system, some training will be needed at some time (changing the individual to match the demands of the equipment). Especially critical are those tasks involving the acquisition of unique psycho-motor skills and a thorough understanding of the work to be performed. From a human factors standpoint, training should be regarded as a planned component in matching the person with the task, it should not be regarded as a substitute for proper workplace design.

Training research conducted by the Bureau of Mines is directed toward assisting MSHA and mine operators in deploying effective training programs for accident reduction and in complying with Federal and State regulations. Accomplishment of the broad objective requires emphasis on establishing valid training baselines and developing methods and media with which training programs can be evaluated and upgraded.

Bureau of Mines involvement in training research is based on the results of training program evaluations which, when coupled with accident analyses, have provided strong evidence that training can have a significant impact on current mine safety profiles, particularly in instances where aggregate data indicate job inexperience is a leading accident contributor.

Legislative emphasis for improved miner health and safety training has recently (October 1978) culminated in regulations (30 CFR, Part 48) mandating the health and safety training and annual retraining of the mining workforce. Although these regulations were promulgated irrespective of the product being mined, method of mining employed, or injury experience, the definition of broad training elements and methods to be employed for training plan approval provides flexibility in training content, instructional emphasis, methods of instruction, and evaluation criteria. This flexibility permits the Bureau to maintain a wide latitude in its efforts to assist mine operator compliance, including research to better organize and formalize the training process and investigation of the utility of current learning technology (simulation devices, training methods and media, etc.) for improving the quality, efficiency, and accident reduction potential of mine vocational and safety training.

## EDUCATION AND TRAINING RESEARCH

Training program evaluations have shown that programs effective in reducing accidents have certain common attributes:

(1) Development of accident and injury baselines to be addressed through training and the definition of training objectives.

(2) Tailoring or developing training materials addressing mine-specific conditions and accident and injury experience.

(3) Availability of competent instructors.

An underlying premise of the above criteria is that an organizational commitment to accident reduction has been made and the presence of these attributes is an outgrowth of that philosophy.

The primary short-term objective is to introduce a certain degree of organization and formalization into the training process, so that mine operators can expend their training resources in tailoring existing inventories of materials to fit their operational and safety needs, as opposed to the expensive and somewhat duplicative process of individual companies developing their own programs.

While informal, on-the-job training may have been the only viable approach in years gone by, it has not proven effective in recent years. Accident analyses indicating that job inexperience is a leading contributor to accidents are growing in number. While there may be better solutions to many of these "human error" accidents, in some instances training is the only investment one can make in the short-term to reduce the probability of recurrence.

Current training programs in various stages of development include -

(1) Shuttle car operator training

(2) Continuous-miner operator training

(3) Roof bolter operator training

(4) Haulage truck operator training

(5) Front-end loader operator training

(6) Pre-shift inspection procedures for principal surface mine equipment types

(7) Training for shaft-sinking personnel

(8) Mine electrician training

(9) Training in the use and care of explosives

(10) Trolley wireman training

(11) Hoist operator training

(12) Mine rescue team training

(13) Training for fighting small underground fires.

A final activity in the preparation of baseline materials involves cooperation with MSHA Education and Training personnel in developing instructional guides for new-miner and annual-refresher training for surface and underground coal. In addition to the instructional guides, another end product will be a training program documenting one set of procedures that mine operators could utilize in tailoring existing training materials to fit mine-specific conditions and injury frequencies.

These training methods and materials are regarded as a mechanism which the mining community may use in support of its compliance with Part 48, and/or as a mechanism for promoting safe employee performance, proficiency, and a reduction in maintenance costs.

An additional objective of Bureau research in education and training is the investigation and application of current learning technology to assist mine operators in effective utilization of training resources. In this regard, a number of equipment operator training projects (shuttle car, continuous miner, roof bolter, and haulage truck) have investigated the use of various types and levels of simulation and training devices (reaction trainer, dynamic concepts trainer, part task and/or procedures trainer, control familiarization trainer) for their possible application in providing more efficient, better, and broader training (simulation of emergency conditions) than could be provided under idealized on-the-job training conditions utilizing solely the actual equipment.

Stand-alone, microprocessor-based teaching machines (branching instruction) are also being considered as a means of reducing the time it takes individuals to fulfill the training objectives, while at the same time maintaining a high level of quality and consistency in the materials presented.

A final objective of education and training research is the periodic survey of regional manpower and training needs to collect data on regional fluctuations in the demand and supply of training, so that potential increases or decreases in the demand for training can be

identified. With this input the mining community (industry, academia, labor, government) can undertake joint efforts to alleviate projected shortages in necessary occupational skills.

## CONCLUSION

In examining reported nonfatal lost-time injuries over the preceding decade, it is obvious that there was a substantial increase in absolute numbers. Normalized data indicate that the annual risk of personal injury to the general coal mining population is only slightly less today than it was in the late 1960's. The growth in the absolute number of disabling injuries coincides with a marked growth in new hires due in part to increased coal demand, and also with a dramatic drop in productivity. The fact that a miner's annual risk of personal injury today is slightly less than it was 10 years ago is little consolation for the additional 3,000 to 5,000 lost-time injuries experienced annually in recent years.

The significant reduction of the individual risk of fatal injuries and the overall reduction in absolute fatals over the last decade, are principally the result of improvements in the physical environment or of protection provided to the worker that minimizes the impact of environmental disturbances. The fact that a similar trend was not evidenced over the same time period for industrial-type nonfatal injuries is cause for concern.

The application of human factors and training research is viewed as an important approach to future reduction of nonfatal injuries. The achievement and maintenance of downward trends in nonfatal injuries should follow the implementation of permanent design solutions, with training acting in a supporting capacity as a planned component of industry efforts to improve safety.

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