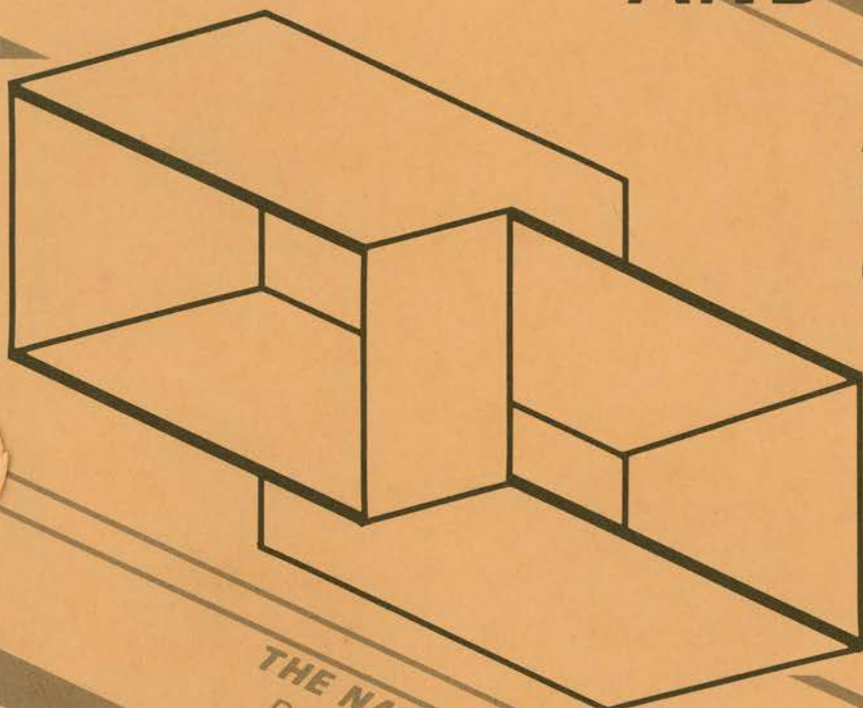
NIOSH

SYMPOSIUM ON OCCUPATIONAL SAFETY RESEARCH AND EDUCATION

A DIALOGUE BETWEEN TWO COMMUNITIES



THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
DIVISION OF SAFETY RESEARCH
DIVISION OF TRAINING AND MANPOWER DEVELOPMENT

PROCEEDINGS

SEPTEMBER 3-5, 1980 MORGANTOWN, WEST VIRGINIA

SYMPOSIUM ON OCCUPATIONAL SAFETY RESEARCH AND EDUCATION

A DIALOGUE BETWEEN TWO COMMUNITIES

PROCEEDINGS JANUARY 1981

Division of Safety Research

and

Division of Training and Manpower Development

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in research in a national effort to eliminate on-the-job hazards to the health and safety of America's working men and women. Under the Occupational Safety and Health Act of 1970, NIOSH is responsible for identifying occupational safety and health hazards and for determining methods to control them. NIOSH also provides for training to help alleviate the critical shortage of occupational safety and health manpower.

In view of these agency objectives, NIOSH seeks to use means to effectively disseminate information relative to such occupational research and provide forums for mutual exchange of accomplishments and needs among dedicated professionals in this field of endeavor. Accordingly, NIOSH is pleased to have sponsored a "Symposium on Occupational Safety Research and Education: A Dialogue Between Two Communities" held September 3-5, 1980, in Morgantown, West Virginia.

This Symposium is just one aspect of NIOSH's committment to an "initiative" in occupational safety. These proceedings of the conference consist of a compilation of the presentations which reflect important issues, research, and the current thinking of those in the field. Publication of the Symposium proceedings makes this information available to a wide spectrum of individuals involved in safety research and education efforts.

J. Donald Millar, M.D.
Director, National Institute for
Occupational Safety and Health

PREFACE

The Division of Safety Research and the Division of Training and Manpower Development of the National Institute for Occupational Safety and Health (NIOSH) have joined efforts in co-sponsoring the "Symposium on Occupational Safety Research and Education: A Dialogue Between Two Communities" held September 3-5, 1980, in Morgantown, West Virginia. As the symposium title implies, the main objective was to provide a common forum for exchange between the research and academic components of the safety discipline. With the additional contribution of labor and industry representatives, a fruitful dialogue ensued which emphasized the common needs of research, academic programs, and training communities. It is hoped that those lines of communication opened by this dialogue will continue with the ultimate benefit contributing to the safety of the American worker.

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WORKSHOP OBJECTIVES

- To bring educators and safety researchers together to establish better communication between the two,
- To exchange ideas about research activities and needed curriculum improvements through guided discussion and presentation of papers, and
- To articulate preliminary guidelines for instructional and research programs.

The Gerald F. Tonks Scholarship Award, presented by Gary Lia of Liberty Mutual Insurance Company, was established at the Symposium. The scholarship award will provide financial support to students pursuing safety careers at Northeastern University, Boston, Massachusetts.

WORKSHOP FACULTY

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Ralph J. Vernon, Ph.D.

CONTENTS

(Papers appear in the order presented at the symposium.)

INTRODUCTION iii

PREFACE v

WORKSHOP OBJECTIVES AND WORKSHOP FACULTY vi

OCCUPATIONAL SAFETY RESEARCH

LABOR NEEDS IN SAFETY RESEARCH 3
(John Molovich)

INJURY EPIDEMIOLOGY 7
(Jerry L. Pursewell, Ph.D., P.E.)

ACCIDENT–INJURY STUDY 13
(Richard G. Pearson, Ph.D.)

DESIGN SAFETY—AN OVERVIEW 19
(Ralph J. Vernon, Ph.D., P.E.)

MACHINE GUARDING 29
(P. H. Hodson)

MACHINE GUARDING SIMULATOR 37
(Stan Freeman)

MULTIPLE PURPOSE MACHINERY 39
(Ralph J. Vernon, Ph.D., P.E.)

A QUANTITATIVE APPROACH TO SAFETY ASSESSMENT OF THE WORKPLACE 51
(Paul C. Lu, Ph.D.)

HANDLES FOR SHARP TOOLS 67
(Michael W. Riley, Ph.D.)

ACCIDENTS AND SOCIOTECHNICAL SYSTEMS: PRINCIPLES FOR DESIGN 75
(Gordon H. Robinson)

CONTENTS (Continued)

ERGONOMICS IN OCCUPATIONAL SAFETY (Donald B. Chaffin, Ph.D.) 91

OCCUPATIONAL INJURIES AND WORKER CAPABILITIES (Robert Arndt, Ph.D.) 103

ERGONOMICS AT PUNCH PRESSES (Christer Bramberger) 113

STRENGTH TESTING/EMPLOYEE PLACEMENT ON PHYSICALLY STRENUOUS JOBS (W. Monroe Keyserling, Ph.D.) 123

STRESS-RELATED RISK FACTORS (Gavriel Salvendy, Ph.D.) 137

PERSONAL PROTECTIVE EQUIPMENT (Robert Litster) 149

STATUS OF EYE PROTECTIVE EQUIPMENT (Allan E. Sherr, Ph.D.) 161

BEHAVIORAL APPROACHES TO PERSONAL PROTECTIVE EQUIPMENT USAGE (Alex Cohen, Ph.D.) 177

USING ECONOMIC INCENTIVES TO IMPROVE OCCUPATIONAL SAFETY (Richard I. Bergmann) 187

KEYNOTE SPEECH: NEED FOR OCCUPATIONAL SAFETY RESEARCH AND EDUCATION (J. Donald Millar, M.D.) 201

OCCUPATIONAL SAFETY CURRICULA: NEW DIRECTIONS

EDUCATIONAL PROGRAM APPROACHES (Howard Ayer, C.S.P.) 217

SAFETY EDUCATION IN LABOR STUDIES PROGRAMS (Ellen Roznowski) 219

BUSINESS EMPHASIS IN SAFETY (Nestor Roos, Ph.D.) 223

CONTENTS (Continued)

PUBLIC HEALTH EMPHASIS IN SAFETY 227
(W. Monroe Keyserling, Ph.D.)

EDUCATIONAL PROGRAM APPROACHES—ENGINEERING 231
(Ralph J. Vernon, Ph.D., P.E.)

ERGONOMICS AS A BASIS FOR GRADUATE EDUCATION IN OCCUPATIONAL SAFETY: A MULTIDISCIPLINARY APPROACH INVOLVING ENGINEERING, PSYCHOLOGY, AND PUBLIC HEALTH 241
(Richard Pearson, Ph.D.)

OVERVIEW OF EDUCATIONAL APPROACHES—SUMMARY 245
(Howard Ayer, C.S.P.)

INDUSTRIAL INPUT FOR SAFETY AND HEALTH CURRICULUM 247
(Robert W. Allen, C.S.P.)

LABOR NEEDS IN SAFETY EDUCATION 251
(Ellen Roznowski)

THE NEED FOR UNIVERSITY AND UNION COOPERATION IN RESEARCH AND EDUCATION FOR CONSTRUCTION 255
(Jim E. Lapping)

ISSUES IN DEVELOPING UNIVERSITY LABOR-MANAGEMENT ACTIVITY ON OCCUPATIONAL SAFETY AND HEALTH 257
(Paul A. Weinstein, Ph.D.)

A POSITION PAPER: CORE PROGRAM REQUIREMENTS 263
(Robert E. McClay)

SUMMARY OF DISCUSSION FOLLOWING THE PRESENTATION 269
(Robert E. McClay)

SAFETY FACULTY REQUIREMENTS 273
(Clifton D. Crutchfield, Ph.D.)

FACULTY REQUIREMENTS: UNIVERSITY EXPECTATIONS 279
(Charles E. Billings)

CONSTRAINTS TO DEVELOPING CURRICULA AND ADMINISTERING PROGRAMS IN OCCUPATIONAL SAFETY 287
(Robert J. Firenze)

CONTENTS (Continued)

DIALOGUE: ACADEMIA AND RESEARCH

CONTINUING EDUCATION FOR PROFESSIONAL DEVELOPMENT (Herbert H. Jones) 297

MODEL FOR A NATIONAL SYSTEM FOR CONTINUING EDUCATION (Susan Mann M.A., R.N.) 303

PREREQUISITES FOR INCOMING STUDENTS: UNDERGRADUATE AND GRADUATE PROGRAMS (M. M. Ayoub, Ph.D., P.E.) 313

ADDENDUM: PREREQUISITES FOR INCOMING STUDENTS: UNDERGRADUATE AND GRADUATE PROGRAMS (Richard G. Pearson, Ph.D.) 317

THE EVALUATION OF EDUCATIONAL PROGRAMS IN OCCUPATIONAL SAFETY (Ronald D. Baker, Ph.D.) 321

SUMMARY OF THE REACTOR PANEL DISCUSSION (John V. Grimaldi, Ph.D.) 325

Comments by Earl H. Stockdale, Gulf Science and Technology Company 327

Comments by M. F. Biancardi, Board of Certified Safety Professionals 329

Reactor Panel: Audience Reactor Comments (Richard G. Pearson, Ph.D.) 331

EPILOGUE 333

APPENDICES

A. Agenda 343

B. Participant List 351

C. Post-Symposium Questionnaire 361

OCCUPATIONAL SAFETY RESEARCH

LABOR NEEDS IN SAFETY RESEARCH

John Molovich
United Steel Workers of America

On behalf of the United Steel Workers of America I would like to thank Dr. Robbins of NIOSH for inviting us to attend this seminar. We do have some problem areas to share. Over the next two days, I plan to talk to as many of you as possible on a one-on-one basis and relate some of our problems as we see them.

Just to give you a brief background. I've worked for the steel foundry in Pittsburgh for about 16 years. I worked for OSHA for about five and a half years in the Pittsburgh and Harrisburg offices, and I've been with the steel workers for approximately two years. The United Steel Workers have ten full-time safety and health people in our safety and health department; three are industrial hygienists. We have a fairly large staff in comparison to some of the other large industrial unions. Though our 1,400,000-strong membership in the United States and Canada is quite a few people, we manage to at least stem the tide of occupational safety and health problems that face us.

Years prior to the passage of the Occupational Safety and Health Act, the United Steel Workers lobbied for a safety and health law. Finally, in 1970, Congress passed a comprehensive safety and health law, because industry failed to enforce its own safety and health programs. It's true that most industries had such programs. I know the basic steel industry had one, but for years it gathered dust. Nobody understood what these programs meant or what they said. The information available to safety and health departments was not filtered down to the rank and file. It was not filtered down to the supervisors and line foremen who had to enforce the safety and health standards at the work site. For this reason the law was passed.

The chief problem with the law today, and we saw this 10 years ago, is that the only standards available to OSHA were National Consensus Standards, written by a consensus making body such as ANSI, NFPA, or the National Safety Council. These bodies are industry oriented. They always were and, in my opinion, always will be, although more recently we have been taking greater part in them. However, we will never have a majority vote on these committees, which pass standards on the basis of a simple majority. We have some real problems with that, because its been our experience that some of the standards that have been promulgated by OSHA or others were written solely to protect industries from third-party suits and from liabilities.

Furthermore, although these standards were minimum standards, they were written in blood. By that, I mean somebody had to die or be maimed or crippled to force a group to write a standard. Almost every OSHA, ANSI, or NFPA standard that is on the books was written in blood.

It is our opinion that this is the wrong way to write standards. Now, after hearing Dr. Robbins, I'm starting to believe that maybe NIOSH and OSHA finally feel the same way. I trust that now the Supreme Court will not require that a pile of bodies be produced before a standard is deemed needed or necessary. Because as I said, that's not the way to write a standard. For years, industries have had what are called job safety analyses. There is a job safety analysis on everything from a blast furnace operator to a janitor. They tell you exactly where the potential hazards are; what can be done to correct these hazards, and so forth. So this is not something that's brand new. These are things that have been present for years in the basic industries.

We need more research such as that indicated by the 1979 NIOSH Draft Document. We need more research in the basics. We have been looking for that pie in the sky for so long that we've lost sight of what the real problems are. We definitely don't need more statistics. Organized labor is up to here in statistics. We don't have to be told that X number of people died in the steel industry due to a carcinogen or due to a safety hazard. Or we don't have to be told that X number of people died in the foundries from silicosis or similar diseases. We don't have to be told, we're there! We have carried out the bodies. We have taken care of the sick. We have visited with the survivors of the deceased workers. We don't need to determine how many people are dying--we know that. We want to know why they are dying. We want to know **what** can be done to make it right.

There are some things that we'd like to see NIOSH do. We'd like to see them testing and certifying all safety equipment. It's our understanding that NIOSH does, in fact, certify respirators, but that's about it. We'd like to see them certify every piece of safety equipment used by industry workers. And there's a very good reason for this. We have in our possession a study showing that 30% of the safety glasses tested fail. And these glasses are "ANSI approved;" they passed the ANSI test. Why is that? Why do workers have to put life and limb on the line every time they put on a piece of safety equipment? Something's not quite right. That's why we'd like to see the government and NIOSH take over testing and certification of all safety equipment. Then we could be reasonably sure that the equipment being used will pass the test.

There is no substantial, in-depth research into machine guarding. Up to just five years ago, it was physically impossible to guard a press break. All the way down the line, industry said that it was impossible. Impossible, that is, until OSHA said, "Well, we're going to find some ways, and we're going to start citing these people, and we're going to make sure that you're going to make these work places safe." And OSHA did, in fact, start citing. And within one year there were some 12 companies on the market with safety devices for press breaks. So, we know it can be done. We know that this country can, in fact, produce the people and produce the safety guards to prevent injuries in the plant. We know it can be done. Historically, its been done for years. We think all that is needed is a little incentive. In our opinion, that incentive is OSHA. And, by the way, we are, and have been, and will continue to be, total supporters of the Occupational Safety and Health Administration.

For years, the hot metal industry (the basic steel industry of foundries) has known of the hazards associated with molten metal and water. Yet every year a dozen or more workers are killed as a result of explosions caused by the mixture of molten metal and water. There was a severe accident in the Chicago works. A steel foundry with five tons of molten steel was put into a pit containing water. The explosion that resulted killed five workers and totally leveled and destroyed the building that housed the furnace operation. Now that foundry knew fully well the significance and the problems associated with water and molten metal. But they took a chance. They took the chance, because what they didn't know, what they really didn't realize, was just how violent an explosion could be. What is wrong with NIOSH making comprehensive tests on the effects of molten metal and water? How much molten metal? How much water? We have evidence or indications from some researchers that as little as a gallon of water coming in contact with 2,000 pounds of molten metal will result in an explosion equivalent to about 1,100 pounds of black powder. Now I don't know how true that is; I don't know if its a low figure or if its a high figure. But this is what NIOSH should be actively studying as far as safety and research goes. As I said, the hazards associated with molten metal and water have been known for years. They were recognized in Egypt 5,000 years ago, where they entered into idol worship. Yet we don't have a standard on the books because of that knowledge. And every time OSHA comes in and makes an inspection and issues a citation in this area the companies take it to court and say its not a known, recognized hazard in our industry. We have a few answers for that, but I don't want to make them here with the ladies present.

Historically, workers have had little or no interest in the promulgation of standards. Since Dr. Bingham has taken the reigns of OSHA, she has turned the agency around somewhat from the early days. Lately, she has had somewhat more input into the promulgation of standards. We, too, have had more input into what we need and what we think should be done as far as the standards go. But, its not enough. I was fortunate enough last month to attend an International Metal Workers Federation meeting on a safety and health standard for the foundry and steel industries throughout the world. And I was surprised to find out that the Germans have a more comprehensive law than we've ever dreamed about. I believe Dr. Robbins touched on it briefly. They have what is called co-determination, where the trade unions take an active part in what and how the workplace is run. I was told by a safety director of one of the largest steel facilities that his job depends on how effective his relationship is with the trade unions. He cannot get a promotion, nor can he get a demotion, unless the authorization is cleared by the trade union that has representation in that plant. I was shocked to hear that. Now that's a heck of a crew to have. I know some supervisors, who, if their jobs depended on what the unions say, would tread a little bit lighter in their treatment of workers in the workplace.

The workers in this country—and I've travelled from California to Maine, and from New Mexico to Wisconsin, as well as visiting Canada—the workers in this country have been, and continue to be, disenchanted with the whole system. The OSHA Act was passed in 1970. It was to be the savior of the workplace. We expected great results—great things to come about. And, to a certain degree, great things have come about. But not enough, and not fast enough. You've got to understand that we've been fighting this battle for a hundred years in this country. Since the industrial revolution, since the Civil War, we've been fighting to try to make the workplace safer. We thought that with the passage of the OSHA act our job would be a little easier. In reality it isn't. We're fighting as hard or harder to provide safe and healthy workplaces, to the point where we're starting to put more emphasis on contract negotiations and contract language to protect our people. The last basic steel contract had a provision for carbon monoxide detection around the blast furnace. Hundreds of workers have been killed from carbon monoxide around blast furnaces. And the emphasis to spell it out in a contract only came after five or six workers died in Chicago. That was the emphasis needed to write carbon monoxide detection into the contract Germany has had that for 15 years.

I've said that the U.S. lost the war to Germany in 1970, and its true. Their industry is much more advanced, their trade unions are much stronger, they have more input into the laws, they have more input into the system. So, I've said that we've lost a war.

The second world war—we lost it in 1970.

I could go on, but I don't want to take up too much time on a very tight schedule. I just want to close by thanking NIOSH for inviting us. As I said, we have a fairly large safety and health staff (ten people), and we offer our assistance to anybody who would need it; NIOSH included. If needed, we can produce people, experts, in our opinion, from our industries to examine some problems and try to find solutions that would be beneficial to everybody.

Again, I'd like to thank Dr. Robbins and NIOSH.

INJURY EPIDEMIOLOGY

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Occupational Safety and Health Administration

INTRODUCTION

This Symposium is being held during what I believe to be historic times in the fields of occupational safety and health. There are several reasons I believe this to be true:

1. The recent Supreme Court decision on OSHA's benzene standard and its implications for future standards development.

2. The generally acknowledged failure of the NIOSH educational resource centers to produce the trained professionals and to provide the impetus to research needed in the area of occupational safety.

3. The anticipated Supreme Court ruling on the issue of cost-benefit analyses for occupational safety and health standards, expected when the Court decides the cotton dust case.

4. The widely publicized concern with government regulation on the one hand and the "reindustrialization" of America on the other hand.

Never before has there been such an urgent need to carefully examine the technical, legal, educational and policy issues related to occupational safety. In my view, the question of injury epidemiology is one of the most important concerns to be addressed if appropriate responses are to be made to these events, which will dramatically reshape the field of occupational safety over the next decade. The current status of occupational injury data is reviewed first, followed by a discussion of the application of injury epidemiology to occupational safety and an outline of a program for the future.

STATUS OF OCCUPATIONAL INJURY DATA

OSHA relies on several different data sources in developing standards. The major data sources are as follows:

1. Data derived from catastrophic accident and fatality investigations completed by compliance officers.

2. Data obtained by review of OSHA compliance officers, 5(a)(1) citations, which point to serious gaps in regulatory coverage.

3. Data developed from analysis of OSHA citations, which may point to hazards that are not being adequately addressed.

4. Data developed in conjunction with the Bureau of Labor Statistics from first reports of injury submitted by states cooperating with the BLS in the Supplemental Data System (SDS) program.

5. Data obtained through questionnaires jointly developed by OSHA and BLS that are completed by injured workers identified through state worker compensation systems. (WIR Studies)

6. Data developed by NIOSH, either with internal staff or contractor personnel.

We also may rely on data submitted by other government agencies, trade associations, labor unions, special public interest groups, consensus standards organizations, the National Safety Council, etc., when it is available. Data from these sources are sometimes useful in highlighting a problem, but are often not representative of the overall population at risk and/or sufficiently detailed for agency rulemaking needs. OSHA also has had some success in obtaining data developed in other countries which can be applied to U.S. industry.

The data which are currently available from the sources enumerated above are generally deficient in one or more of the following areas:

1. The population at risk is seldom known with any degree of certainty. Most often, there are insufficient data to determine how many workers are exposed to a given hazard for some proportion of their workday.

2. There are often only incomplete data for a given type of injury. We may know personal data, part of body injured and perhaps general information about the mechanism of injury. However, little is known about the specific workplace factors that contributed to the injury, since most data collection focuses on errors the worker may have committed.

3. The general concept of dose-response information is almost entirely undeveloped in safety as compared to health studies. We do not know what level of risk should be considered "significant" as defined by the Supreme Court decision in the benzene case. In general, we have taken the approach that a given hazard must be abated through the use of engineering controls that are expected to produce a total or almost complete elimination of the hazard. However, this approach will be unsatisfactory from a legal standpoint if we must relate each aspect of the controls to a demonstrated "significant" reduction in risk.

An example drawn from our current rulemaking related to falling injuries will illustrate some of the points stated above. As a general category of injury, those due to falling comprise 21 percent of all injuries. Further analysis of the injury data may permit a breakdown between injuries sustained in falls on the same elevation as compared to falls from heights, but little additional information is available about the conditions which produced the fall. If a Work Injury Report (WIR) survey is conducted, it can provide additional data differentiating certain types of falls, such as those from scaffolds, but current budgetary constraints limit OSHA-BLS to four (4) WIR surveys per year, so it is difficult to cover the major types of falling injuries in such detail. Even with data such as that obtained from the WIR scaffold study, some major questions remain unanswered. For instance, is the commonly used X-brace a satisfactory alternative to the use of a mid-rail on a scaffold? From an ergonomic viewpoint, it can be demonstrated that a midrail offers additional protection from falling, but what is the "dose-response" for these two counter-measures? Also, how can data be assembled to demonstrate a "significant risk" of falling for one system as compared to the other?

INJURY EPIDEMIOLOGY APPLICATION TO OCCUPATIONAL SAFETY

Dr. William Haddon has observed that progress was made in the area of transportation safety when the terminology in the field was changed to refer to traffic "accidents" as injuries produced by automobile collisions. Such a subtle change of reference might have an effect on occupational safety. We have focused our attention on "accidents" in the workplace, while the health professionals have focused on illness in the workplace. As a result, the general population tends to think of an "accident" as something which could happen to anyone, i.e., one of the consequences of the work task, while occupational illness is more likely to be linked with specific job exposures.

While there have been some limited attempts to study certain classes of injuries and to develop countermeasures, most efforts have instead focused on certain types of "accidents" and the development of remedies. For instance, BLS data indicate that approximately 2,000 amputations of various types occur each month in the workplace. Instead of studying the epidemiology of these injuries as a whole, previous efforts have focused on certain types of "accidents" where amputations may occur, such as punch press accidents. It would appear that studying amputations as a whole would accomplish two things: (1) public attention will be focused on this terrible toll in the workplace, rather than being divided into many types of "accidents" which each produce amputations, and (2) common variables in the workplace which produce these injuries will be more readily identified and countermeasures will be suggested which have broader application.

If we begin to view the overall problem of safety as one which concerns the prevention of traumatic injury in the workplace, then our attention will be directed to a more global set of concerns than has been true in our past efforts. For instance, we will be much more concerned with an overall understanding of the types and levels of physical forces which produce a given traumatic injury in the workplace. Our attention will then be directed to workplace and personal protective equipment designs which keep these forces below the injury threshold. It is unusual for such an approach to be followed in the area of occupational safety, although it has been followed for many years in the area of transportation safety. We must have a better understanding of the agent(s) of injury.

Using an injury epidemiology approach will provide a more balanced analysis of the relative contributions to the injury cycle of the work environment versus the worker. We focus on "accidents," a significant temptation exists to determine one or two "causes" of the "accident," rather than trying to understand a more complex set of variables which were involved in producing the traumatic injury. The worker is overwhelmingly listed as the "cause" of the "accident," even though this approach severly limits our options for interrupting the epidemiological injury cycle. Workers can be better trained and perhaps selected and motivated to work more safely, but the payoff in preventing injuries will be limited if the work environment is neglected as a major contributor to the injury cycle.

We have not treated the work environment as a contributor to the injury cycle because we have only begun to understand the many ways in which the worker is influenced by the interacts with his work environment. This field of study is called ergonomics, i.e., the study of laws (nomas) governing the design of work (ergo) systems. Future approaches to analyses of the work environment should focus more attention on ergonomic factors.

FUTURE PROGRAM FOR INJURY EPIDEMIOLOGY

Several areas of inquiry must be pursued in order to deal with the problems of data collection described earlier. These are highlighted in the following paragraphs.

The basic structure of information collected about "accidents" needs to be changed. As a minimum, the investigation needs to contain more information about the work environment, using some form of man-machine system model to structure the data collected. Most of the information currently collected focuses on the employee, with limited coverage of the type and severity of the injury sustained. Some form of coding, such as the system developed by the American Association for Automatic Medicine (AAAM), needs to be developed for occupational injuries.

Many questions remain unanswered about the availability and accuracy of information collected as a function of the following variables:

1. Time interval between the injury and the investigation,

2. Background of the investigator,

3. Training of the investigator,

4. Position of the investigator, i.e., OSHA compliance officer versus independent or employer investigators, and

5. Relative value of more structured versus less structured interactive modes of information collection.

OSHA and NIOSH are developing a research agenda to effectively answer these questions. The expected outcome of this overall research effort is a set of well developed, validated and teachable methodologies for collecting information.

At least three distinct levels of data collection can be anticipated, each with an established methodology. The first level can be considered the basic data set collected by employers to meet the requirements for reporting compensable injuries. The principal value of this information will be to target major types of injuries for further analysis. The second level of information will be developed by one or more of the following methods, once the target injury type has been identified:

1. OSHA compliance officers who have been trained to use the new methodology,

2. OSHA consultants who now provide services in all 50 states,

3. Special investigating teams under contract to OSHA.

The purpose of this data collection will be to develop a more complete description of the work environment, and the nature of the injury and the worker. Countermeasures may be suggested at this stage for some types of injuries.

A third level of data collection is expected for the types of injuries which do not yield to the level of investigation completed at step two. This type of investigation is to be conducted by a multidisciplinary team which will operate under contract to OSHA. The team would have a variety of experts available to deal with the engineering, medical, ergonomic and psychological aspects of the injury problem under investigation.

In summary, the investigation approach would begin with a large population of workers where the most important types of injuries would be identified. Special studies of these injuries using an epidemiology approach would yield countermeasures for some of the injury types under study. Those remaining would be studied more intensively using a multidisciplinary approach.

Major problems will exist in handling the information collected at each level of investigation unless careful consideration is given to data coding systems for storage and retrieval of information. OSHA and NIOSH will fund corollary studies of data handling systems so that an efficient system is developed.

ACCIDENT–INJURY STUDY

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INTRODUCTION

This paper can be divided into three major sections, starting with some comment on what I believe is a need for a conceptual model for safety research, to be followed by some critical comments on current approaches to accident–injury data analysis, then closing with some suggestions for an action program.

THE NEED FOR A CONCEPTUAL MODEL

It is not possible here to review and critique all of the existing models of and approaches to safety research. Suffice it to say that most of them have their limitations, and I find these inadequate, principally out of their failure to suggest where specific corrective actions should be directed.

The conceptual model which I do advocate is that of the systems approach, and I feel it is high time that we applied this approach to the problems of industrial safety. We should be familiar with the systems development concept and the kinds of criteria which apply in the evaluation of systems design. One of these criteria, of course involves safety considerations relative to the humans in the system. One feature of this approach is that, with regard to systems evaluation, we can talk about system errors––when things go wrong––rather than talking about human error or machine failure as has typically been the case. Another point that this approach emphasizes is that when functions are assigned initially (during the design stage) to man and machine, we can keep safety criteria in mind at this point. Then, with systems evaluation, we can close the loop, thereby providing data relevant to the question of whether the right job of systems design was done in the first place.

Thus, systems evaluation answers the questions of what functions were compromised and what ingredients of the system failed. In this approach, then, there should be no mystery about the contributing factors or causes of the accident. This approach avoids the problem inherent in many approaches, which seems to imply that there is but a single cause to each and every accident. Finally, the approach recognizes that there may be other kinds of errors apart from the design and human operator variety. For example, systems evaluation can provide feedback on the entire system. It is important to emphasize this point because there currently is so much emphasis on product (or equipment) design, yet we ought not to ignore the fact that many accidents and injuries do occur because of improper installation and maintenance. By now I hope you recognize that I regard the industrial plant as a man–machine system in my comments.

In sum, then, I think we have an adequate conceptual model available, and I think we ought to use it. Now let me turn to some critical comments on certain problem areas as related to the topic of accident–injury data analysis.

ACCIDENT–INJURY DATA ANALYSIS

In the process of accident–injury evaluation it is necessary to assume that reliable and valid data have emerged from the processes of investigation and of data coding by analysts. Such an assumption often cannot realistically be made. Furthermore, attempts to manipulate and statistically evaluate the data will not permit valid conclusions if the original accident reports are unreliable. But this is another topic which cannot be addressed here.

One of the major problems that I have come to recognize is that of getting beyond the data file stage. Indeed, I think we have a disease to deal with here—one that I have termed "filecabinetitis." What we may need is an "epidemiological" study of this record collection disease whose symptoms involve an individual who caresses and pats the file cabinets which contain masses of accident data, but who doesn't know what to do with it. Periodically he may be called upon to provide data to management, but again this exercise normally is of little utility to those who are concerned with safety problems. The proliferation of periodic reports based upon unimportant categories utilizing file data or computer outputs may be, in short, an industrial and governmental disease. Typically, such categories may include such terms as plant location, region of the country, time of day, month of year, regulations violated, etc. Each of these categories, of course, may have a unique meaning if the data are properly analyzed, but too often they have been arbitrarily contrived and the entire process boils down to a routine exercise in paper generation whose significance is nothing.

The next topic I want to mention deals with the need for intelligent correlations of available data. In running typical correlations, the limitations of judgment are that inherent in man should be taken into account; in brief, the psychophysics of the situation should be considered when categories of analysis are constituted. This has implications for the coding of the data in the first place, and, secondly, in the design of accident report forms and the precision of data that we require from accident investigators. Thus, if one can get by with simpler (less detailed), but more reliable information, let's do it that way. Another point is that data should be scaled, or coded, along meaningful dimensions. And, this ought to be done in a manner that keeps in mind the ultimate goal—that of dealing effectively with safety problems.

Next I would call for a greater consideration of multivariate analyses including multiple regressions approaches and factor analysis. This implies that more highly sophisticated analysts will be needed in safety research programs, but this is what I think is needed. This point recognizes the fact that accidents are a complex phenomena, and that typically a multiplicity of factors are involved in energy transfer and injury causation.

The end result of all these considerations, then, can be a valid and reliable assessment of the major sources of system error. With knowledge of these sources, our resources can then be applied where it counts through the feedback loop of the system approach.

Let me now move on to the final portion of this paper, which deals with some of the more specific rules of the game for the operation of this kind of program.

AN ACTION PROGRAM

Among the major points I will make, you will note reference to problems involving the type of data collected. My point here is that an integrated attack involving different types of data is recommended for the intelligent solution of safety problems. Focusing upon one type of data (i.e., using a narrow approach) may produce results having limited potential for generalization to total system performance effectiveness.

My first point is that greater attention needs to be given to questions of experimental control and statistical sophistication. Many of the studies found in the literature (if you look at them carefully) are characterized by uncontrolled observations, simple summary statistics, and circular reasoning. As a result, the effect has been to perpetuate a body of folklore such as identified with the common phrase "speed kills." Accordingly, there is a need to go beyond the routine use of descriptive statistics involving meager data to studies of mass data using more complex statistical analyses as advocated previously. An example is the "NEISS" system of the U.S. Consumer Product Safety Commission. Why doesn't a similar system exist for U.S. industry?

My second point is that more attention should be given to the importance of incident and near accident data. One of the advantages of incident data, of course, is that we can collect much more information (in contrast to accident data) to gain insight into hazardous situations where we can anticipate accidents will occur—this, in turn, suggesting where corrective actions can be taken. While the incident approach has been applied most commonly in transportation and military research, I think its application to industry has been neglected and could be a promising one.

In the same vein, my third point is that the importance of "non-injury" accident data should not be discounted. Quite commonly, accidents in which injuries would be expected to occur, but do not, are of critical value in pointing out ways in which injuries can be prevented. Again, more studies are needed here, especially in industry.

My fourth point is that we ought to encourage the collection of minor accident and injury data within industry. While elaboration is not possible here, let me suggest that both the punitive attitudes of some companies, and the use of so-called safety contests by others, have the potential of suppressing the report of minor accidents and injuries which should be brought to the attention of safety specialists as an additional input to the systems evaluation process.

My fifth point is that much knowledge can be gained from analysis of what I have termed the "biomechanical interface." What I mean by this is the traumatic interaction involving energy exchange which occurs when material structures and human structures come into violent contact with one another. By studying this interface carefully, a two-way interaction is identified which tells something about the relative physical properties of each structure. Thus, by studying a given structure one can learn not only something about the magnitude of the forces needed to deform it, but also something about designing, modifying, or protecting the structure so as to take into account the laws of energy transfer and human survival.

My sixth point is to argue for a crusade against lethal aspects of the work environment. One of the useful aids in studying the lethal aspects of our environment is what I call an accident-injury correlation matrix. This involves a listing on one axis of major segments and critical areas of the body (such as skull, eyes, chest, spine, hands, etc.) and, on the other axis, of types of injuries (for example—lacerations, fractures, sprains, puncture wounds, thermal burns, electrical shock, etc.). The number of categories on each axis should be tailored to the organization in terms of the amount of detail desired and the types of injuries commonly encountered. For example, in some situations one might want to look at specific aspects of the extremities (i.e., fingers, hands, forearm) or details of the face (eyes and ears, etc.). The idea behind use of this matrix is to identify specific causes of the type of injury to a particular body area. These "causes" are identified by number in a particular cell of the matrix. A large industrial organization, working at the macro level, might use categories which include various types of equipment and materials found at different work places, in various working environments, and in specific tasks. For example, the number 15 might be assigned to "forklift truck;" this number then can be identified as the cause of specific injuries in a given accident case. This type of data would be accumulated case by case for a given industrial plant; the cumulative data would yield an idea of the magnitude of the company's problems. That is, if a large number of the same type of causes show up time and time again in some of the more serious injury categories, then one knows where to devote attention in the most optimal fashion. On the other hand, if a specific type of accident is of major concern, this same matrix can be used on a micro level. For example, one might use several different numbered categories to describe various portions of the forklift truck as these relate to injuries of operators.

My seventh point is that system error evaluations (i.e., accident data) should be related to performance appraisals of the worker. What I am arguing for here is that in the systems approach, involving as it does function allocation, task analysis, and skill analysis, we should ultimately have some idea of what type of performance is required by the operator, especially as regards safety-related behaviors. Thus, if systems effectiveness is to be evaluated intelligently, it seems most logical to appraise performance on those dimensions of behavior which have been specified in the first place, and then use the results to effect improvements in the system. In short, the performance requirements of the job become the rating scale for its evaluation once the system is put into operation. Thus, there should be no mystery as to what should be evaluated with regard to human performance, and the use of other kinds of rating scales would seem to be a waste of time. It seems self-evident to me that the potential for an accident exists most highly in those areas of job performance in which an appraisal indicates that the worker falls short of desired standards.

In the same light, my eighth point involves the need to reject what I would identify as "mystery causes" found in accident data; here I include such common data categories as human error, fatigue, and stress. Are not these the categorizations which are proposed so often when the cause of the accident is obscure?

My final, and perhaps most important, point takes us back to where we started, i.e., with the accident itself. Nationwide we need a new approach to the design of an accident-injury report form to replace those approaches which are associated with NASI Z-16 and the National Safety Council. These latter are clearly inadequate in terms of dealing with such issues as multiple injuries (i.e., multiple types and body areas), multiple causes of death, and pre-existing disease which can be the cause of an accident (and possibly death itself). My concern here is so strong that, indeed, a separate paper would be needed for elaboration.

CONCLUDING REMARKS

In conclusion, I would like to emphasize that an approach that deals effectively with the safety, accident, and injury problem does exist. It is inherent in the systems philosophy involving evaluation of accident data, and the feedback of resulting knowledge for the improvement of system effectiveness. The approach or conceptual model is there. What is needed next is to provide a generation of safety researchers who can apply it with sophistication for the benefit of mankind.

DESIGN SAFETY – AN OVERVIEW

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Those attending the Symposium on Occupational Safety Research and Education will all agree on the need for research in occupational safety. Initially, however, I suspect there would be minimal agreement as to the form or direction the research should take. Some of us would insist that epidemiology is essential and, indeed, it may be the precursor to other research in that good epidemiology identifies problems with some precision. Others will hold an opinion that ergonomics is the answer in that man is most often the victim in an incident that occurs and, indeed, the science of work is an important factor in the prevention of occupational trauma. While we recognize that personal protective equipment does not prevent accidents, at the same time we recognize that personal protective equipment is often essential in injury reduction. Then, of course, there are those present who will believe that "design safety," i.e., design of the man-machine-environmental system so that unplanned interruptions to planned activities are reduced to an acceptable minimum, is of paramount importance. Hopefully, there are those present who will believe that aspects of all of these concepts are appropriate if undesired incidents are to be reduced and selectively eliminated from the workplace, including those that result in traumatic injuries.

It is interesting to note that evidence suggests a trend in social science research which indicates that improper design is a significant contributor to traumatic injuries in the workplace and that proper design has the most to offer in the reduction of these injuries. This is a wholesome trend and suggests a realization of true cause-effect relationships in the reduction of occupational injuries. The research of Dr. Donald A. Norman, professor of psychology at the University of California in

San Diego, indicates the system is most often at fault in industrial, nuclear, and aircraft accidents. He continues to say that today's systems seem, sometimes, to be designed to cause the very errors they should be established to prevent. He poses a question; "Instead of forcing people to act like machines for the benefit of machines, why not make it the other way around?"

The National Institute of Industrial Psychology (NIIP) in London, England, recently published the results of some interesting research. Their publication, 2000 Accidents — A Shop Floor Study of Their Causes, reveals the results of a study of 2,367 work accidents in four workshops and was directed toward identifying important causation factors and determining "the way in which what is already known can usefully be applied to the prevention of accidents in the industrial situation". Mr. Powell and his colleagues provided these summary statements about design safety:

(1) There is evidence to support the view that accidents are built into most industrial work and that changes in the design of the work will bring about a significant improvement in the accident rate.

(2) A wider use of ergonomic systems design is needed in the design of systems of work in order to eliminate built-in accident factors.

Since many of those present in this Symposium are researchers, the NIIP research document reported some findings pertaining to the subject of accident prevention research. While the study suggests multiple causation factors in accidents, "...many factors known to have an effect in the laboratory-type situation were barely perceptible in the four workshops." The statistical significance of the data summarized in the study is reported to be $< .05$.

While the multiple nature of accidents is accepted, it is interesting to review reported research to determine its real-world value in preventing accidents. Much of the research seems to be peripheral to the cause-effect relationships and, as the National Institute of Industrial Psychology study suggested, the real value of the research may be barely perceptible when related to the workplace. This has been a concern of many researchers who are pragmatically as well as theoretically inclined—those who may be characterized as believing that research has limited shelf-life value.

The Bureau of Labor Statistics, U.S. Department of Labor, contracted with the State of New York to complete a study on the characteristics and costs of work injuries and illnesses in the State of New York for a five year period, 1966–1970. Results of the study were made available in 1976. While some individuals may argue that the study is outdated, it is suggested that there is limited evidence to indicate that the basic data has changed significantly except that the costs related to the work injuries and illnesses have increased. Some of the New York data should provide some insight into the direction of research, i.e., into prioritizing research needs. One method of selecting priority is to look at the agent or agency of the accident, i.e., the object, substance, or part that contributed to the accidental occurrence. This was accomplished in the New York study and is the base for the data in Table I.

With the exception of the "Other Miscellaneous Objects" agency category, there is an indication that the working surfaces, vehicles, and machines agencies are important. They represent 45.0 percent of the total number of compensated injuries, 48.3 percent of the direct costs and have an average direct cost of $2,058 per injury.

Further analysis of the working surfaces data reveals that 74.0 percent of the injuries within the agency were associated with floors—inside surfaces (37.6 percent), outside surfaces (19.3 percent), stairs, (13.8 percent), and scaffolds (3.4 percent). These four sub-categories accounted for 68.1 percent of the direct costs within the working surface agency.

When the vehicle agency data is considered, 58.7 percent of the injuries and 63.5 percent of the direct costs within the category were represented by over-the-road type vehicles (automobile, taxi, truck, ambulance, motorcycle).

In the machine agency, metalworking power presses and woodworking saws are the major contributors to both injuries and direct costs of injuries; 28.2 percent of the machine-related injuries occur with power press and saws combined and these injuries constitute 19.1 percent of the direct costs of machine-related injuries.

To conclude these introductory remarks to "design safety", we wish to suggest that the term "design" does not indicate the design of hardware or machines or facilities or buildings only. To be sure, ventilation systems should be designed to meet performance objectives. Accident investigation systems are, or should be, designed to meet objectives. Operating procedures for blanking fluid lines, for entering enclosed spaces, or for locking out energy systems should be designed. While there is a critical need for hardware-related design safety concepts at the inception of a product or a process, there is an equally critical need for safety personnel with design capability and credentials to be equally involved in the planning of designs for the operation and maintenance of production systems including the man-machine-environmental subsystems and the components thereof.

Thank you very much.

Table 1
COMPENSATED WORK INJURIES
BY MAJOR AGENCY OF ACCIDENT AND TYPE OF ACCIDENT
New York State, 1966–1970, All Industries

MAJOR AGENCY OF ACCIDENT	TOTAL ALL CASES		TYPE OF ACCIDENT									
	NUMBER	PERCENT	STRUCK AGAINST AN OBJECT	STRUCK BY AN OBJECT	CAUGHT IN, BY OR BETWEEN	FALL ON SAME LEVEL	FALL TO DIFFERENT LEVEL	SLIP (NOT FALL) OR OVEREXERTION (HANDLING)	EXPOSURE TO TEMPERATURE EXTREMES	INHALATION, ABSORPTION, INGESTION	CONTINUAL OCCUPATIONAL ACTIVITY	OTHER
	A. NUMBER OF CASES											
TOTAL: ALL CASES	595,019	100.0	6.7	24.3	11.7	10.8	9.0	26.7	2.9	1.9	0.5	3.3
MACHINES: TOTAL	70,754	100.0	5.8	14.0	69.3	0.2	1.0	7.0	2.5	----	0.3	(A)
METALWORKING MACHINES	22,538	100.0	5.6	18.1	68.8	0.1	0.2	4.5	2.4	----	0.2	----
WOODWORKING MACHINES	5,914	100.0	1.9	14.7	81.8	(A)	----	1.4	0.1	----	(A)	----
TEXTILE MACHINES	5,864	100.0	5.7	6.8	80.4	0.1	0.2	5.4	0.8	----	0.6	----
LEATHER, FUR WORKING	1,801	100.0	4.1	4.3	84.9	0.1	----	4.2	1.9	----	0.4	----
PAPER PRODUCTS MACHINES	3,457	100.0	6.9	6.7	82.0	0.2	0.4	2.7	0.9	----	0.2	----
PRINTING AND ALLIED	3,132	100.0	8.3	4.6	81.5	(A)	1.0	3.5	1.1	----	0.1	----
CHEMICAL GOODS MACHINES	585	100.0	9.2	11.5	70.6	0.2	0.3	5.8	2.4	----	----	----
FOOD, TOBACCO PRODUCTS	7,631	100.0	3.9	3.4	89.9	0.1	0.1	2.1	0.5	----	(A)	----
STONE, CLAY, GLASS	987	100.0	6.4	18.9	62.5	0.2	1.6	7.9	2.4	----	----	----
RUBBER AND COMPOSITION GOODS MACHINES	3,232	100.0	3.8	7.5	79.2	(A)	0.2	2.1	6.6	----	0.2	----
PACKAGING, WRAPPING MACHINES	1,548	100.0	6.3	9.4	76.7	0.1	0.5	3.2	1.6	----	0.2	----
LAUNDRY, DRY CLEANING	2,146	100.0	7.9	12.1	32.1	0.6	0.2	15.7	30.6	----	0.9	----
FARM, GARDEN MACHINES	1,744	100.0	3.9	25.7	51.0	0.6	2.6	15.9	0.1	----	----	----
CONSTRUCTION MACHINES	2,296	100.0	9.5	37.2	20.6	0.7	18.0	13.3	0.5	----	0.1	[illegible]
MINING, OIL, ORE REFINING MACHINES	93	100.0	4.3	39.8	34.4	1.1	6.5	14.0	----	----	----	----
OFFICE MACHINES	1,714	100.0	10.1	14.2	35.9	0.2	----	37.0	0.1	----	2.5	----
HOUSEHOLD MACHINES	804	100.0	6.8	31.5	11.2	2.5	0.4	47.1	0.2	----	0.2	----
MISCELLANEOUS MACHINES	3,177	100.0	9.8	23.4	45.3	0.4	0.9	18.7	1.3	----	0.3	----
OTHER MACHINES	2,091	100.0	9.1	16.0	55.5	0.4	1.3	16.7	0.6	----	0.2	----
PRIME MOVERS AND POWER TRANSMISSION: TOTAL	3,595	100.0	5.5	26.5	40.8	0.5	0.3	25.8	0.6	----	(A)	----
MOTORS-NOT VEHICULAR OR TOOL	822	100.0	3.8	31.4	17.3	0.1	0.5	45.3	1.7	----	----	----
PUMPS	600	100.0	6.7	27.2	23.7	0.2	0.3	41.2	0.6	----	----	----
AIR COMPRESSORS	473	100.0	5.5	36.5	26.6	0.4	0.4	26.1	0.2	----	----	----
FANS, BLOWERS	910	100.0	6.9	19.5	65.3	0.2	0.1	8.0	----	----	----	----
SHAFTS	43	100.0	11.6	30.2	51.2	----	----	7.0	----	----	----	----
BELTS, BELT SHIFTERS	194	100.0	4.1	6.7	84.5	----	0.5	4.1	----	----	----	----
OTHER POWER TRANSMISSION	490	100.0	4.5	27.8	48.0	2.2	0.2	17.1	----	----	0.2	----
OTHER PARTS	62	100.0	6.5	17.7	62.9	----	----	12.9	----	----	----	----
NOT INDICATED	1	100.0	----	----	100.0	----	----	----	----	----	----	----

CONTINUED
A. LESS THAN 0.05 PERCENT.

Table 1 (continued)

COMPENSATED WORK INJURIES

BY MAJOR AGENCY OF ACCIDENT AND TYPE OF ACCIDENT

New York State, 1966–1970, All Industries

MAJOR AGENCY OF ACCIDENT	TOTAL ALL CASES NUMBER	TOTAL ALL CASES PERCENT	TYPE OF ACCIDENT: STRUCK AGAINST AN OBJECT	STRUCK BY AN OBJECT	CAUGHT IN, BY, ON BETWEEN	FALL ON SAME LEVEL	FALL TO DIFFERENT LEVEL	SLIP (NOT FALL) OR OVEREXERTION (HANDLING)	EXPOSURE TO TEMPERATURE EXTREMES	INHALATION, ABSORPTION, INGESTION	CONTINUAL OCCUPATIONAL ACTIVITY	OTHER
				A. NUMBER OF CASES								
ELEVATORS, HOISTS AND CONVEYORS: TOTAL	13,293	100.0	8.8	39.8	28.7	3.7	7.2	9.6	(A)	----	0.1	2.1
PASSENGER ELEVATORS	2,681	100.0	5.9	19.3	29.2	13.3	13.1	11.4	----	----	0.2	7.6
FREIGHT ELEVATORS	1,099	100.0	6.7	27.8	34.3	6.1	7.9	10.4	----	----	0.4	6.4
CRANES	3,275	100.0	5.4	59.7	16.5	0.8	8.7	8.7	(A)	----	0.1	0.2
SHOVELS, DERRICKS, DREDGES	195	100.0	12.8	53.3	11.3	0.5	10.8	11.3	----	----	----	----
ALL OTHER HOISTING	2,003	100.0	4.6	58.3	17.5	1.3	2.7	15.5	----	----	(A)	----
CABLE OPERATED CONVEYORS	174	100.0	5.2	53.4	28.2	0.6	3.4	9.2	----	----	----	----
CONVEYORS ON RAILS	635	100.0	15.9	70.2	7.9	0.2	0.8	4.9	----	----	----	0.2
ALL OTHER TYPES OF KNOWN CONVEYORS	3,231	100.0	16.4	21.5	50.7	0.6	4.6	6.0	0.1	----	(A)	(A)
VEHICLES: TOTAL	76,426	100.0	8.9	26.9	7.5	2.0	14.1	20.1	0.7	----	0.1	19.8
MOTOR VEHICLE-MOVING	31,680	100.0	3.0	24.6	2.1	0.4	5.3	17.4	0.2	----	0.1	46.9
MOTOR VEHICLE-NOT MOVING	23,128	100.0	14.9	15.5	13.2	2.5	34.4	17.4	2.0	----	(A)	0.1
HAND, FOOT OPERATED VEH.	19,167	100.0	10.9	45.7	9.2	2.7	3.3	28.0	(A)	----	0.1	(A)
ANIMAL DRAWN VEHICLES	94	100.0	5.3	19.1	5.3	----	54.3	6.4	----	----	----	9.5
RAILWAY VEHICLES	1,141	100.0	12.5	20.2	10.9	10.1	23.1	19.0	0.3	----	0.6	3.3
WATER	270	100.0	13.0	12.2	5.9	19.3	13.7	31.1	----	----	----	4.8
AIRCRAFT	743	100.0	19.9	12.8	7.5	12.8	12.2	10.8	1.1	----	0.4	22.5
OTHER VEHICLES	203	100.0	8.4	37.4	14.8	3.4	15.8	16.3	----	----	----	3.9
CHEMICALS, ELECTRICITY AND BOILERS: TOTAL	25,587	100.0	----	2.3	----	0.3	0.2	----	51.0	45.0	----	1.3
BOILERS, PRESSURE VESSELS	740	100.0	----	37.0	----	2.2	1.8	----	57.7	----	----	1.4
ELECTRICITY	1,178	100.0	----	0.1	----	3.9	2.4	----	67.8	----	----	25.8
EXPLOSIVES	789	100.0	----	38.1	----	2.7	1.0	----	57.4	----	----	0.8
CHEMICALS: LIQUID, SOLID	7,870	100.0	----	----	----	----	----	----	----	100.0	----	----
CHEMICALS: GASES, FUMES	1,256	100.0	----	----	----	----	----	----	----	100.0	----	----
HIGHLY INFLAMMABLE SUBSTANCES	11,378	100.0	----	----	----	----	----	----	100.0	----	----	----
DUSTS	805	100.0	----	----	----	----	----	----	----	100.0	----	----
RADIATION	53	100.0	----	----	----	----	----	----	----	100.0	----	----
PARASITES	1,518	100.0	----	----	----	----	----	----	----	100.0	----	----

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A. LESS THAN 0.05 PERCENT.

Table 1 (continued)
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BY MAJOR AGENCY OF ACCIDENT AND TYPE OF ACCIDENT
New York State, 1966–1970, All Industries

MAJOR AGENCY OF ACCIDENT	TOTAL ALL CASES NUMBER	TOTAL ALL CASES PERCENT	TYPE OF ACCIDENT: STRUCK AGAINST AN OBJECT	STRUCK BY AN OBJECT	CAUGHT IN, BY OR BETWEEN	FALL ON SAME LEVEL	FALL TO DIFFERENT LEVEL	SLIP (NOT FALL) OR OVER-EXERTION (HANDLING)	EXPOSURE TO TEMPERATURE EXTREMES	INHALATION, ABSORPTION, INGESTION	CONTINUAL OCCUPATIONAL ACTIVITY	OTHER
			A. NUMBER OF CASES									
HAND TOOLS: TOTAL	39,839	100.0	6.7	65.2	3.1	1.6	0.4	19.1	2.9	----	0.8	0.2
STRIKING, SHOCK TOOLS	5,861	100.0	2.2	84.6	0.8	0.3	0.1	11.2	0.2	----	0.3	0.2
CUTTING TOOLS	8,556	100.0	4.9	90.6	0.7	0.1	(A)	2.9	----	----	0.7	0.1
TWISTING, GRASPING TOOLS	6,417	100.0	15.7	52.1	4.5	4.4	0.7	21.5	0.1	----	0.8	0.1
LIFTING, PRYING TOOLS	3,725	100.0	4.6	64.8	5.3	3.6	1.0	20.4	0.1	----	0.2	(A)
MISCELLANEOUS TOOLS	5,815	100.0	9.0	36.9	1.8	2.1	0.6	46.2	0.9	----	2.0	0.6
MECHANICAL, ELECTRICAL POWERED TOOLS	9,465	100.0	4.5	56.3	5.7	0.9	0.5	19.8	11.5	----	0.7	0.1
WORKING SURFACES: TOTAL	120,682	100.0	3.8	----	----	47.8	33.3	15.1	----	----	----	----
GENERAL	527	100.0	3.0	----	----	9.1	78.7	9.1	----	----	----	----
FLOOR-INSIDE SURFACE	45,366	100.0	4.7	----	----	78.9	1.8	14.6	----	----	----	----
OUTSIDE SURFACE	23,345	100.0	2.7	----	----	69.4	5.0	22.8	----	----	----	----
STAIRS	16,608	100.0	3.8	----	----	11.2	69.6	15.5	----	----	----	----
SCAFFOLDS, STAGINGS	4,111	100.0	2.3	----	----	1.5	91.1	5.0	----	----	----	----
PLATFORMS, RAMPS	4,449	100.0	4.5	----	----	15.7	66.4	13.4	----	----	----	----
ROOFS	1,013	100.0	2.1	----	----	12.3	60.1	5.5	----	----	----	----
FIXED OBJECTS	7,635	100.0	4.2	----	----	35.7	44.7	15.4	----	----	----	----
PORTABLE OBJECTS	17,628	100.0	3.4	----	----	0.8	86.6	9.2	----	----	----	----
MISCELLANEOUS OBJECTS: TOTAL	208,133	100.0	15.2	34.4	4.1	0.7	0.1	44.7	(A)	----	0.7	0.2
CONTAINERS, PACKAGES	68,425	100.0	5.1	24.1	2.6	0.8	0.1	66.7	----	----	0.7	(A)
FURNITURE (NOT WORK SURFACES)	17,733	100.0	25.5	26.0	6.3	0.8	0.1	41.0	----	----	0.2	(A)
FIXED BUILDING	13,216	100.0	35.3	39.7	14.5	0.6	0.4	9.4	----	----	0.1	(A)
METAL STOCK AND PARTS	49,651	100.0	19.6	42.7	4.3	0.4	0.1	32.6	(A)	----	0.3	(A)
WOOD STOCK AND PARTS	11,538	100.0	14.1	50.8	2.7	0.7	0.4	31.1	----	----	0.2	----
STONE, CLAY AND GLASS STOCK	12,016	100.0	25.8	52.3	1.6	0.2	0.1	19.6	----	----	0.2	0.2
OTHER STOCK AND PARTS	7,300	100.0	12.7	16.9	0.7	1.2	0.1	66.8	----	----	1.4	0.1
GENERAL AIDS TO WORK	28,254	100.0	12.4	37.9	3.6	0.7	0.1	41.9	----	----	2.1	1.2
ANIMALS, PERSONS AND ALL OTHER: TOTAL	36,710	100.0	2.3	27.3	0.1	6.4	1.7	48.2	1.3	----	2.9	9.8
ANIMALS	1,753	100.0	1.3	70.5	1.4	4.4	15.1	7.2	----	----	----	0.2
PERSONS	15,681	100.0	2.4	55.7	0.1	4.1	1.0	35.4	0.1	----	0.1	0.9
ENVIRONMENT	536	100.0	1.1	0.4	----	5.6	3.4	0.7	77.1	----	7.5	4.3
POSITION ASSUMED	11,389	100.0	3.2	0.1	0.1	9.9	0.9	84.8	----	----	0.9	0.1
REPEATED MOTION, PRESSURE, SHOCK	956	100.0	----	----	----	----	----	----	----	----	79.7	20.3
GENERAL HEALTH	1,346	100.0	2.2	----	----	32.8	6.5	6.8	0.1	----	0.4	51.2
CLOTHING RUBBING	81	100.0	18.5	6.2	----	----	----	2.5	1.2	----	14.8	56.8
NO INFORMATION	4,968	100.0	0.4	0.3	0.1	0.3	----	45.4	0.5	----	2.9	50.2

Table 1 (continued)
COMPENSATED WORK INJURIES
BY MAJOR AGENCY OF ACCIDENT AND TYPE OF ACCIDENT
New York State, 1966–1970, All Industries

B. AMOUNT OF COMPENSATION

MAJOR AGENCY OF ACCIDENT	TOTAL ALL CASES: AMOUNT (IN $000'S)	TOTAL ALL CASES: PERCENT	STRUCK AGAINST AN OBJECT	STRUCK BY AN OBJECT	CAUGHT IN, BY OR BETWEEN	FALL ON SAME LEVEL	FALL TO DIFFERENT LEVEL	SLIP (NOT FALL) OR OVEREXERTION (HANDLING)	EXPOSURE TO TEMPERATURE EXTREMES	INHALATION, ABSORPTION, INGESTION	CONTINUAL OCCUPATIONAL ACTIVITY	OTHER
TOTAL: ALL CASES	$1,140,950.3	100.0	4.2	17.4	8.3	12.6	15.0	30.8	1.8	3.6	0.6	5.7
MACHINES: TOTAL	$104,405.9	100.0	4.0	13.8	67.0	0.4	2.1	10.0	2.2	----	0.5	(A)
METALWORKING MACHINES	$32,826.6	100.0	3.9	13.7	74.8	0.4	0.2	5.7	1.1	----	0.2	----
WOODWORKING MACHINES	$10,266.2	100.0	1.3	12.3	84.3	0.1	----	2.0	(A)	----	(A)	----
TEXTILE MACHINES	$6,089.0	100.0	7.1	5.4	68.5	0.1	2.0	12.7	1.6	----	2.6	----
LEATHER, FUR WORKING	$1,818.1	100.0	3.6	3.4	79.9	2.6	----	6.8	3.1	----	0.5	----
PAPER PRODUCTS MACHINES	$6,208.9	100.0	3.0	7.6	83.6	(A)	1.0	3.2	1.1	----	0.4	----
PRINTING AND ALLIED	$4,598.8	100.0	6.9	3.0	82.6	0.1	0.7	5.5	1.0	----	0.3	----
CHEMICAL GOODS MACHINES	$947.6	100.0	3.2	10.9	73.1	0.3	0.2	9.7	2.6	----	----	----
FOOD, TOBACCO PRODUCTS	$7,398.5	100.0	2.4	3.7	89.4	0.1	0.2	3.7	0.5	----	(A)	----
STONE, CLAY, GLASS	$2,068.1	100.0	2.2	21.6	62.8	0.5	4.5	7.6	0.4	----	----	----
RUBBER AND COMPOSITION GOODS MACHINES	$5,122.7	100.0	1.5	6.0	84.0	(A)	0.2	2.4	5.8	----	0.1	----
PACKAGING, WRAPPING MACHINES	$1,653.5	100.0	4.7	6.5	83.0	0.2	0.8	2.9	1.5	----	0.3	----
LAUNDRY, DRY CLEANING	$3,351.4	100.0	5.0	6.7	30.4	2.0	0.1	17.2	37.3	----	1.3	----
FARM, GARDEN MACHINES	$3,293.5	100.0	1.1	18.3	53.4	1.8	3.6	21.7	(A)	----	----	----
CONSTRUCTION MACHINES	$7,843.3	100.0	5.3	47.3	15.6	0.3	19.3	11.8	0.3	----	0.1	0.1
MINING, OIL, ORE REFINING MACHINES	$363.1	100.0	1.5	38.3	44.7	0.2	3.2	12.1	----	----	----	----
OFFICE MACHINES	$2,334.9	100.0	9.3	9.4	17.4	0.1	----	56.2	(A)	----	7.6	----
HOUSEHOLD MACHINES	$1,019.3	100.0	8.3	24.4	9.4	2.2	0.6	54.5	0.3	----	0.2	----
MISCELLANEOUS MACHINES	$4,031.1	100.0	7.1	19.4	36.1	0.5	1.3	34.6	0.4	----	0.5	----
OTHER MACHINES	$3,171.4	100.0	5.2	14.2	53.0	0.1	0.6	26.4	0.7	----	0.1	----
PRIME MOVERS AND POWER TRANSMISSION: TOTAL	$6,119.5	100.0	2.1	19.6	40.5	0.3	0.2	37.1	0.2	----	(A)	----
MOTORS-NOT VEHICULAR OR TOOL	$1,324.3	100.0	1.5	24.0	12.2	0.2	0.5	61.1	0.6	----	----	----
PUMPS	$1,183.2	100.0	2.6	14.9	21.5	0.4	0.2	60.2	0.2	----	----	----
AIR COMPRESSORS	$821.2	100.0	2.2	35.9	29.5	(A)	0.6	31.8	(A)	----	----	----
FANS, BLOWERS	$1,289.7	100.0	3.1	16.2	74.4	0.1	(A)	6.1	----	----	----	----
SHAFTS	$82.7	100.0	3.3	18.1	74.9	----	----	3.7	----	----	----	----
BELTS, BELT SHIFTERS	$337.0	100.0	1.3	3.9	91.3	----	0.1	3.4	----	----	----	----
OTHER POWER TRANSMISSION	$963.3	100.0	1.3	16.6	42.4	0.8	(A)	38.8	----	----	0.1	----
OTHER PARTS	$117.3	100.0	2.0	9.4	69.7	----	----	18.9	----	----	----	----
NOT INDICATED	$0.8	100.0	----	----	100.0	----	----	----	----	----	----	----

CONTINUED

A. LESS THAN 0.05 PERCENT.

Table 1 (continued)
COMPENSATED WORK INJURIES
BY MAJOR AGENCY OF ACCIDENT AND TYPE OF ACCIDENT
New York State, 1966–1970, All Industries

MAJOR AGENCY OF ACCIDENT	TOTAL ALL CASES: AMOUNT (IN $000'S)	TOTAL ALL CASES: PERCENT	STRUCK AGAINST AN OBJECT	STRUCK BY AN OBJECT	CAUGHT IN, BY OR BETWEEN	FALL ON SAME LEVEL	FALL TO DIFFERENT LEVEL	SLIP (NOT FALL) OR OVER-EXERTION (HANDLING)	EXPOSURE TO TEMPERATURE EXTREMES	INHALATION, ABSORPTION, INGESTION	CONTINUAL OCCUPATIONAL ACTIVITY	OTHER
B. AMOUNT OF COMPENSATION												
ELEVATORS, HOISTS AND CONVEYORS: TOTAL	$29,439.7	100.0	3.6	36.3	23.9	4.3	19.2	9.5	(A)	----	0.1	3.1
PASSENGER ELEVATORS	$7,168.2	100.0	1.7	12.8	18.1	12.7	37.9	9.2	----	----	0.2	7.5
FREIGHT ELEVATORS	$2,692.1	100.0	1.9	19.5	28.6	5.4	22.2	11.0	----	----	0.2	11.3
CRANES	$8,648.0	100.0	2.8	57.5	13.1	0.3	19.2	6.3	(A)	----	0.1	0.7
SHOVELS, DERRICKS, DREDGES	$577.4	100.0	2.5	72.9	10.0	0.2	5.0	9.4	----	----	----	----
ALL OTHER HOISTING	$3,937.5	100.0	1.9	59.3	10.9	3.4	4.7	19.8	----	----	(A)	----
CABLE OPERATED CONVEYORS	$479.6	100.0	0.7	46.0	35.6	0.1	14.7	2.9	----	----	----	----
CONVEYORS ON RAILS	$634.5	100.0	7.8	65.9	5.1	0.1	7.4	10.7	----	----	----	0.1
ALL OTHER TYPES OF KNOWN CONVEYORS	$5,302.2	100.0	9.7	16.8	59.1	0.9	6.4	7.0	0.1	----	(A)	(A)
VEHICLES: TOTAL	$155,637.0	100.0	4.7	23.6	4.2	2.3	17.3	20.0	0.7	----	0.1	25.9
MOTOR VEHICLE-MOVING	$78,959.3	100.0	2.0	26.7	1.0	0.3	7.2	11.7	0.8	----	(A)	50.2
MOTOR VEHICLE-NOT MOVING	$40,125.6	100.0	8.5	11.7	9.9	3.7	46.2	19.1	0.8	----	(A)	(A)
HAND, FOOT OPERATED VEH.	$28,704.4	100.0	6.6	33.4	4.9	4.9	3.7	46.2	(A)	----	0.1	(A)
ANIMAL DRAWN VEHICLES	$156.7	100.0	1.1	18.3	4.4	----	39.1	2.5	----	----	----	34.5
RAILWAY VEHICLES	$3,608.4	100.0	3.4	35.8	5.4	6.2	30.1	13.3	(A)	----	0.6	5.2
WATER	$640.1	100.0	4.4	6.3	4.0	23.4	29.4	20.8	----	----	----	11.8
AIRCRAFT	$2,835.5	100.0	4.3	4.5	1.5	4.7	5.6	5.3	6.0	----	3.4	[illegible]
OTHER VEHICLES	$607.1	100.0	2.1	29.6	7.6	9.6	27.8	26.0	----	----	----	5.1
CHEMICALS, ELECTRICITY AND BOILERS: TOTAL	$62,405.6	100.0	----	3.6	----	0.5	0.4	----	24.1	66.4	----	5.0
BOILERS, PRESSURE VESSELS	$1,838.6	100.0	----	40.9	----	5.1	4.6	----	38.5	----	----	[illegible]
ELECTRICITY	$4,719.0	100.0	----	(A)	----	3.5	2.7	----	32.8	----	----	61.0
EXPLOSIVES	$3,022.7	100.0	----	49.0	----	2.1	1.2	----	45.4	----	----	2.3
CHEMICALS: LIQUID, SOLID	$12,232.5	100.0	----	----	----	----	----	----	----	100.0	----	----
CHEMICALS: GASES, FUMES	$5,372.4	100.0	----	----	----	----	----	----	----	100.0	----	----
HIGHLY INFLAMMABLE SUBSTANCES	$11,410.7	100.0	----	----	----	----	----	----	100.0	----	----	----
DUSTS	$19,230.8	100.0	----	----	----	----	----	----	----	100.0	----	----
RADIATION	$201.4	100.0	----	----	----	----	----	----	----	100.0	----	----
PARASITES	$4,377.6	100.0	----	----	----	----	----	----	----	100.0	----	----

CONTINUED

A. LESS THAN 0.05 PERCENT.

Table 1 (continued)
COMPENSATED WORK INJURIES
BY MAJOR AGENCY OF ACCIDENT AND TYPE OF ACCIDENT
New York State, 1966–1970, All Industries

MAJOR AGENCY OF ACCIDENT	TOTAL: ALL CASES AMOUNT (IN $000'S)	TOTAL: ALL CASES PERCENT	TYPE OF ACCIDENT: STRUCK AGAINST AN OBJECT	STRUCK BY AN OBJECT	CAUGHT IN, BY OR BETWEEN	FALL ON SAME LEVEL	FALL TO DIFFERENT LEVEL	SLIP (NOT FALL) OR OVER-EXERTION (HANDLING)	EXPOSURE TO TEMPERATURE EXTREMES	INHALATION, ABSORPTION, INGESTION	CONTINUAL OCCUPATIONAL ACTIVITY	OTHER
					B. AMOUNT OF COMPENSATION							
HAND TOOLS: TOTAL	$52,930.1	100.0	4.0	45.1	2.3	4.1	1.7	39.4	1.4	----	1.9	0.1
STRIKING, SHOCK TOOLS	$7,973.3	100.0	2.5	69.5	0.4	1.7	(A)	25.0	0.1	----	0.8	(A)
CUTTING TOOLS	$5,740.3	100.0	4.2	82.4	1.8	0.9	0.1	7.7	----	----	2.7	0.2
TWISTING, GRASPING TOOLS	$8,245.1	100.0	10.2	32.3	8.6	10.4	4.0	38.0	(A)	----	2.4	(A)
LIFTING, PRYING TOOLS	$5,535.9	100.0	2.9	43.1	2.9	9.0	4.0	37.9	(A)	----	0.2	(A)
MISCELLANEOUS TOOLS	$11,714.1	100.0	2.5	18.4	0.9	3.2	0.8	70.1	0.2	----	3.7	0.2
MECHANICAL, ELECTRICAL POWERED TOOLS	$13,721.3	100.0	2.8	46.8	4.3	1.6	1.6	36.4	5.2	----	1.1	0.1
WORKING SURFACES: TOTAL	$291,152.7	100.0	1.9	----	----	43.6	45.3	9.2	----	----	----	----
GENERAL	$2,029.7	100.0	1.2	----	----	3.4	89.0	6.4	----	----	----	----
FLOOR-INSIDE SURFACE	$95,126.1	100.0	2.5	----	----	84.4	2.3	10.7	----	----	----	----
OUTSIDE SURFACE	$45,173.1	100.0	1.6	----	----	76.8	7.2	14.3	----	----	----	----
STAIRS	$35,736.3	100.0	1.9	----	----	8.4	78.5	11.2	----	----	----	----
SCAFFOLDS, STAGINGS	$22,311.8	100.0	0.7	----	----	0.7	96.9	1.7	----	----	----	----
PLATFORMS, RAMPS	$10,695.8	100.0	2.0	----	----	11.1	78.2	8.6	----	----	----	----
ROOFS	$5,437.7	100.0	0.3	----	----	6.4	92.0	1.4	----	----	----	----
FIXED OBJECTS	$24,736.8	100.0	1.9	----	----	27.6	62.9	7.6	----	----	----	----
PORTABLE OBJECTS	$49,905.3	100.0	1.4	----	----	0.5	92.4	5.6	----	----	----	----
MISCELLANEOUS OBJECTS: TOTAL	$352,382.9	100.0	7.6	24.6	2.1	1.0	0.4	63.1	(A)	----	0.7	0.7
CONTAINERS, PACKAGES	$134,833.7	100.0	2.0	14.2	1.1	1.1	0.2	80.9	----	----	0.6	(A)
FURNITURE (NOT WORK SURFACES)	$29,024.7	100.0	17.6	15.9	2.7	1.1	0.1	62.3	----	----	0.2	(A)
FIXED BUILDING	$15,448.7	100.0	30.6	41.5	9.4	1.6	0.9	15.8	----	----	0.1	(A)
METAL STOCK AND PARTS	$71,957.7	100.0	10.3	31.5	3.1	0.9	0.5	53.4	(A)	----	0.4	(A)
WOOD STOCK AND PARTS	$21,550.1	100.0	5.6	44.9	1.5	1.3	1.1	45.5	----	----	0.1	----
STONE, CLAY AND GLASS STOCK	$19,732.0	100.0	9.7	50.9	1.1	0.2	0.4	34.7	----	----	0.3	2.6
OTHER STOCK AND PARTS	$14,125.9	100.0	4.4	12.6	0.3	0.9	0.2	79.6	----	----	1.4	0.6
GENERAL AIDS TO WORK	$45,710.0	100.0	6.4	26.8	1.9	1.2	0.5	57.7	----	----	1.7	3.8
ANIMALS, PERSONS AND ALL OTHER: TOTAL	$86,476.8	100.0	1.4	25.5	(A)	6.7	2.7	39.7	1.5	----	3.7	18.7
ANIMALS	$2,800.0	100.0	1.6	55.0	0.6	9.8	23.7	9.0	----	----	----	0.3
PERSONS	$35,958.7	100.0	1.5	57.0	(A)	4.2	2.0	34.4	0.1	----	(A)	0.8
ENVIRONMENT	$1,848.3	100.0	0.2	0.1	----	2.7	4.1	1.3	68.8	----	13.7	9.3
POSITION ASSUMED	$23,690.7	100.0	1.7	0.1	(A)	12.3	1.6	81.7	----	----	2.2	0.4
REPEATED MOTION, PRESSURE, SHOCK	$2,558.0	100.0	----	----	----	----	----	----	----	----	86.4	13.6
GENERAL HEALTH	$15,271.7	100.0	0.6	----	----	6.1	3.5	2.0	(A)	----	(A)	87.7
CLOTHING RUBBING	$112.9	100.0	51.8	3.6	----	----	----	1.1	0.3	----	22.7	20.4
NO INFORMATION	$4,236.5	100.0	0.8	0.2	0.2	1.7	----	48.8	0.3	----	3.7	44.3

MACHINE GUARDING

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The organization to which I belong is even younger than your parallel organization OSHA, having been established as recently as 1975. Certain major incidents (see Figure 1) led to the establishment of a Government Committee, Chaired by Lord Robens, a past Chairman of our National Coal Board. This committee studied the organization of Safety Enforcement and Research in the United Kingdom; they recommended that separate autonomous bodies, such as the Government organized Factory Inspectorate, Mines Inspectorate, Nuclear Inspectorate and the Safety in Mines Research Establishment should be amalgamated into an integrated body with a common policy and administration establishment. More importantly, the concepts of safety responsibility were extended and a principal of 'reasonably practicable' introduced into these recommendations.

These recommendations culminated in the Health and Safety at Work Etc Act 1974[1] (Figure 2), which established the Health and Safety Commission (HSC) which is responsible for the administration of the Act, the carrying out or sponsoring of Research, and the maintenance of a continuous review of the adequacy of the legal requirements of the Act. They submit to Government proposals for new or revised regulation and approved codes of practice.

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1 Health and Safety at Work Etc. Act 1974 - Her Majesty's Stationary Office, London Reprinted 1976.

Figure 1

INFLUENCES LEADING UP TO THE NEW ACT

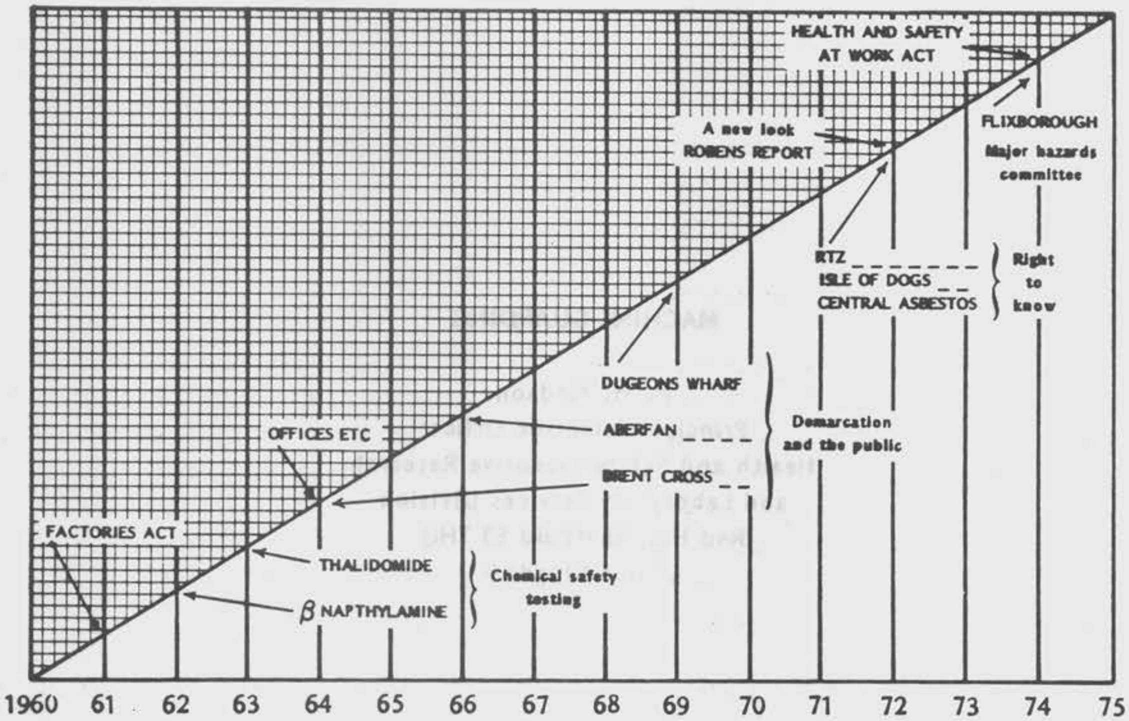


Figure 2

HEALTH AND SAFETY AT WORK, ETC. ACT OF 1974

Primary Provisions	Established
1. Securing the health, safety, and welfare of persons at work.	Health and Safety Commission
2. Protecting persons other than persons at work against risks arising from activities of persons at work.	Health and Safety Executive (Part 1 Sect. 10)
	Set Out
3. Controlling the keeping and use of explosive, flammable or dangerous substances . . .	Duties and powers of the above.
4. Controlling the emission to atmosphere of noxious or offensive substances from premises . . .	Duties of employers, employees.
(Part 1 Section 1)	Suppliers
	(Part 1 Sect. 11 Part 1 Sect. 2 Part 1 Sect. 6)

The Health and Safety Executive (HSE) is responsible for implementing the provision of the Health and Safety at Work Act 1974 and reports to the Commission.

The Primary Provisions which concern this seminar are:

- The safety and health of those at work
- The safety and health of those affected by the work
- Substances in use, storage, or being moved around
- Noxious or harmful emissions

The subscripts on Figures 2 and 3 refer to the relevant sections of the Health and Safety at Work Act. Figure 3 shows more detail of the specific duties of industry and HSC. All of these duties can give rise to the research or investigation of some kind, but note the specific reference to Research under (3) in the middle column, and under the duties of the Commission. Figure 4 shows those factors which give rise to decisions that there is a legitimate and necessary involvement of the HSC/HSE, and in many instances, a need to take initiatives because of the broad area of the problem, or the urgency of remedial action.

Figure 5 shows those bodies or organizations which make the need for research known to the Executive. Many of them are part of the Executive or the Commission and its advisory bodies. Problem areas are indicated to HSE by Trades Union and Employers' organizations through Joint Advisory or Joint Standing Committees - many of whom predate the Commission by many years and by new Industry Advisory Committees. There is a wealth of available industrial know-how, and research proposals are discussed in great detail by interested parties and the Research Division of the HSE. This Division has a responsibility for the overall program.

This program, which is ongoing, continually changing as some topics are completed, others added and priorities altered, has defined and limited resources available. HSE's three laboratories, their equipment, and staff account for about 70% of the total monetary cost of the HSE research programme. Figure 6 shows the research responsibilitity distribution in the HSE Research Division and the staff utilization. Research that cannot be done in-house, or for which better resources or expertise exist elsewhere, is commissioned outside on contract. The slide also shows the areas of activity to which these extramural funds were devoted in the 1979/80 year.

Figure 7 shows stages that lead to the choice of HSE Research Topics. The first three illustrate the kind of scrutiny and general appraisal that is applied to any proposal. Note that topics are compared with competing topics in the same field, and that financial support for any project from sources outside HSE adds considerably to its chance of acceptance into the program.

Figure 3

RESPONSIBILITIES FOR HEALTH AND SAFETY RESEARCH AND SOME AREAS IN WHICH A NEED FOR RESEARCH CAN ARISE

Duties Under the Act

Employers (Toward Employees)	Designers, manufacturers Importers, suppliers of articles or substances for use at work	The Commission
To ensure that so far as is reasonably practicable the following are safe and without risks to health:	To ensure the carrying out of:	". . . to make such arrangements as it considers appropriate" for
1. Plant	1. Safe design and construction	1. Carrying out research
2. Systems of work	2. Any necessary testing and examination	2. . . . encouraging research by others
3. Use, handling, storage, and transport of articles and substances	3. Any necessary research for the discovery and elimination or reduction of risks	(Part 1 Sect. 11)
4. Place of work (i.e., access, etc.)	(Part 1 Sect. 6)	
5. Working environment (and towards others)		
6. To conduct undertaking so that persons not in his employment are not at risk		
7. To prevent the emission of harmful or noxious substances to atmosphere		
(Part 1 Sects. 2, 3, and 5)		

Figure 4

SITUATIONS WHICH GIVE RISE TO HSC/HSE RESEARCH

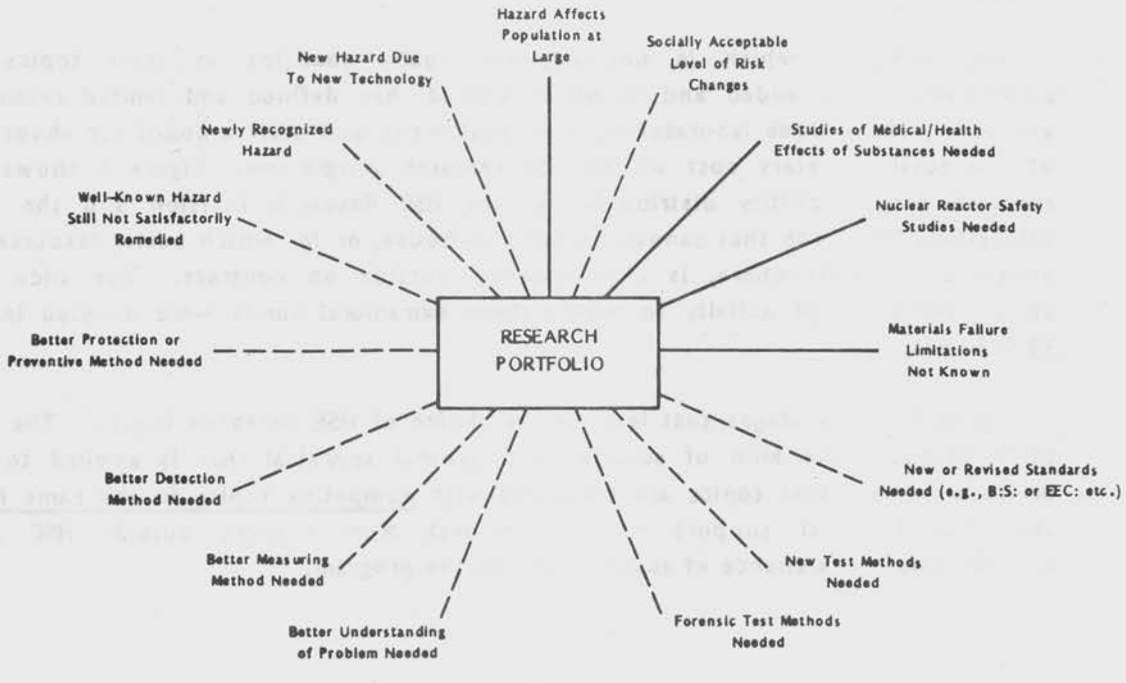


Figure 5

ORIGINATORS OF PROPOSALS FOR RESEARCH PROJECTS

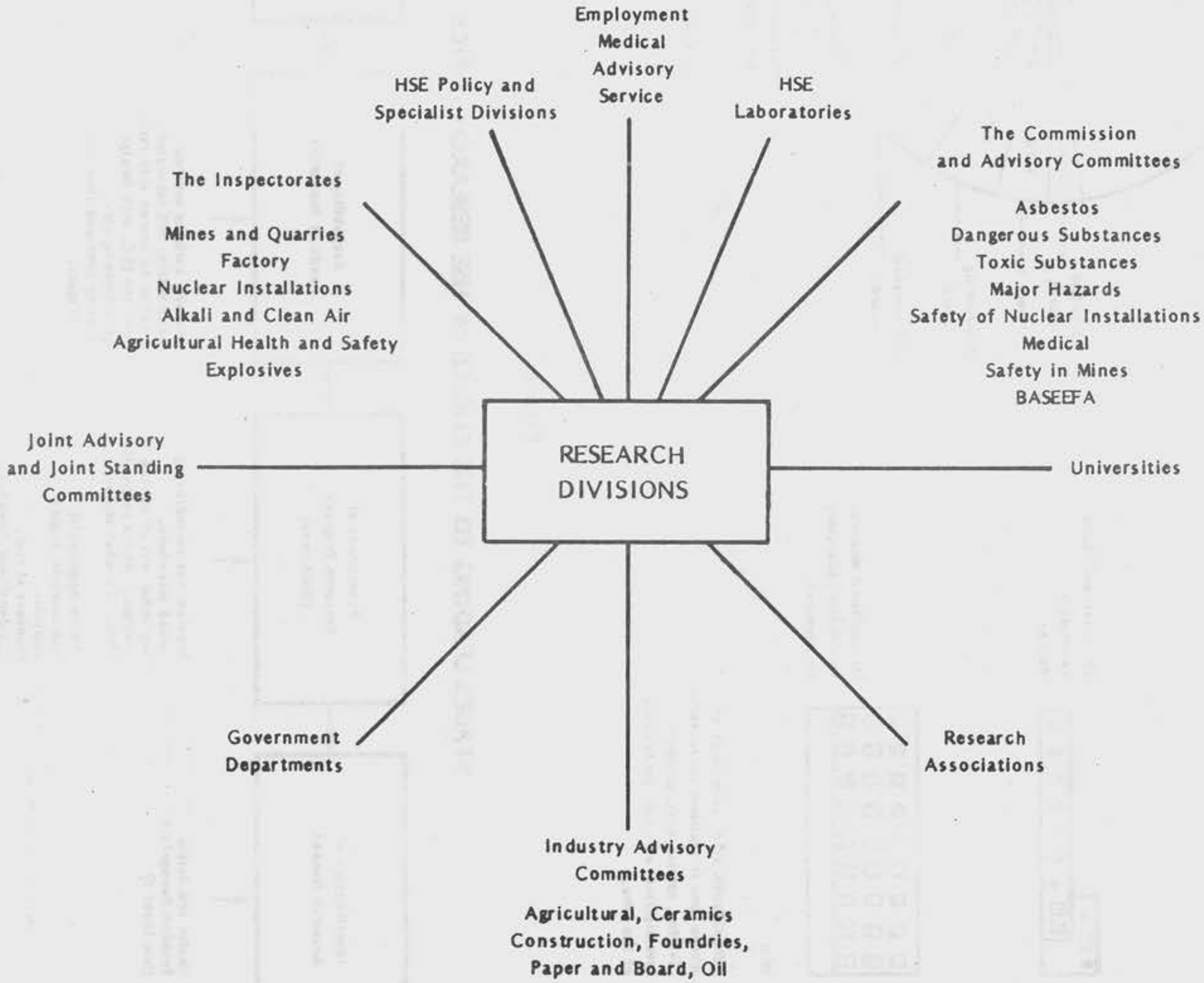
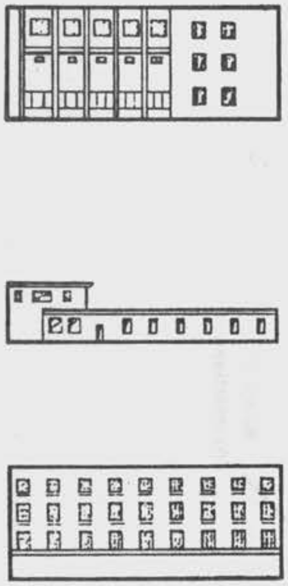


Figure 6

THE RESOURCES AVAILABLE FOR RESEARCH 1979–80 YEAR)

MATERIALS



MEN

350 scientific staff, about half of whose time is available for research. (Testing, service work, accident investigation, etc. take up the rest of the time.)

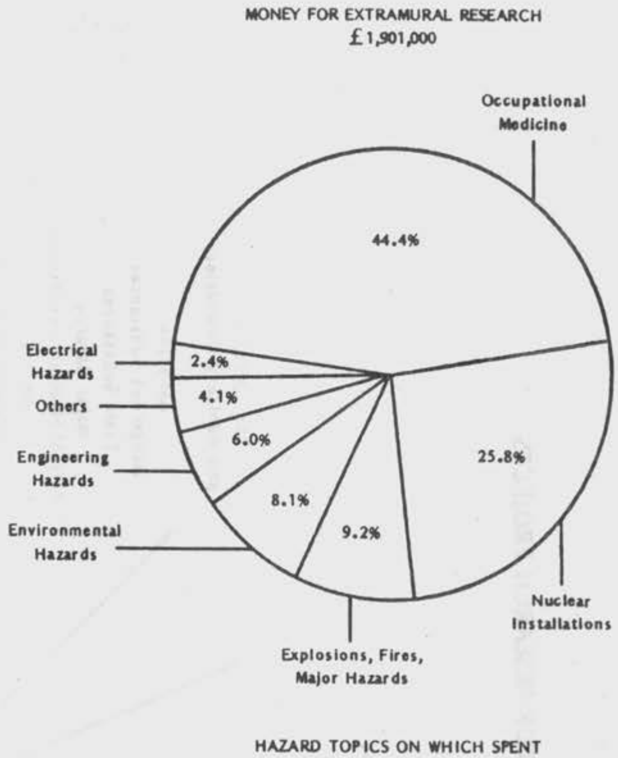
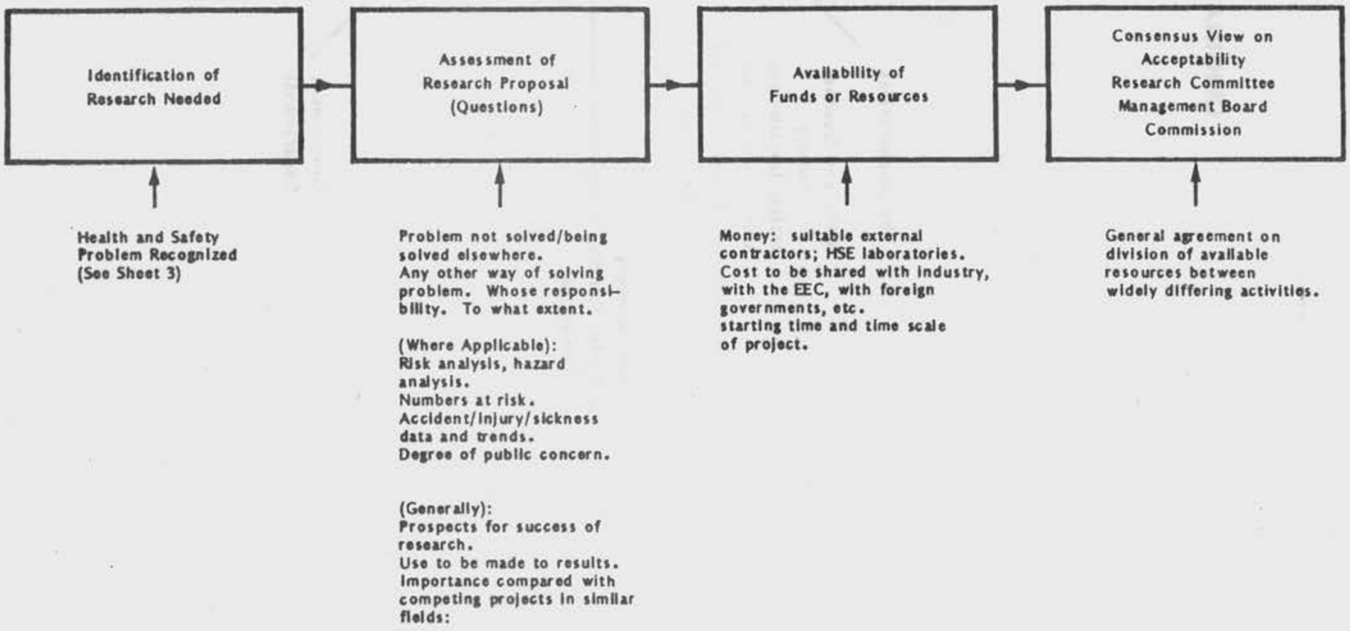


Figure 7

STAGES LEADING TO THE CHOICE OF HSE RESEARCH TOPICS



The Machine Safety Section, of which I am head, is part of the Safety Engineering Laboratory based at Sheffield, England, Figure 6. It was established in 1976 with a staff of eight with disciplines in Electronic, Electrical and Mechanical Engineering. Its functions are shown at Figure 8 and these reflect the division between research and support activities referred to in Figure 6. HSE has to bid for its funds each year and there has been virtually no increase in the last three years. Inflation has taken its toll. The demand for support services has increased as the reputation of the section has been enhanced, and with effectively reducing resources, the capacity for in-house research has reduced.

Figure 4 shows, by the hatched lines, those situations that give rise to a demand for research by the section. The capacity of the section to carry out research is extended by the short term employment of sandwich course students. These are young people, some of whom have returned to studies after an initial period of employment and training. The technical courses they follow are at Polytechnics and their studies lead to a range of Honours Degrees. Sandwich Course implies that a four or five year course will include a year in industry at the third or fourth year. Their applied engineering progress is monitored by a supervisory tutor. Careful interviewing before employment ensures that both employer and employee derive maximum benefit from the short association.

Another method of extending research capability is that of association with a company which can jointly contribute money, men or materials. A potential difficulty is the natural desire of the contributing Company to retain a development advantage over competitors. However, where a safety development is concerned it is the policy of the HSE to ensure that, should the participating Company lose interest or desire to restrict the development, the agreement to cooperate will allow HSE to offer cooperation to a third party. The section would actively participate in the research so that detailed intellectual knowledge of the project was common to all parties.

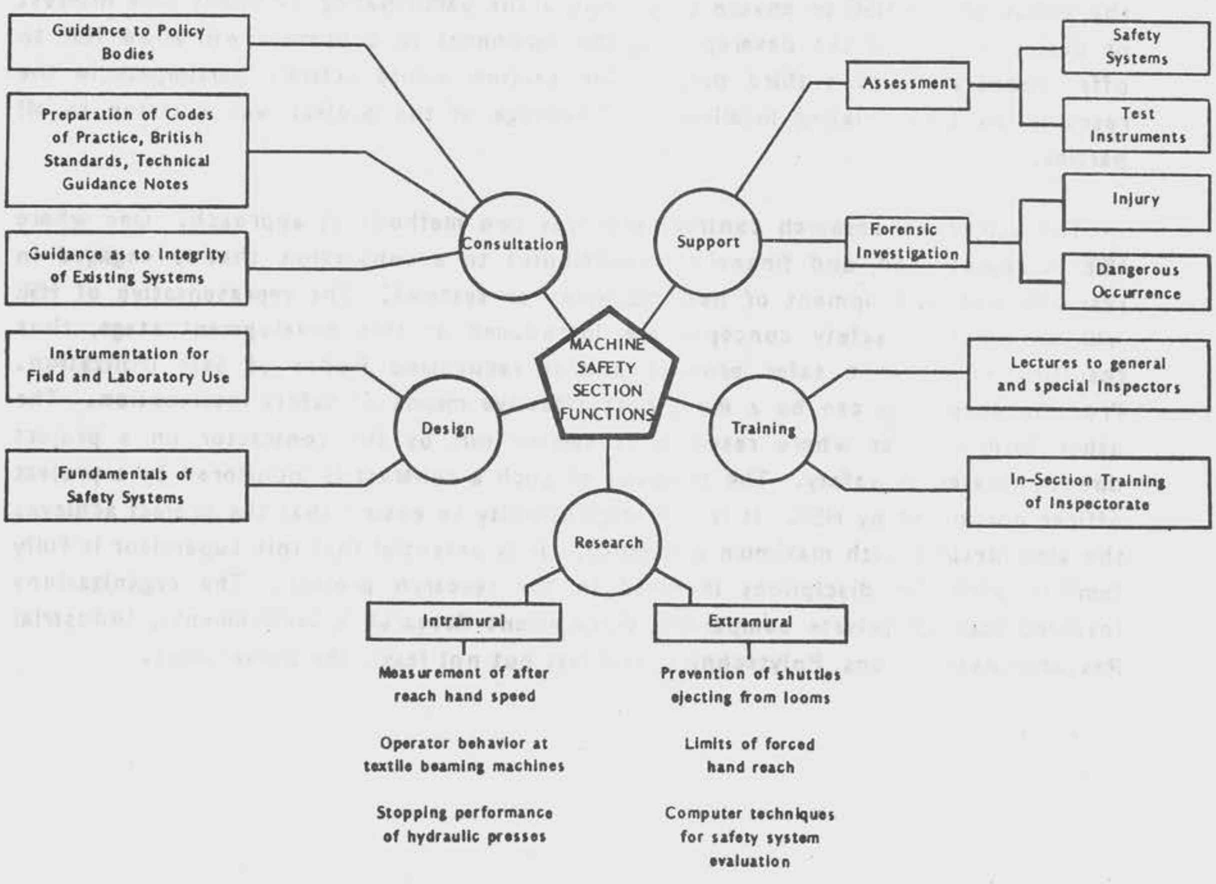
The extramural research contract provides two methods of approach. One where HSE is represented, and financially contributes to a consortium that is engaged in research and development of new machines or systems. The representative of HSE will ensure that safety concepts are introduced at this development stage, thus resulting in either a safer product and/or recognized Codes of Safe Utilization. Properly used, this can be a most cost effective means of safety intervention. The other form is that where research is carried out by the contractor on a project directly related to safety. The progress of such a contract is monitored by a project officer nominated by HSE. It is his responsibility to ensure that the project achieves the aims desired with maximum efficiency. It is essential that this supervisor is fully familiar with the disciplines involved in the research project. The organizations involved may be private companies, Government Research Establishments, Industrial Research Associations, Polytechnics, and last but not least, the Universities.

Figure 8 shows some of the Intra and Extramural activities with which it has been associated. In addition it shows the Consultation and training functions that it provides within HSE. There is a close link between these functions and research. It is essential that the conclusions of such research are effectively disseminated among the HSE organization, thus ensuring national uniformity of enforcement and advice.

In conclusion, I would like to draw the delegates attention to the fact that while the Health and Safety Executive Research Laboratories and Service Division is a new body, the Laboratories integrated into that Division enjoyed a long and honoured history of Safety Research under the name of the Safety in Mines Research Establishment. Its roots originated in 1908 in a non-governmental research organization financed by a Miners Welfare levy on every ton of coal mined. This tradition of applied safety research is still maintained and is evidenced in the Director of Research having been appointed from an Inspectorate of Mines and Quarries origin.

Figure 8

THE MACHINE SAFETY SECTION OF THE RESEARCH DIVISION



MACHINE GUARDING SIMULATOR

Stan Freeman, Developer
University of Washington
Educational Resource Center

The Machine Guarding Simulator developed and built at the University of Washington Educational Resource Center, was displayed at the symposium. The simulator illustrates over 20 principles of machine guarding, primarily guarding of punch presses and press brakes. Some of these principles are:

1. Two-hand control,
2. Foot switch operation (2 types),
3. Nip point control,
4. Sliding bolster plate,
5. Automatic operation,
6. Light curtain,
7. Barrier guard, and
8. Inching.

Now 90% complete, the simulator represents a year of design and construction effort that now makes it possible to bring a variety of dynamically illustrated machine guarding principles to: the classroom, the continuing education circuit, or public lectures.

The simulator was demonstrated by its developer, Stan Freeman.

MULTIPLE PURPOSE MACHINERY

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While there are many multiple-purpose machines in industry, in this paper we will discuss only positive-clutch power presses used in the metal forming and fabrication industry. Too frequently, an effort is made to "put a guard on the machine" when the machine under consideration is a multiple-purpose machine on which many operations may be performed. Hence, the "guard" envisioned by the person of good intentions may never permit the performance of the operation scheduled for the machine. The person in production knows that the type of "guard" often recommended will not permit the operation to be performed in an efficient and effective manner. This includes some "guards" designed by the machine manufacturer and the "guard" manufacturing companies. Is it not time for persons insisting on the guard to recognize that he or she must understand operations performed on multiple purpose machines? When that knowledge is acquired along with the ability to understand the operations, then the person recommending a "guard" is in a position to make understandable, believeable and acceptable recommendations. It is obvious that there is a need to "safeguard the operations" and that the method of safeguarding may vary with each operation and that design of the tool, jig, die set, and method of feeding may, in themselves, be methods of safeguarding the operation with subsequent reduction in injuries.

If "safeguarding the operations" is a worthy consideration, perhaps we should look at the injury experience on power presses. Hopefully, this will provide some guidelines to assist us in our deliberations. The source of data to which we will refer is the New York State "Characteristics and Costs of Work Injuries in New York State, 1966-1970", published in 1976. This study was completed under contract with the U.S. Department of Labor, Bureau of Labor Statistics.

In the study, a total of 22,538 injuries were reported as occurring with metalworking machines and they had an average compensation cost of $1,476. Twenty-eight percent (6,368) of these involved power presses with an average compensation cost of $2,010. A summary of the power press injuries is provided in Table I.

TABLE 1

NATURE OF INJURY AND AVERAGE COMPENSATION COST FOR INJURIES ON POWER PRESSES

NATURE OF INJURY	NUMBER	PERCENT	AVERAGE COMPENSATION COST
Fractures	2,439	38	$ 1,305
Cuts, Abrasions	2,213	35	823
Amputation, Traumatic	1,167	18	5,653
Bruises, Contusions	221	3	655
Strains, Sprains	149	2	909
Amputation, Surgical	79	1	6,593
Hernia	37	(a)	926
Burns, Scalds	17	(a)	678
Concussions	12	(a)	5,150
Dislocations	10	(a)	1,939
Other, Not Stated	15	(a)	17,052
Occupational Disease	9	(a)	2,464
	6,368		

(a) < 1 percent

A total of 6,368 of these power press injuries were classified by the type of accident and are provided in Table II.

TABLE II

TYPE OF ACCIDENT AND AVERAGE COMPENSATION COST FOR INJURIES ON POWER PRESSES

TYPE OF ACCIDENT	NUMBER	PERCENT	AVERAGE COMPENSATION COST
Caught In, On, or Between	5,389	85	$2,151
Struck By	620	10	1,234
Striking Against	188	3	650
Slip (not fall) or Overexertion	138	2	2,001
Contact with Temperature Extremes	13	(a)	514
Continuous Occupational Activity	10	(a)	2,284
Fall to Different Level	7	(a)	1,420
Fall to Same Level	3	(a)	4,175
	6,368		

(a) < 1 percent

When the part of body injured in power press accidents is considered, the New York data reveals the following for 6,245 injuries.

TABLE III

PART OF BODY INJURED AND AVERAGE COMPENSATION COST FOR INJURIES ON POWER PRESSES

PART OF BODY INJURED	NUMBER	PERCENT	AVERAGE COMPENSATION COST
Hands and Fingers	5,589	89	$2,032
Face and Neck	271	4	459
Upper Extremities	172	3	3,064
Lower Extremities	123	2	1,013
Trunk	115	2	2,670
Head	36	(a)	2,803
Two or More and Other	32	(a)	4,202
Eyes	30	(a)	4,389
	6,245		

(a) < 1 percent.

When considering the frequency and the apparent morbidity associated with these events, evidence indicates the high frequency of probable point-of-operation events since they can be represented by fractures, cuts, and amputation of hands and fingers and upper extremities that are caught in, on, or between. As a general deduction, it can be stated that 20 to 25 percent of all injuries associated with all metalworking machines involve point-of-operation exposures on power presses.

PRELIMINARY STUDY

Use of data of the type discussed has been justifiably criticized by some authorities. Hammer stated:

> Various attempts have been made to measure the safety level of a produce or system through analysis of past accident statistics. In some instances, rate per unit of hours or of total losses have been used. Neither one of these is entirely satisfactory.

Criticism of this type encouraged Lee to believe that rate of incidence occurrence, a relationship correlating injury data of man to machines, could be a useful indicator. For example, suppose a company had two types of manchines, "A", and "B", with twenty individual machines of type "A", and ten of type "B". During the course of one year eight injuries occurred on type "A" and six on "B". According to the number of incidents "A" would be labeled more hazardous than "B". But when exposure to the number of machines is considered, "B" is identified as causing 2/10 more injuries, "A" has eight on twenty machines (average 8/20) and "B" has six on ten machines (average 6/10). "B" has a rate of incident occurrence of 0.6 injuries per year; "A" has a rate of incident occurrence of 0.4 injuries per machine per year.

Multiplying by average cost of injury converts this incident rate to injury cost per machine per year which then may be used in 1) assessing the advantages of safeguarding the machine, 2) assessing injury cost over the expected life of the machine and 3) comparing machines relative to injury costs. Despite these apparent applications of the injury incident rate and the injury cost rate, these rates have seldom been mentioned in the literature. Whenever injury is used in conjunction with rate, correlation has been with the man or man-hour or payroll dollars and not with the machine. When damage to mechanical equipment is discussed, machine correlation is generally included. As an example of correlation with mechanical equipment when damage is concerned, Hammer discussed a mishap rate used by the Air Force for aircraft purchasing. This mishap rate is similar to the injury incident rate only in that it is related to machine (type of aircraft), but is different in that it is only concerned with damage to property (aircraft loss) and makes no mention of injury to persons.

Lee selected the household furniture manufacturing industry for studying the development of rate of incidence data. He utilized injury occurrence data acquired from the state of New York and determined that power presses predominated the injury occurrence data when metal working machines were considered (Table IV).

Lee reported that 84.3 percent of the compensated injuries for the metalworking machines involved injury to the hands or fingers and that 71 percent of the injuries occurred at the point of operation. He suggested "a high correlation or injuries on these machines to hand and finger to injuries at the point of operation. Since a machine inventory was needed to develop a rate of incidence occurrence, and no acceptable machine inventory was available for the household furniture manufacturing industry, Lee conducted a survey of Texas manufacturers in the industry with a transapplication of the compiled data to the industries in New York state; from this data the number of each of the selected machines was developed.

The transapplication was accomplished by selecting the Texas companies to be sampled according to an employment size distribution of New York State manufacturing establishments in the Household Furniture industry. The employment size distribution for this industry was assembled for information in the bulletin "County Business Patterns 1971, New York", which contained a distribution according to size of each Standard Industrial Classification (SIC). The SIC codes and titles for each strata used were 2511 for wood household furniture, 2512 for upholstered household furniture, 2514 for metal household furniture, 2515 for mattresses and bedsprings and 2519 for household furniture (not elsewhere classified).

TABLE IV

NUMBER OF INJURIES AND AVERAGE COST FOR NEW YORK STATE IN THE HOUSEHOLD FURNITURE INDUSTRY - METALWORKING MACHINES (LEE)

MACHINE	NUMBER OF INJURIES	AVERAGE COST ($)
Metalworking Machines		
Power Presses	151	$1,458
Foot and Hand Presses	11	1,615
Blades, Shears, Cutters, Slicers	17	869
Saws	9	536
Grinders, Polishers, and Buffers	23	1,221
Drill Presses and Borers	18	1,058

The Rate of Incidence developed for the metalworking machines in the household furniture manufacturing industry is provided in Table V.

Lee concluded that machine rate of incidence occurrence data and related cost rate data would provide management useful information to (1) justify updating existing machines, (2) justify improvement in design of machines, (3) reduce injuries, and (4) provide data and opportunity for management to make finite and measurable gains.

POWER PRESS OPERATIONS

Power press operations are often performed on the open-back inclinable (OBI) press illustrated in Figure 1. There are two basic operations performed on a press of this type, (1) primary and (2) secondary. As the term "primary" suggests, this is usually the first operation performed on the material from which a part is to be produced. Such operations are trimming, shearing, corner cutting, piercing, notching and others. Secondary operations are, as implied, second or third or other operations performed on material that has usually had previous work performed on it in a primary operation. Secondary operations include forming, bending, drawing, embossing, coining and others.

Figure 1

OPEN-BACK INCLINABLE (OBI) PRESS

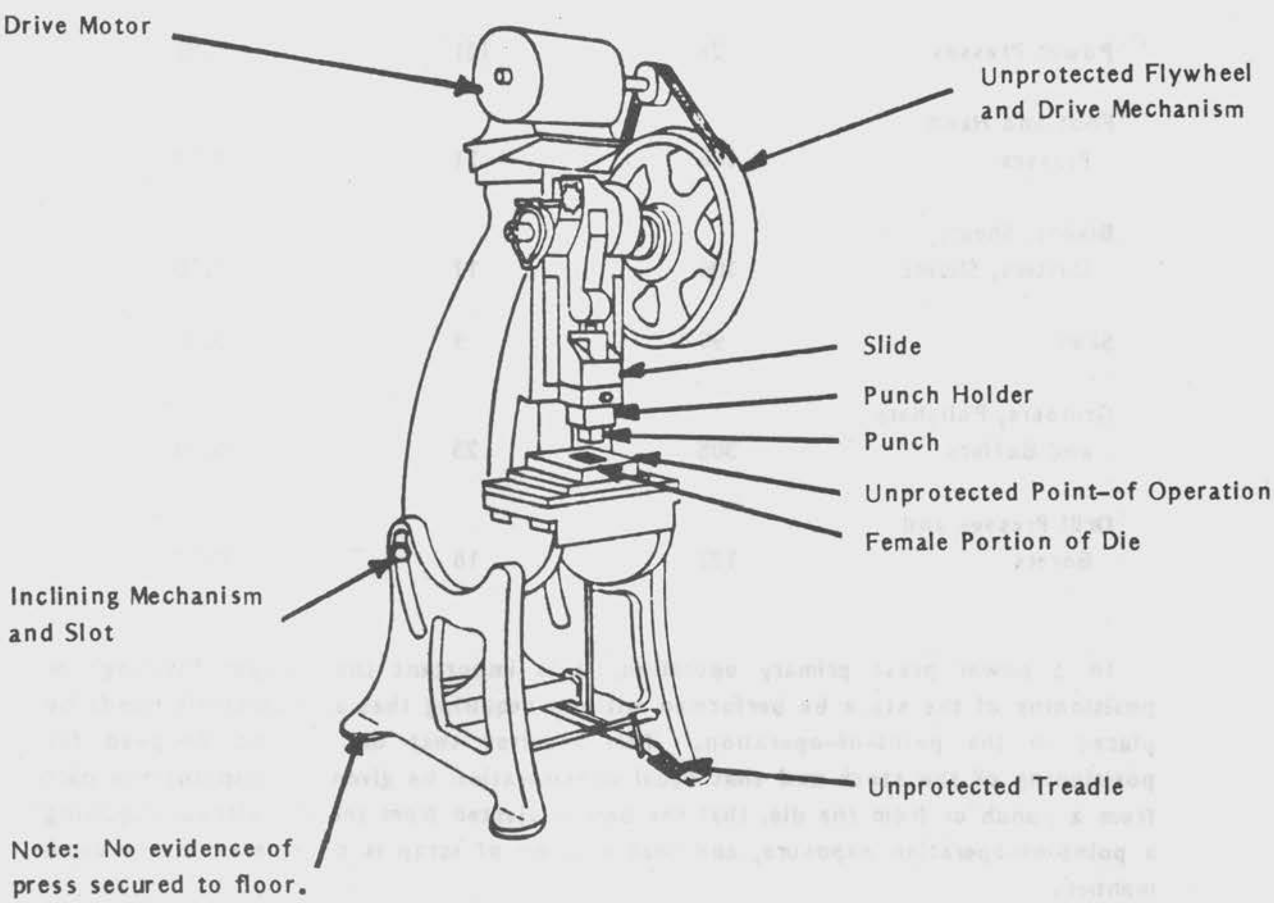


TABLE V

RATE OF INCIDENCE PER METALWORKING MACHINE FOR THE HOUSEHOLD FURNITURE INDUSTRY

MACHINES AND TOOLS	TOTAL NO. OF MACHINES	NO. INJURY 5 YRS. NEW YORK DATA	INJURY INCIDENT RATE (INJURY/ MACHINE)
Metalworking Machines			
Power Presses	26	151	5.81
Foot and Hand Presses	148	11	0.07
Blades, Shears, Cutters, Slicers	106	17	0.16
Saws	96	9	0.09
Grinders, Polishers and Buffers	308	23	0.08
Drill Presses and Borers	122	18	0.15

In a power press primary operation, it is important that proper "nesting" or positioning of the stock be performed without requiring that an operator's hands be placed in the point-of-operation. This requires that die set be designed for positioning of the stock and that equal consideration be given to stripping the part from a punch or from the die, that the part is ejected from the die without requiring a point-of-operation exposure, and that ejection of scrap is considered in the same manner.

In secondary operations, the importance of ejection of parts and scrap by proper stripping mechanisms and designing the die set to take advantage of gravity, pneumatic, or mechanical knock out concepts is vitally important. It will be obvious that part feeding methods are very important and gravity, follow, push, strip, dial or other types of feed mechanisms are acceptable.

The tool and die makes plays a very important role in the design and fabrication of the die set. This highly skilled craftsman may be employed by the company and may produce "tool and die" work for any customer. Usually, he is given a part design, or a part prototype and specifications as well as specifications of the press or presses on which the die will be set and the parts produced. It is imperative that proper feeding, part ejection and scrap ejection be considered when the die set is designed. At the same time, it is vitally important that there be no requirement for the press operator to place his head into the point-of-operation and that a die-mounted barrier guard be designed as an integral part of the die. This is interpreted to mean that the die set or the presses on which it may be mounted will not require retrofitting to meet a requirement and it also means that when the die set is mounted on a press that the die guard is also mounted because it is an integral part of the die set. Examples of die guards installed as an integral part of the die are illustrated in Figure 2. Once the die set has been properly designed to include proper feeding, nesting and ejection without requiring point-of-operation exposures to the operator, a majority of power press accident potentials have been minimized.

It is obvious that additional power press safeguarding methods, mechanisms and procedures are necessary. These will include those immediately important; proper seating, proper lighting, placement and handling of stock and scrap, single-stroke device, treadle protection, flywheel protection, location of start-stop switch, and others. Peripheral safeguarding considerations must include traffic control in and around the press, die setter's die handling methods, safety turnover bar for use by die setter, noise attenuation, press lubrication and maintenance, lock-out controls, die set storage, and others.

The press operator is part of a system, or he and the press and the environs compose a "work sphere" and the conditions within that work sphere must be optimum if safe performance is to be achieved. Once that is achieved, then the properly selected (i.e., meeting required physical and metal capabilities) and properly trained press operator should be able to produce parts at an accelerated rate and accomplish this with minimal interruptions to planned activity and with an extremely low probability of injury.

RESEARCH NEEDS

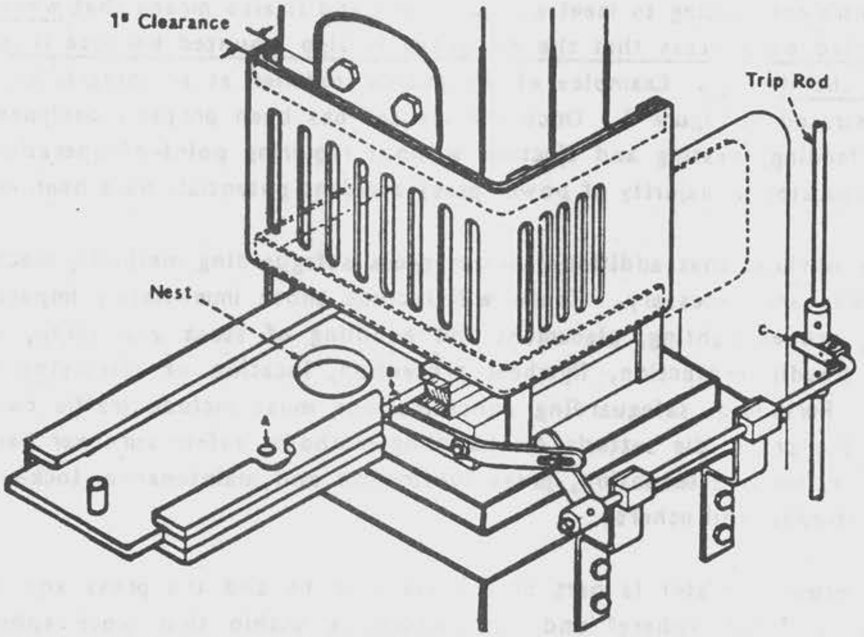
Given the injury experience is a guideline to be used by NIOSH in determining research needs and given that available resources should be expended where the need is greatest, it becomes evident that traumatic injuries occurring at the point-of-operation on multiple purpose machines should be given a very high priority.

It is apparent that the relatively high frequency of injuries of this type is sufficient to gain the attention of both management and labor.

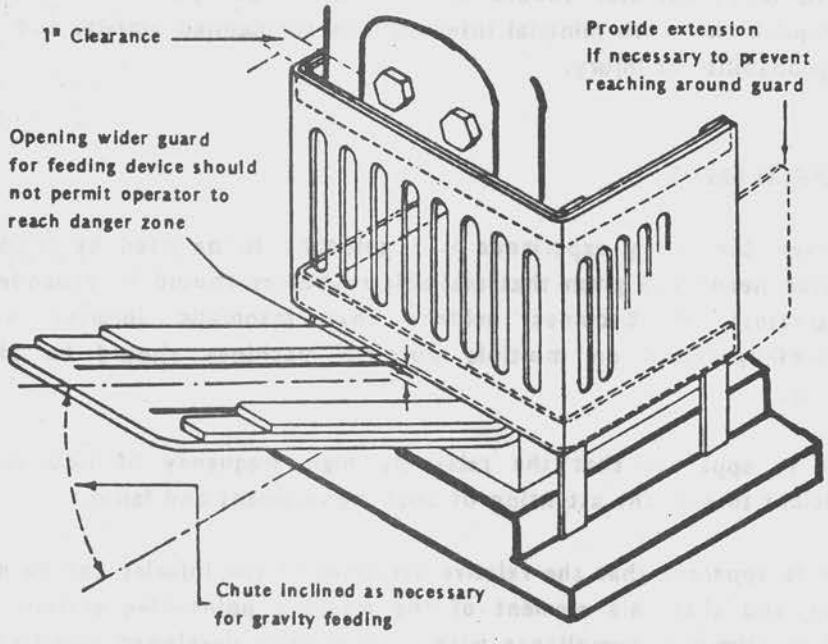
It is apparent that the relative serverity of the injuries can be measured in dollar values and that this element of the machine point-of-operation syndrome can be used to stimulate compliance with appropriately developed standards and that effect will be a reduction in "...lost production, wage loss, medical expenses, and disability compensation payments" which is a major purpose of P.L. 91-596.

Figure 2

DIE GUARDS INSTALLED AS INTEGRAL PARTS OF DIES



(A) Die enclosure guard with manually operated plunger feed. Press cannot be tripped until part is properly nested in the point of operation; note hole "A" must be aligned with pin "B."



(B) Die enclosure guard with inclined chute for gravity feed. Note that die enclosure guard is adaptable to inclined press.

With the current need and effort to increase American productivity, such a research effort furthered by NIOSH could have very positive effects in management and labor circles given that economic incentives were a part of the effort. Production increases with adequately designed die sets.

A national effort should be mounted to identify those multiple-purpose machines contributing adversely to injury exposures in the workplace and the true related injury experience so that rates of incidence and rates of loss could be developed to be used in guiding management decisions. It is suggested that three such machines are (1) power presses, (2) radial arm saws, and (3) table saws.

Given the successful completion of the national survey, the data accumulated should serve as a base for developing a new set of machine point-of-operation safeguarding requirements that would be quantifiable by machines and operations performed on the machines.

A part of the national survey should be directed to include the total engineering design requirements of tools, jigs, dies, feeding mechanisms and other point-of-operation controls and ergonomic or human factors engineering aspects of the design and operation of selected machines.

SUMMARY

Power press operations have been utilized to illustrate the injury experience and complex problems associated with the need to develop research priorities that include protection at the point-of-operation for multiple purpose machines. In terms of contributing to significant injuries or illnesses in the workplace, machine related injuries are exceeded only by working surfaces and vehicles. The machine related injuries far exceed the reported number of significant occupational health injuries, illnesses, and diseases from all combined occupational health agents.

It is suggested, and supported in part by evidence, that combined basic engineering machine and tool design coupled with ergonomic or human factors engineering research is a basic approach to developing believeable controls for point-of-operations exposures on multiple purpose machines.

REFERENCES

1. Authur D. Little, Inc. "The Present Status and Requirements for Occupational Safety Research", HEW/NIOSH, 1972.

2. Firenze, Robert J., The Process of Hazard Control, Kendall/Hunt, 1978.

3. Hammer, Willie, Handbook of System and Product Safety, Prentice-Hall, 1972.

4. Lee, Lawrence G., "The Development of the Application of the Injury Incident and Injury Cost Rate Analyses and the Application of These to the Household Furniture and Meat Products Industry", Unpublished Report, Texas A&M University, 1975.

5. Liberty Mutual Insurance Company, Power Press Guarding, 1965.

6. National Institute for Occupational Safety and Health, Machine Guarding - Assessment of Need, Superintendant of Documents, U.S. Government Printing Office, 1975.

7. National Safety Council, Accident Prevention Manual for Industrial Operations, 7th Edition, 1977.

8. New York State Department of Labor, Characteristics and Costs of Work Injuries in New York State, 1966-1970, Volume I, II, III, 1976.

9. Masters, Randall W., "The Location of Two-Hand Trip Devices on Full Revolution Mechanical Power Presses with Regard to Operator Safety", unpublished thesis, Texas A&M University, 1973.

A QUANTITATIVE APPROACH TO SAFETY ASSESSMENT OF THE WORKPLACE*

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ABSTRACT

Decisions on workplace safety have been accorded increasing importance since the birth of OSHA. The general criteria for designing and maintaining a safe workplace affecting every worker remains descriptive and inexplicit. The selection of safety design criteria for a given workplace heavily relies upon professional input(s) and recommendation(s), despite the fact that the relative attribute of safety that can be changed from time to time and judged differently by different people and in different contexts.

This paper suggests a paradigm for identifying and screening out potential deficiency in workplace safety design based upon the principles of risk assessment for safety factors in a workplace and upon comparative scoring of responses. This simple and rapid approach combines a risk factor analysis, value judgement, cause factor and resulted hazard, and safety assessment index. Clinical laboratories are compared as an example of case study to demonstrate the feasibility of this approach.

* Partially supported by the Health and Safety Research Division of the Oak Ridge National Laboratory.

INTRODUCTION

In recent years, decisions on workplace safety have been accorded increasing importance since the birth of OSHA. The rights granted to workers for safe workplaces have been changing drastically; workers no longer have to perform their jobs strictly at their own perils. However, the general criteria for designing and maintaining a safe workplace remain descriptive and inexplicit. Today, efforts to support and observe the safety codes and measures for workplaces are quite evident. Nevertheless, hazards persist; accidents still occur; and disputes over safety continue. The task of managing workplace safety is an assignment of continuous improvement with rapid response. The consequence of not responding to the safety problem in time could be monumental and costly. The necessity is overwhelming for a system to quickly identify those workplaces with the greatest need for immediate closer evaluation and scrutiny.

Safety could be regarded as a judgement of the acceptability of risk, which is a measure of the probability and severity of hazard to worker's health. A risk estimate can assess the overall chance that an unfortunate event will occur, but it is powerless to predict any specific event. And, a workplace is said to be safe only when its risks are judged or weighted to be acceptable. Despite the relative attribute of safety that can be changed from time to time and judged differently by different people and in different contexts, the decision on the acceptability of risk is often based upon the judgement of all involved parties other than the workers who actually perform their jobs there and face the consequences. As a result, their first-hand observation, invaluable experience, and actual operational knowledge regarding the safety aspect of that workplace could very well be left out forever as part of the continuous judgement input. The inclusion of opinion from this important source could lead to, among other things, further reduction of hazard. The need of a system to incorporate the opinion of workers' judgement into the overall decision for workplace safety is apparent.

It is the intent of this paper to suggest a simple and rapid quantitative approach to identify and screen out those workplaces that have high hazard potential, through a ranking or scoring system, including the participation of workers. Consequently, this approach should be regarded as a tool to assist the prioritizing of the ordering during the safety assessment process, so that those workplaces with the greatest need for evaluation are identified and reviewed first.

THE APPROACH

The concept of safety assessment based upon hazard evaluation and/or symptom vs. cause analysis has been discussed in numerous publications (Refs. 1–7). This presentation takes the approach of ranking or ordering workplaces based on their potential hazards to workers. The final product of this approach is the hazard assessment index, which is the result of risk evaluation, value judgement, and cause/symptom analysis on a given workplace. This hazard assessment index is derived multiplicatively from two separate indexes, namely hazard potential index and safety judgement index. Their relationship is as following:

Safety Assessment Index
= (1 – Hazard Potential Index) x (Safety Judgement Index)

Hazard Potential Index

The Hazard Potential Index (HPI) is an objective index reflecting the relative degree of hazard for that workplace based upon sequential analysis of pre-determinated parameters. Each parameter represents one of the important criteria for consideration from the safety standpoint. All of these parameters are then grouped into 6 different components. The scores of all parameters within the component are combined through addition to give a component score. All component scores are combined through multiplication to give a hazard potential score, which in turn determines the HPI.

The root of an unplanned incident or accident in a workplace can be traced, through cause-tee process, back to one or a combination of the three fundamental causations, namely environment, worker, and equipment. Further separation of these three causations results in 6 components, as listed in Exhibit 1. These are the common denominators of workplaces, potential factors to induce hazard or accident. The primary component refers to those parameters that could compromise workers' safety and health, easily identifiable with common sense or minimum training, e.g., slippery floor and sharp object. Likewise, the secondary component refers to those parameters identifiable with some training, e.g., radiation and flammability. The tertiary component refers to toxic substances specifically, e.g., benzene and vinyl chloride. As a group, these substances have recently received close attention, not only from NIOSH, but also from EPA and other agencies, as well. The worker component refers to parameters relating to the characteristics of workers as a group, e.g., physical and mental conditions. The equipment component relates to characteristics of equipment and tool used, e.g., springing motion and conveyor belt. Finally, the supplemental component refers to parameters that could affect hazards indirectly due to their presence or absence, execution, and decision, e.g., medical service and safety training. Each of these components could include as many parameters as necessary to reflect the completeness and throughness for analysing workplace safety, and each parameter posesses a set of scores quantitatively representing guidelines or criteria. However, excessive inclusion of parameters could defeat the goal of this approach — a rapid and simple approach. Hence, the refinement of parameter selection to maximize the effectiveness of hazard detection with minimum data and effort would rely on additional research.

After examining the workplace situation for a specific parameter, the examination data can be displayed in a format as shown in Exhibit 2. Based upon the data, a score is assigned to that parameter, as shown in Exhibit 3. The highest score is a seven and the lowest one is a one, representing the highest and lowest probability or

Exhibit 1

A SCHEME OF HAZARD FACTOR GROUPING

Causation	Component	Parameter
Environment	Supplement	walking surface, egress, platform, electricity, heat, fire hose, sprinkler, alarm, sharp object, . . .
	Secondary	radiation, dust, noise, ventilation, flamability, toxicity/severity, explosive, combustibility, . . .
	Tertiary	chronic toxicity/severity, carcinogenicity, mutagenicity, teratogenicity, reproductive toxicity, exposure level, . . .
Worker	Worker	education, training, experience, turnover rate, productivity, physical and mental conditions, sick days, psychology, . . .
	Supplement	medical service and check-up, management philosophy, accident trend, waste disposal, safety education, budget, personnel, . . .
Equipment	Equipment	machinery equipment, power tool, maintenance, protective device, handling frequency, storage, complexity, . . .

Exhibit 2

FORMAT FOR DISPLAYING ACUTE TOXICITY DATA

Workplace:

Chemical:

Terrestial Animal Toxicity:

Oral LD_{50}:

Dermal LD_{50}:

Inhalation LC_{50}:

Exhibit 3

ACUTE TOXICITY SCORING SYSTEM FOR TERRESTRIAL ANIMAL

Score	Criteria#
7	Oral LD_{50} = less than 5 Dermal LD_{50} = less than 5 Inhalation LC_{50} = less than 500@
5	Oral LD_{50} = 5 – 50 Dermal LD_{50} = 5 – 200 Inhalation LC_{50} = 500 – 2000@
3	Oral LD_{50} = greater than 50 – 500 Dermal LD_{50} = greater than 200 – 500 Inhalation LC_{50} = greater than 2000 – 20000@
2	Oral LD_{50} = greater than 500 – 5000 Dermal LD_{50} = greater than 500 – 5000 Inhalation LC_{50} = greater than 20000 – 50000@
1	Oral LD_{50} = greater than 5000 Dermal LD_{50} = greater than 5000 Inhalation LC_{50} = greater than 50000@
–3	No data but suspected to have a score of 3, 5, 7
–1	No data but suspected to have a score of 1 or 2
*	No data available, no estimate made

#: mg/kg

@: ug/L; equal or less than 4 hr. exposure severity or quantity of hazard potential respectively. A zero score, whenever it is applicable, represents no effect or hazard. Negative scores refer to no data available, but a potential hazard exists according to experts' estimates. Thus, the scores of –3 and –1 represent no data available, but indicate expectancy of a high and low positive score, respectively, according to experts' estimates. The asterisk(*) means that neither data nor estimate are available to determine the confidence of the HPI. Examples of scoring the toxicity parameter and the exposure level parameter are shown in Exhibits 2, 3, 4, and 5. Assuming there is fugitive emission of product or raw material in a workplace, than the toxicity of this substance would be a very important parameter to know. Exhibit 2 displays the data, and Exhibit 3 shows the suggested scores according to the LD_{50} value. Likewise, the potential exposure level of this substance to workers would be another important parameter to know. Exhibit 4 displays the data for exposure, and Exhibit 5 shows the suggested scores. It should be noted that the data collected for scoring should be based upon factual information and/or established relations of cause vs. result obtained from literature search, experiments, and actual situations.

Once a score is obtained for every parameter within that component, an additive approach is adopted to combine all the scores to give a component score. This is done under the assumption that all parameters within the same component would carry equal weight or equal importance relative to other parameters. Since some components are conceivably more important in one workplace than others, it would be illogical to assure all components would carry equal weight in all workplaces. Therefore, a multiplicative approach, which needs no weighting and, hence, produces less controversy over subjective judgement, is adopted to combine all the component scores to give a hazard potential score. The HPI value is derived from taking a percentage of the hazard potential score. A hypothetical case of calculating HPI is illustrated in Exhibit 6. Note that the confidence value of HPI is obtained by taking a percentage of the asterisked (*) quantity. A high HPI means that the hazard potential for that workplace is relatively high.

Safety Judgement Index

The Safety Judgement Index (SJI) is a subjective index reflecting the consensus of management and worker toward the safety measures of a workplace, based upon sequential analysis of survey opinions. The formation of this index requires a periodic safety judgement opinion survey that requires the participation of both management and workers. A continuous educational program is mandatory prior to the index determination process; information regarding the full spectrum of workplace safety analysis, including data collected for HPI purposes, is delivered to both management and worker. Survey results are tabulated and processed through averaging to reach SJI by the following equation:

Safety Judgement Index = (Worker Score Average + Management Score Average)/2

Exhibit 4

FORMAT FOR DISPLAYING OCCUPATIONAL EXPOSURE LEVEL

Workplace:

Chemical:

Occupational Exposure Level:

Vapor:

Solid:

Exhibit 5

OCCUPATIONAL EXPOSURE LEVEL SCORING SYSTEM

Score	Criteria
7	vapors: greater than 100 PPM solids: greater than 10 mg/m^3
5	vapors: 11 – 100 ppm solids: 5 – 10 mg/m^3
3	vapors: 2 – 10 ppm solids: 1 – 5 mg/m^3
1	vapors: 0 – 1 ppm solids: 0 – 1 mg/m^3
–3	No data but suspected to have a score of 5 or 7
–1	No data but suspected to have a score of 1 or 3
*	No data available, no estimate made

Exhibit 6

HAZARD POTENTIAL INDEX SCORE DISPLAYING FORMAT

Workplace:

	Parameter	Score	Confidence
	1	6/7	
	2	0/7	
	3	1/7	
	4	*/	
	5	6/7	
Component I		13/28	5 – 1*/5 = 80%
	6	3/7	
	7	7/7	
	8	0/7	
	9	*/	
	10	*/	
Component II		10/21	5 – 2*/5 = 60%
Component III		11/35	5 – 0*/5 = 100%
Component IV		5/35	5 – 0*/5 = 100%
Component V		8/28	5 – 1*/5 = 100%
Component VI		15/35	5 – 0*/5 = 100%

Hazard Potential Index (HPI) = $13 \times 10 \times 11 \times 5 \times 8 \times 15 / 28 \times 21 \times 28 \times 35^3$
= 858000/705894000
= 0.0012154

or = 0.0012154 x 10000%
= 12.15%

with a confidence of
30 – 4*/30 = 86%

Since safety judgement is, in reality, an value judgement, scientists and engineers are, indeed, little better qualified to make a decision than anyone else, including workers who might be or should be willing to bear the estimated risks. Equally true, scientists and engineers are in no position to make investment and safety decisions for a corporation or enterprise, either. The very same right that entitles workers to have a safe working environment also applies to management for assuring its existence. Hence, it would be most logical to allow both parties to express their own safety judgement opinions. In order to reach a nonbiased and valid safety judgement, knowledge would play an important role. Especially, both ignorance and false knowledge on the part of the worker could actually be contributing factors to induce hazards not only to himself but also to his fellow workers. The importance and significance of safety education to workers, as well as some educational formats, have been discussed at least in one publication (Ref. 3). Exhibit 7 suggests a much simplified display format that includes hazard description, mode, cause, effect, corrective action, and damage comparison with and without protection, as part of a safety education program. Information presented for this purpose would have the advantage of being readily translatable into easily understandable terms. A case in point would be converting mortality to day-loss-in-life (Ref. 8). Aided with knowledge, workers would be capable of identifying hidden or new hazards through their daily encounter, in addition to making a sound and valid judgement. The SJI reflects the degree of agreement on safety judgement between management and worker through an anonymous, valid, and equal survey base.

The SJI is reached through survey results. Exhibit 8 shows a questionnaire format designed to conduct this survey promptly. Some technical information is displayed in the questionnaire as a quick reference while questions are asked. Survey results are tabulated and averaged for each side; an average of both scores is the SJI. A 100% SJI value indicates the safety survey opinion is in highest agreement, whereas an SJI value of other than 100% indicates low agreement or some disagreement. A wider margin between two survey scores indicates a wider disagreement.

Safety Assessment Index

The Safety Assessment Index (SAI) is a product of subjective opinions and objective facts. It is intented to be used as a tool to assist in identifying and screening out those workplaces with high hazard potentials. As such, SAI serves to identify workplaces that should receive additional scientific and/or regulatory reviews; it should not be used solely to make ultimate decisions regarding workplace safety. Ironically, this approach may have its merit in serving as a guideline for a safer workplace by identifying problems, correcting conditions and modifying designs.

While SAI is used to prioritize a workplace in terms of safety, the formation of an SAI value provides the means to evaluate the safety framework of a workplace. The safety or hazard potential of a workplace relies primarily on the objective index--HPI. A high HPI refers to high hazard potential or low safety potential. On the other hand, the "confidence" that workplace deserves such an HPI ranking relies

Exhibit 7

SAFETY PARAMETER INFORMATION DISPLAYING FORMAT

Workplace:

Component:

Parameter:

Description: (describe the hazard)

Mode: (how does the hazard affect worker)

Cause: (what creates the hazard)

Effect: (the result when hazard affects worker)

Corrective Action: (what should be done to avoid the hazard)

Damage Comparison:

Without Protection: (damage severity if no protection)

With Protection: (damage severity if protection X given)
(damage severity if protection Y given)

Exhibit 8

SAFETY JUDGEMENT OPINION SURVEY FORMAT

Workplace:

Component:

Parameter:

Safety Information: (selected parameter safety information)

Current Status: (regulatory status or industrial standards)

Corrective Capability: (current technology to correct or modify the hazard and the costs)

Parameter Ranking: (the HPI score)

Answer all of the following questions with a number of 1 through 10, with 10 being the highest or best.

If you have a choice, your willingness to work under your current job environment is ____

If you owned this workplace, your safety ranking to this parameter for your workplace is ____

Your safety concern to this parameter for your workplace is ____

If the cost to improve this safety parameter is coming out of your pocket, your willingness to improve is ____

With the current status, corrective capability and cost of improving this safety parameter in mind, your belief about this safety parameter being in a reasonably good condition is ____

If this safety parameter is ranked 5 on a scale of 10 for your workplace, your overall objective ranking toward your entire workplace as a whole relative to this parameter in terms of safety is ____

Your specific comment:

on the subjective index—SJI. A high SJI refers to high safety agreement in survey opinions, whereas a low SJI refers to low agreement due to opinion difference, which could be the results of hidden facts, worker psychology, management philosophy, and others. Regardless of the cause behind this low SJI value, a signal for close examination has been established.

The criteria situation for the safest and the worst workplace can be revealed through an exercise of combining indexes. A workplace is said to possess high safety potential when its (1 – HPI) and SJI values are high enough to reach a high SAI value. Likewise, a workplace is said to possess low safety potential when its (1 – HPI) and SJI values are low enough to reach a low SAI value. A priority list can be achieved based upon the SAIs.

Because this ranking approach is a screening tool, it assumes some compromise between completeness and speed. The accuracy of the ranking depends on having a complete data base, parameter inclusion, and valid survey, which could be some of the new areas for future research, as we are discussing in this gathering.

CASE STUDY

To test this approach of assessing workplace safety, two clinical laboratories with limited data were compared. Laboratory I is relatively unknown, operating on a 40 hrs/week and low volume basis, staffed with less employees and a less forceful management, having a higher ratio of cost/test and a slightly higher ratio of tests/employee, and facing a low ratio of work space/employee and limited resources—capital as well as expertise—as opposed to laboratory II. The profiles of equipments and working environment are very compatible between these laboratories. Other than that laboratory I is a small operation whereas laboratory II is not, a small margin of two HPI values alone would almost place them in the same safety category. However, the wide difference between the two SJI values, with a higher SJI for laboratory I, separates their SAI values significantly. Examination of laboratory incidents reveals a lower incident/person/year occurrence for laboratory I in the areas of puncture wound, superficial cut, injury due to handling of heavy object(s), heavy metal contamination, and, especially, hepatitis infection. These findings appear to be in agreement with the advocation of SAI.

CONCLUSION

The safety assessment index approach can be used as a screening tool in selecting priority hazardous workplaces. This approach relies on the evaluation of subjective opinions and objective facts. It could be a feasible means for guiding future workplace safety design and permits the regulatory agency or safety department of an enterprise to direct its research resources toward those workplaces of particular interest within its jurisdiction or function.

REFERENCES

1. "A Review of the Development of Safety Philosophies," F. R. Farmer, Annals of Nuclear Energy, Vol. 6, pp. 261–4 (1979).

2. "Principles and Standards of Reactor Safety," E. G. Schlechtendahl, G. F. Schultheiss, D. Smidt, Proceedings of International Atomic Energy Agency, Vienna, pp. 135–43 (1973).

3. "Techniques of Safety Management," D. Petersen, McGraw-Hill Book Co., New York (1971).

4. "Safety and Reliability," G. H. Kinchin, Annals of Nuclear Energy, Vol. 6, pp. 265–8 (1979).

5. "Public Safety—A Growing Factor in Modern Design," A Symposium held at the fifth annual meeting of the National Academy of Engineering, National Academy of Engineering, Washington, D.C. (1970).

6. "Introduction to Safety Engineering," W. P. Rodgers, John Wiley and Sons, Inc., New York (1971).

7. "Proceedings of the 24th Annual Industrial Engineering Conference," held April 8 to 10, 1973, at Morgantown, West Virginia, by American Institute of Industrial Engineers, Bulletin No. 109 (1973).

8. "A Catalog of Risks," B. L. Cohen, I. S. Lee, Health Physics, Vol. 36, pp. 707–722 (1979).

HANDLES FOR SHARP TOOLS

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ABSTRACT

The combining of anthropometric data and hand tool guidelines for sharp tools is discussed and applied to three different jobs in a meat packing activity. Recommendations for areas of study are made.

INTRODUCTION

In the world of work, many tools are used which have sharp working surfaces (blades). Injuries often occur from having the hand slip off the handle and onto the blade and from the blade striking another part of the body. The most general example of such a tool is the knife. This discussion primarily deals with the industrial knife and its use in the meat packing industry.

State and national meat packers have expressed an interest in reducing knife related accidents. Each year these accidents cost them, and ultimately the consumer, millions of dollars.

Present day meat packing has evolved from a small butchering operation into a huge industry using modern work methods. In this evolution many things have changed, but the basic tool, the knife, remains relatively unchanged. The knife is involved in many "lost time" accidents and permanent disability cases in Nebraska, and also nationally. A real problem in knife design is the configuration and size of the handle.

As the workers in the meat packing industry perform their assigned tasks of cutting carcasses over an eight or ten hour day, fatigue sets in. This is especially true of the muscles involved in maintaining grasp as these muscles are statically loaded a high percentage of the time. Static loading of muscles inhibits blood flow necessary to bring replacement energy supplies and remove waste products critical to muscle metabolism. It causes accelerated fatigue in the muscles involved. To accentuate and accelerate this problem, the knife handle becomes slippery due to worker perspiration and body fluids of the slaughtered animals. This requires a tighter grip, which causes more severe static loading of the muscles.

Occasionally the worker, in attempting to jab the knife into the meat, hits a bone or the work surface, stopping the penetration of the knife. If the hand slips, it slides over the blade, with the possibility of severe and often permanent damage.

Present knife handle designs do little to prevent this sliding over the blade. They provide an indentation or small tang to stop the first finger from going forward. This is inadequate when the knife is slippery and/or fatigue is present. Many handles are wood, which will become slippery when wet with animal body fluids. Those that are plastic are sometimes made with a rough or textured surface to inhibit sliding. This too is defeated by the body fluid slipperiness.

One attempt at a solution to this problem has been to have the worker wear a chain mail or nylon mesh glove to protect his hand. This has several drawbacks. It increases fatigue, decreases grip capability, is clumsy to wear, is hot, and becomes dirty. Also, as the glove becomes worn and abraded, it is more comfortable to wear but it affords less than adequate protection.

BACKGROUND

In the ergonomics literature there is a variety of material that can be applied to the design of knife handles. The 1978 NASA Reference Publication 1024 Volumes I, II and III (1978) are excellent sources of anthropometric data and information. There are 236 annotated bibliographies and 13 dealing specifically with the hand. Reported survey data provides information on 15 different measures of hand anthropometry. The Human Engineering Guide to Equipment Design (1972), as well as many other documents, provides much anthropometric data about the hand. Data related to hand size and shape while the hand is closed, relaxed or lying flat, is available for both males and females.

The ergonomic guidelines for the design of hand-held tools have also been recently published. Tichauer and Gage (1977) concluded that the establishing of standards for optimum design of hand tools involved general, anatomical, mechanical, physical, and anthropometric considerations. Greenberg and Chaffin (1978) presented a guide for designing hand tools and small presses. In this presentation, specific recommendations are made concerning tool's weight, size, shape, color, texture, temperature, and vibration. Riley and Cochran (1978) summarize the important characteristics of hand-held tools according to the four factors of anthropometry, biomechanics, tool characteristics, and functional anatomy.

As had been indicated in the introduction, the present knife handle design does not significantly reduce the potential hazard to the worker, and no relief is in sight. Although many textbooks and design books talk about handle design, they seldom address the problem of size and configuration to minimize fatigue or maximize capability. They neither specifically describe the design nor do they cite research that supports particular handle designs. Considerable work has been done on grip strength. These studies do not address handle size, shape and force capability, or fatigue. There are, however, several that have briefly examined some aspect of handle design.

Pheasant and O'Neill (1975) examined various screwdriver handle designs available in Great Britain and compared them with smooth and rough cylinders. They found no difference in torque capability and the handle shapes available. They did find that twist and capability increased as handle diameter increased from 1 to 3 cm with a leveling off tendency from 3 to 5 cm and a drop from 5 to 7 cm. They found 5 cm to be the best diameter for cylindrical handles. They did not investigate fatigue or long-term performance.

Patkin (1969) found that cylindrical handles needed a flat side to "improve control of possible twisting". Mr. Patkin also used electromyography to compare "good and bad" handle designs. Patkin has done considerable other work on handle designs, but in the more delicate area of surgical instruments.

Ayoub and Lo Presti (1971) conducted a study to find the optimum size of cylindrical handles by use of electromyography. They found that for cylindrical handles of approximately 1.0 to 2.5 inches in diameter, electromyography indicated no difference in effort, with dramatic increases outside of this range. They did do a fatigue study and found the 2.5 inch diameter was inferior, dropping the optimal range to 1.0 to 2.0 inch. This compares very closely to the Pheasant and O'Neill results.

In summary, some work has been done to establish the optimum size of cylindrical handles, but little work has been done on other designs. Also, there is no good methodology established to evaluate handle design characteristics.

INDUSTRIAL EXAMPLE

In an attempt to improve the safety and productivity, three different jobs involving eight workers in a beef slaughtering operation were studied. The primary area of investigation was the knife handle. Other factors such as work place, layout and job design were also evaluated.

From the data collection process, which involved reviews of accident reports, employee interviews, supervisor interviews, videotaping of operations, and filming operations, a modification evaluation program of different knife handles was instigated. First, the knife handles presently being used were evaluated. Second, the size and shape of the handles were modified. Third, the workers used the modified knives and reported their responses in an interview. Fourth, based on the users' comments, additional modifications were made and the process repeated. Through this iterative procedure, the workers' responses indicate that improved knife handles have been designed.

The three critical dimensions of the existing knife handles were determined to be (1) the gripping surface length, (2) the depth of the handle, and (3) the thickness of the handle (see Figure 1). Of the three jobs being evaluated all used the same knife handle with different blade configurations. Although the same manufacturer made all the knives used in these three jobs, the handles of other manufacturers do not appear to be any better. Two things were identified as potential areas in need of improvement. The circumference of the handle and the gripping surface length were both judged to be too short.

The circumference was judged to be too small according to the work of Ayoub and Lo Presti (1971). Their work estimated the circumference of cylindrical handles to be 6.30 inches for maximum grip strength. Although the knife handles being studied were not cylindrical, but rectangular, the increase in circumference would increase hand sensory facilitation and total surface area for grasping.

In order to identify the best parameters to change for handle modification, only one dimension was initially changed on any one knife. Knife handles were fabricated that increased the circumference. The increase was made in test knives by only increasing the depth or by only increasing the thickness. Evaluation by workers indicated an increase in thickness was much preferred.

The gripping surface was judged to be too small because only 25 percent of the male population's hands would fit between the front and rear tangs of the standard knife handles. This fit was based on having the knife handle at the base of the fingers and approximately perpendicular to the direction of the touching fingers in the open hand. This situation is the most conservative because most knife users actually allow the knife handle to lie in their hands with the butt of the handle between the wrist and the little finger and the front of the knife handle near the first knuckle of the forefinger.

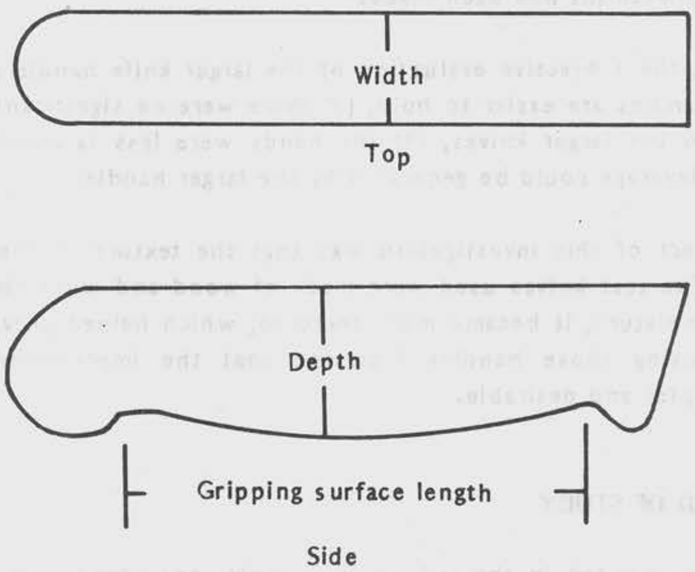
The first handle modification of the gripping surface length increased the dimension, but after worker review, the amount of increase was reduced by one-half.

The combining of the increased handle thickness and gripping surface have been well received by the workers. Whether accidents can be reduced or productivity improved by these modifications cannot yet be determined.

On one of the three jobs being evaluated an additional handle-blade modification was made. Because of the task requirements, the worker holds the standard knife such that the blade of the knife is on the thumb side of the grasping hand, with the cutting edge of the knife toward the forearm. This means that the handle is held in a position 180 degrees from that which it was designed to be held. The particular cutting action of the task is up and then pulled toward the worker.

Figure 1

KNIFE HANDLE DIMENSIONS



Because of this particular activity, workers had the standard knife handle's rear tang in contact with the palm of the hand—between the base of the little finger and the medial side of the wrist. As a result, large callouses were created on the hand. Also, the front tang of the standard knife offered only minimum protection from the cutting surface for the thumb. The solution for this situation was for a new blade and handle configuration. The handle was first increased in thickness and gripping surface length, and then the handle was rotated 180 degrees with respect to the blade's cutting edge.

The result of the evaluation of this knife by the workers indicated that a significant improvement had been made.

In general, the subjective evaluation of the larger knife handle can be summarized as: (1) the handles are easier to hold, (2) there were no significant work interference problems with the larger knives, (3) the hands were less fatigued using the knives, and (4) more leverage could be generated by the larger handles.

A side effect of this investigation was that the texture of the knife handle is a key factor. The test knives used were made of wood and when this particular wood encountered moisture, it became more textured, which helped prevent hand slippage. All workers using those handles indicated that the improvement in texture was noticeably helpful and desirable.

AREAS IN NEED OF STUDY

As was documented in the industrial example, one standard size handle will not properly fit all sizes of hands if the handle is designed for the average individual. Only if handles are designed for the extreme, in this case the larger hand, can the greatest percentage of the workers be able to use the same design. In a knife handle, a larger wooden handle can be reduced in size by sanding or grinding if necessary for an employee having a smaller hand. However, increasing the size of the standard handle by retrofitting is much less likely to succeed. If handles are made of plastic or other such materials, a larger variety of handle sizes needs to be available from which to select.

The "hostile" environments of the meat packing industry significantly influence the hand—handle interface. Water, perspiration, blood and tissue fluid frequently are found on hand and knife handles, especially in the slaughter operations. Normally, in the slaughtering areas there will be high relative humidity. The air temperature in the slaughtering areas is influenced by seasonal variation and normally during the summer months the temperatures are uncomfortably warm.

In the processing and "cooler" areas in the meat packing industry the air temperatures are reduced. As a result, workers' hands can be cold enough to reduce dexterity.

A major problem with knife handle guarding is directly related to the activities required in the particular job. A guard that completely encircles the hand does not allow the user to readily rotate or change the position of the blade from above the thumb to below the little finger and vice versa. Large protective shields or guard rings at the base of the blade frequently interfere with job activities because they hit the side of a carcass and thus change the angle of the cutting edge that is needed; they may inadvertently "catch" on muscle tissue, hide, etc., and thus create a potential hazard; and they may be difficult to clean and therefore create a sanitation problem. Because of the variety of activities no one particular guard will be appropriate for all jobs.

The texture of the knife handle is an important factor in contributing to the likelihood of a worker being able to firmly and easily grasp the handle. Because the liquids and fats make the handle slippery, some texture in the handle aids in improving the contact between the hand and handle. The texture of the handles may inhibit keeping the knife handles clean. Wooden handles tend to retain materials within the wood grain which provides the handle texture. This trapped material is potentially hazardous because of the bacteria that may exist there. This bacteria could possibly be transmitted from one carcass to another and thus persent a health hazard. Plastic handles with simulated wood texture presently still become very slippery when wet.

An additional problem found in meat packing is carpal tunnel syndrome. This is not unique to knife usage. This problem is a major one found in many industrial settings.

Other potential problem areas are carelessness, lack of attention, improper training, violation of safety rules, work pace, job design, worker fatigue, safety apparel and regulations.

In summary, many aspects of knife design, usage, guarding, and sanitation need additional study. There is no one single answer to the problems that exist. The job design is one of the more influential factors. Knife handle modifications can reduce stress and fatigue. Guarding should improve safety if the job activities allow it. Improved knife handle materials are needed to provide texture and cleanliness. Information dealing with the influence of various ambient temperatures on workers using sharp tools is needed.

For the safety of workers and the improvement of productivity many areas need additional research. The hand is a primary element in the work environment and thus must be protected, especially when sharp tools are used.

REFERENCES

1. Anthropometric Source Book Volume I: Anthropometry for Designers, NASA Reference Publication 1024, 1978.

2. Anthropometric Source Book Volume II: A Handbook of Anthropometric Data, NASA Reference Publication 1024, 1978.

3. Anthropometric Source Book Volume III: Annotated Bibliography of Anthropometry, NASA Reference Publication 1024, 1978.

4. Ayoub, M. M. and P. Lo Presti, "The Determination of an Optimum Size Cylindrical Handle by Use of Electromyography", Ergonomics, 1971, Vol. 14, No. 4, 509-518.

5. Greenberg, Leo and Don B. Chaffin, Workers and Their Tools, Pendell Publishing Co., 1978.

6. Patkin, M., "Requirements for Handle Design - Further Observations", presented at the Sixth Annual Conference of the Ergonomics Society of Australia and New Zealand, Canberra, Australia, 1969.

7. Pheasant, S. and D. O'Neill, "Performance in Gripping and Turning - A Study in Hand/Handle Effectiveness", Applied Ergonomics, 1975, 6,4,205-208.

8. Riley, M. W. and D. J. Cochran, "Evaluation Criteria and Operational Checklist for Hand-held Tools", presented at American Industrial Hygiene Association Annual Meeting, Los Angeles, California, May 1978.

9. Tichauer, R. R. and H. Gage, "Ergonomic Principles Basic to Hand Tool Design", American Industrial Hygiene Association Journal, Vol. 38, No. 11, 1977, pp. 622-634.

10. Van Cott, Harold P. and Robert G. Kinkade, Editors Human Engineering Guide to Equipment Design, sponsored by Joint Army-Navy-Air Force Steering Committee, 1972.

ACCIDENTS AND SOCIOTECHNICAL SYSTEMS: PRINCIPLES FOR DESIGN

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ABSTRACT

Recent industrial accident studies have noted that various organizational variables, e.g., department boundaries, management - worker communication, training programs, can have a high impact on accident occurrence. They have also noted a lack of methodology for oganizational design that reflects the needs of safety. Sociotechnical systems theory is outlined as a possibly useful structure and methodology. The redesign of an underground mine is presented as a case study where safety was an important issue. Principles derived from numerous sociotechnical designs are analyzed as to their potential applicability to safety problems.

INTRODUCTION

Recent studies of industrial accidents have focused on two issues; an explicit concern for managerial and organizational level problems, and a largely implicit concern for the lack of design methodology or principles to cope with these problems. The purpose of this paper is to look at emerging sociotechnical theory, methods and case studies for possible help with the methodological/principle problem.

Several studies have looked in some detail over reasonable time horizons at actual industrial accident experience (Cohen, 1977, Jones, 1979, Powell, et. al., 1971, and Shafai-Sahrai, 1973). These studies have largely agreed that issues beyond the simple one person/one machine workplace are the most important in satisfactory programs in accident reduction. Management support, worker - supervisor - management communication, allocation of tasks, worker and supervisor training, and understanding accident causation are commonly found problem areas, even though the researchers started with differing hypotheses and employed vastly different methodologies.

These studies also agree (although here one must do some reading between the lines) that no direction, methodology, or set of guiding principles is available to systematically cope with these problems in either new or redesigned plants. Jones (1979) states that much past work has been misdirected at attacks on symptoms and that the worker is affected by a vastly richer complexity of forces than has been ordinarily realized. Cohen (1977) says that the scientific studies, although largely agreeing on problem areas, provide no "blueprint" for designing new programs. Powell (1971) and Swain (1974) agree that appeals to carelessness, inattention and other motivational attributes of the individual worker are generally quite ineffective and that therefore redesign of the work system itself is necessary.

CURRENT PROBLEMS

One common problem with safety programs is their assignment as a staff function rather than diffused into the line organization (Firenze, 1978, Hammer, 1976). Programs can also easily become overdependent on one person (Jones, 1979), especially in smaller plants. Safety committees can actually contribute to the isolation of line workers if improperly staffed and run (Shafai-Sahrai, 1973). Plants with good safety records have been found with no safety committees at all (Jones, 1979, Cohen, 1977). It is clear that committees must actively participate in production decisions (Cohen, 1977) and not allow a split to occur between production and safety decision-making. This problem also contributes to the often observed short-term effectiveness of programs, where good programs tend to disappear as personnel and production needs change (Smith, 1975).

An observed problem related to the line/staff issue is one of inadequate communication. Many studies have concluded that the workers on the shop floor had too little of the information that was available at administrative levels but not passed downward (Firenze, 1978, Cohen, 1977, Cohen, et. al. 1979, Powell, 1971, and Hammer, 1976). Shafai-Sahrai (1973) notes additionally that the existence of safety rules, per se shows no correlation with actual accident experience; this is probably related to a lack of meaningful communication to the floor. He also notes that safety committee members themselves had fewer accidents, presumably related to their increased knowledge and awareness.

Whereas communication of methods, models of causation, and safety priorities may properly come down from management or technical staff to the shop floor, it has also been stressed that most hazards themselves are relatively difficult to observe by inspection and are best uncovered by the workers themselves (Firenzi, 1978, Swain, 1974, Mones, 1979). Powell (1971) notes further that there is a high variability in the time course of hazards and that small changes in work procedures can lead to large changes in hazard levels. Powell (1971) suggests a possibly useful link here between quality control and hazard identification. Hazards thus appear to be either technically sophisticated, relating to highly specific work procedures, or relating to issues beyond the workplace. In all cases this appears to call for coordinated efforts between the worker for identification, the technical staff for design, and management for resources and goals.

Another problem noted by Powell (1971) is the organizational boundary between units. They note several instances of boundaries between maintenance, operations, and supervision creating a situation discouraging useful cooperation and necessary information flow. They also suggest that the boundary between shop floor and the medical treatment center be examined, noting much useful information in the medical center that could assist in identifying hazards at the workplace. Tuttle, et. al. (1975) notes a problem with a shift boundary, in this instance a time rather than organizational boundary. They suggest provisions for more effective information transfer across shifts.

Housekeeping is mentioned by all researchers, although it is relatively clear that they believe this more an indicator of management's concern for the shop floor than a possible countermeasure. Nonetheless, poor housekeeping per se can be a direct cause of accidents.

A number of other problem areas uncovered in these studies can be related to an inadequate model of the worker held by management and conveyed to the worker via the organization design. The view of workers as largely irresponsible and needing detailed instructions on methods that has evolved from the "scientific management" era is criticized by Cohen (1977). Powell (1971) and the author's own accident investigation experiences indicate that is is precisely when workers take additional discretionary responsibility that they often have accidents. Workers trained and supervised solely on the repetitive, usual tasks will understandably have problems when confronted with the unusual, occasional tasks necessary to "keep things going" (Powell, 1971).

Management support systems that either explicitly (e.g., piece-work) or implicitly favoring competitive work inhibit the cooperation often necessary in times of stress or machine breakdown, for example, when accidents tend to occur more often (Jones, 1979). Short-term production goals may have a similar effect.

An overreliance on techniques such as "guarding" can similarly result from management's attitude toward the worker's abilities. Jones (1979) points out that in smaller shops, or with short runs, it may be better to use additional training rather than to attempt guarding.

Another inadequate accident countermeasure is the overreliance on personnel selection and matching to jobs. Inadequate attention to individual differences, large variations in work over time, and lack of selection on the non-normal discretionary aspects of the job are only some of the reasons why this method fails. "Proneness" is another area where selection fails, largely because "proneness" may well be a time-varying phenomenon, occuring in most workers in times of personal stress, for example (Cherns, 1975).

It was noted above that these various researchers have found little in the way of guiding principles or design methodologies to cope with these problems. Four fields can be identified as possible contributors: (1) human factors (ergonomics), (2) industrial engineering, (3) systems safety, and (4) industrial psychology (or sociology or relations). Each of these specialists appears to have assumptions or limitations that have made them reasonably ineffective in systematic attacks on the problems outlined above. Human factors and industrial engineering have largely attacked problems at the one person/one machine level. Where they have considered larger systems, accident prevention has not been the focus. Industrial engineering has largely neglected its original problems with the design of work (and safety) for the more esoteric mathematical and computer areas, neither of which is particularly helpful here. Human factors successes in military systems have not translated well into private industry, at least partly related to organizational and communication differences and the more diffuse goals and measures in the private sector.

"Systems Safety" represents a collection of techniques derived largely from the reliability area [see Proceedings (1979) or Malasky (1974) for example]. While they have evidently been useful in military and aerospace systems there has been a largely unsuccessful transfer to the "factory." It is unclear precisely what the transfer problem is except that the problems in the industrial sector outlined above appear quite remote in their make-up from those associated with rocket launching.

It is perhaps even more surprising and disappointing that the relevant fields in the social sciences have contributed little here. Their biggest problem is probably their inability or at least unwillingness to consider variations in the technical system, which they almost universally take as a given, developed on some external engineering or scientific rationale. The technical system design, however, contains many assumptions about the social system, even if not understood by its designers. It can also have many forms, some of which may have large and important effects on its complementary social system and therefore on safety. Like the engineers, the social scientists also consider the one person/one job element as the correct level for most of their attack, again missing many relevant problems and possible solution directions. At the organizational level they tend to such "design" suggestions as "... promote an organizational climate that encourages safety." (Tuttle, et. al., 1975) with little explicit help as to how a manager or designer could effect, sustain, or diffuse this idea.

Sociotechnical Systems Theory and Application

Sociotechnical systems theory represents a new way of conceptualizing and designing organizations. It suggests forms of jobs and work organizations that are more responsive to newer ideas concerning people; especially their motivation, and to increased demands that organizations respond quickly to change. The basic idea behind sociotechnical theory is that one must arrange a joint optimization of the interacting technical and social systems in the organization. Three areas most clearly distinguish this theory and its methodology from other concepts and methods: (1) an explicit attempt to analyze and specifically design an open system, optimally adaptive to changing environments (2), considerations of the social system extending well beyond human factors or traditional management techniques, including the large number of motivational and quality of working life issues now recognized as crucial to a successful and productive organization, and (3) explicit plans for implementing change, including training, transitional organizations, and frameworks for the continual evolution of social systems, since social systems cannot be changed in the neat, discrete ways that technical systems can.

The historic development of jobs and organization design is presented by Davis (1977b), including the origins of sociotechnical theory from the Tavistock Institute in London during the 1950's and 60's and the evolution of traditional one man/one job designs to the current ideas of designing around minimum self-maintaining sociotechnical units with emphasis on necessary roles as opposed to highly specified jobs. Davis also presents the ideas of joint optimization of the two interacting systems and the important concept that alternative technical systems must be considered even though the engineers and architects usually aim for a unique technical system specification at an early date. The reasons for managements' concern with new jobs and organizational forms are presented in Davis (1971), where he outlines the changes resulting from our transition to the post-industrial society. The forms that these new organizations are likely to take are discussed in Davis (1977a) where he outlines fourteen attributes commonly shared in new, sociotechnical designs.

The need for organizations to evolve, adapt and respond to an increasingly complex environment is discussed by Emery and Trist (1965). They suggest that organizations increasingly confront a "turbulant" environment, where events cannot be well predicted in advance and the organization's actions, and those of its competitors influence the environment in unpredictable ways. They suggest that sociotechnical designs offer promise in organizational survival in this environment.

The shape and form of appropriate sociotechnical units is discussed by Herbst (1974). These units should have control over a meaningful, understandable and measurable piece of the total production process. They should also have capabilities for self-regulation, at least routine maintenance, and be able to adapt to changing needs. Their social system should have the training and capability to evolve into productive forms while maintaining agreed standards for quality of working life of its members.

Sociotechnical theory sees the important role of the production social system as variance control; people monitoring, diagnosing, and correcting variables that go beyond some tolerance limit (Herbst, 1974). Repetitive operations that can be performed in exactly the same way each time should be considered for automation. This is quite obviously the way people's roles are changing in the newer, automated processing plants, for example. Davis and Engelstad (1977) devised a method of analysis beginning with the separation of the total process into "unit operations" and then uncovering the "variances" that need to be controlled within each unit operation. They further identified "key variances" that affected things "downstream" and whose occurrence, uncontrolled, would alter the product in an important way. They identified the problem of uncontrolled variance being transmitted to adjacent departments and discuss the final step of deciding which variance should be controlled by whom, at what location.

Englestad (1979) applies these techniques to a sociotechnical analysis of a paper mill, finding uncontrolled variations (variances) being transmitted along the process and affecting both productivity and workforce satisfaction.

Cherns and Wacker (1978) present a framework for understanding the various functions of the social system and assessing related performance. They postulate that the social system can be usefully thought of as four, interacting subsystems: production, adaptation, training/renewal, and integration. They point out that the technical system interacts with each of these and therefore an optimal sociotechnical system requires the joint optimization of each subsystem with appropriate parts of the technical system.

Sociotechnical systems design is a new management philosophy, particularly regarding the value and role of people, their responsibility, and the role of supervision. Trist (1973) contrasts this new view with traditional scientific management, noting that sociotechnical theory greatly changes such ideas as one man/one job as an appropraite unit of analysis, fractionation as appropriate for productivity, people as simple extensions of machines, and coordination by layers of supervision. Hill (1971) presents this issue using a division of Shell International as a case study. Gyllenhammer (1977) discusses what he sees as the appropriate recognition of the value of workers and responsibilities of large, private corporations in todays and tomorrows world. As president of Volvo he is, of course, involved in some of the most extensive and radical designs to date, with the elimination of the tranditional assembly line at Kalmar illustrating the possible extent that technical systems may have to be redesigned to meet the realistic needs of their complimentary social systems.

A Sociotechnical Design Which Concerned Safety

One relatively extensive redesign using sociotechnical concepts has taken place in the U.S. which explicitly concerned issues of safety. Trist et. al (1977) report on the design process, problems of implementation and diffusion, and results in this three year experiment in an underground coal mine. This case study will be used as an example to relate sociotechnical theory to potential accident issues.

As is often the situation, one major impetus for change in this organization was new technology, in this case a highly sophisticated, complex machine for removing the coal from the mine wall. Overall productivity was far less than the machines estimated capacity and it was clear that the social system was improperly designed for the new technology, which essentially shifted the problems for "getting" coal to transporting the coal and maintaining the machinery. Safety continued to be a major problem.

The old system was representative of many manufacturing systems. A crew of workers had specific jobs and were coordinated by a foreman. They were paid partially on tons of coal. The foreman was responsible for productivity and safety. Maintenance was performed by a separate group. The problems here were greatly enlarged by the dynamic environment, both physical (geology of the mine) and procedural (changing regulations concerning safety). The foreman's problems were largely the difficulty in coordinating the work in the mine's environment and the perceived double-bind between safety and production.

The new design used autonomous work groups, with each worker trained in several former "jobs," each with equal pay, and with the team of workers coordinating their own efforts. Responsibility for production lay with this work team. They received additional training in "management" level issues they now had assumed. The foreman was therefore freed to work on safety, planning ahead, and getting proper resources. Incentive pay was now over all three shifts within one mine shaft, reducing the former inefficient and hazardous competition between shifts. Two maintenance men were reassigned as regular team members. The design was considered to be "evolving" rather than fixed or predetermined, and additional training was inserted whenever it seemed necessary. (One major unforeseen training need turned out to be middle management, who felt threatened by the new organization and who began to see information in the form of "orders" for resources flowing <u>upward</u> rather than down.)

Both productivity, in terms of tons of coal, and safety, in terms of accidents and citations, improved. In addition, the "autonomous" group was able to adjust to changed safety regulations with much less productivity loss than the "nonautonomous" groups. The men reported to their union that they felt more respect from management and were less tired at the end of the shift from less stress in relations with the "boss." They also reported leaving things in less of a "mess" for the next shift. The results here clearly stand squarely against the common folklore in management that increased safety must come at the expense of productivity. While such may be the case if the design of both the social and technical systems is left intact, and safety is simply "added" on as a further constraint, it will in all probability seldom be the case where new designs take it into account from the beginning.

Sociotechnical Principles and Their Application

Cherns (1977) has synthesized the experiences gained in many sociotechnical design efforts into a set of ten principles. These will serve here as a framework for exploring potential applications to the problems of safety. The current state of the industrial accident problem, the experiences in the underground mine, and other organization and work design issues will be discussed within the framework of these principles.

For our purposes Chern's ten principles can be grouped under six headings: variance control, boundary location, work group organization, management support, design process, and quality of working life.

Variance Control. Sociotechnical theory sees an appropriate role for people as controlling variances, or unprogrammed, random events. The need for this role is increasing as technology becomes more automated. The continuous process machine is an example. Increasingly, people are asked to watch and wait – then act quickly to disturbances or breakdowns. Both the timing and the precise nature of the required response may be unpredictable. Inadequate control is often diagnosed as related to lack of information ("information flow" is another of Cherns' principles).

The important organizational issue related to the control of variance is that it should be controlled as close to its source as possible. This design will facilitate the necessary knowledge for effective control, the awareness that a variance has occurred, and make possible a learning system whereby future variances may be reduced. Obviously each of these issues can be viewed as an information need. A qualitative organizational error is made if a variance is "exported" to an adjacent department. Obviously, detection and effective control are more difficult, and a learning system greatly inhibited by communication flow through coordinating management structures (if at all).

In the underground mine case the new, sophisticated coal cutting machine shifted the jobs to controlling breakdowns in the machine and in the transportation system variances. The workers' organization and training had to change correspondingly. It is probably the case that while an increasing number of job reflect variance control, workplace design, tools, and training still reflect earlier systems, wherein continuous, repetitive functions were dominant. Specific job design and training for variance control may well be one of the most critical issues for safety. Many accidents can be clearly traced to workers attempting to cope with something gone wrong, and forced to use their own discretion in applicable methods because of time stress and the lack of available supervision. It seems evident that accidents would be reduced if these unpredicted events were catalogued and made an explicit part of both training and design. Many conveyor accidents, for example, involve either unjamming or slippage – two variances that could easily be part of both job design and subsequent training.

Boundary Location. Boundaries can be based on technology (a group of similar machines), territory (people in a common area) or time (a shift). Misplaced boundaries cause coordination, scheduling, and communication problems. Sociotechnical theory suggests that boundaries be drawn so as to contain a group necessary to carry out some reasonably complete segment of the work. In the mine case the boundary between maintenance and operations was redrawn to include some maintenance function within operations, avoiding delays with breakdowns. Correctly placed boundaries also make it easier for a worker to understand his/her role and to appreciate the contribution made by that role.

Boundaries between maintenance and operations and between operations and production or industrial engineering appear as possible accident problems. Problems originally diagnosed as communication problems may well relate more to a misplaced boundary which effectively inhibits information flow. Boundaries between safety committees and those making production or method decisions should be examined as potentially reducing the effectiveness of the safety effort.

Work Group Organization. Two of Cherns' principles relate to the structure of the work group itself—minimum critical specification and multi-function.

Minimum critical specification rejects the idea that, in addition to specifying what is to be done, we must tightly specify precisely how the work is to be accomplished. This idea was at the core of "scientific management," with its "one best way." It unfortunately lingers on as a misunderstood extension of concepts like optimization in operations research. Whatever value the idea had in 1900 it has clearly outlived that usefulness. One statistic of relevance is that the average worker today has approximately nine years more formal education than his counterpart in 1900 (Davis, 1977a).

The important gain when decision-making and method selection is close to the actual work floor is adaptability to change. Organizations are increasingly finding this ability to be crucial for their profitability, if not survival. The need for specification of "how" is lessened by organizing the workers into groups such that knowledge and skills can be rationally shared. Leaders or experts then can arise naturally, on a temporary basis, as their particular abilities are called for. The group themselves makes these decisions. Training then stresses the learning of a variety of relevant skills - becoming multi-functional. In the mine case all workers in the autonomous work group were encouraged to learn all tasks required of the group. Thus if particular problems came up in machine maintenance or roof shoring, for example, the team could easily shift its manpower to cope. Absent workers, for example, are more easily adjusted for, as are any workers undergoing temporary handicap. The relative ease with which the mine group reorganized their work to meet changed safety regulations indicates the range of benefits from decisions and methods selection made at the operating level. Many organizations adopting the multifunctional training system have also adopted a "pay for skill" wage plan, wherein wage level is tied to the number of skills learned.

Multi-functionally trained groups can act more effectively and rapidly in emergencies, and this form of work organization and training is common in fire, police, medical trauma, and military groups.

A careful look at what people are actually doing on their jobs shows that discretionary actions, not in the job description, are often crucial to success of the unit - people getting things done in spite of, rather than using, the detailed rules and procedures. The multi-skilled group, with appropriate autonomy, simply represents a design explicitly recognizing this reality.

The group's self-coordination, and its ability to select and devise methods, are aided by each member being familiar with a range of required skills and tasks. Cooperation and information flow are more effective if individuals are familiar with details of the tasks being attempted by other group members.

These new organizational forms appear to increase our safety problems in-so-far as standard methods "from above" are less relied upon. It seems to be the case, however, that a majority of accidents involve people doing work that is distinct from their usual job, and with no standard method available. The difference is that sociotechnical theory assumes a higher level of training, understanding of the processes, and responsibility than "scientific management" assumed, and thus expects workers to be able to make substantive contributions to methods. The role of the production or industrial engineer, or safety expert, becomes that of a consultant, called in by the work group. In the mine, methods previously the concern of the foreman became the responsibility of the work group. They were therefore in a better position to continually and rapidly adapt to changes imposed by their work environment.

Management Support. Cherns calls this "support congruence". The principle is deceptively simple — support from management (and organizational rules) should reinforce desired organizational behaviors. This principle, as logical and common sense as it appears, is very often violated, the revelation of which is a surprise to management. Violations are common in safety.

Three problem areas can be identified: 1) rules, regulations, lectures, memos, and reprimands are made on safety, while short-term production is paid for in piecework or other direct incentive systems; 2) cooperation is requested and required for certain safety related issues, particularly involving maintenance of large processing systems, but pay and promotion is clearly based on recognition of individual achievement, often in an openly competitive environment; and 3) supervisors are promoted for production (again short-term) and berated for safety failures under their jurisdiction.

Problem (1) often manifests itself in workers finding shortcut solutions to problems and increasing hazard levels. Management conveniently turns its back, encouraging these "clever" techniques for short-term gains — until an accident occurs, at which time they do not hesitate to drag out the dusty rule book. Achievement recognition based on competition between individuals [problem (2)] is a mainstay of American culture. It is becoming increasingly dysfunctional as automation comes into place and work necessarily becomes less fractionalized. Cooperation must be explicitly rewarded while not forgetting that individuals still need personal recognition. Problem (3) leads supervisors to spend less time investigating safety and performing training and supervision appropriate to safety maintenance. They, like the workers, simply hope that luck will be on their side.

The underground mine made three changes relevant to this principle: 1) the change in pay to reflect coal delivered over all three shifts in one location, rather than each shift separately, to foster needed cooperation for safety; 2) removing the responsibility for short-term production from the foreman, freeing him from his perceived double-bind between production and safety and allowing him the time to plan for safety; and 3) removing the traditional one man/one job structure, with differential pay, and forming a team with equal pay to better handle needed cooperation in production.

Designers and managers should carefully think through exactly what procedures they wish followed, especially during maintenance or system breakdown. Conflicts between safe and expedient solutions should be resolved. Cooperation will often appear as a desirable behavior that is explicitly not encouraged by the existing reward structure.

Lack of support congruence can have a major effect on information flow, particularly the sharing of knowledge of things like idosyncratic process control procedures (Engelstad, 1979). The organization structure must be designed to help counter possible perceived accumulations of power from withheld information, either by individuals or groups.

Design Process. Cherns has three principles that we will consider here; design process, transitional organization, and completion. In addition, the minimum critical specification principle discussed under "work group organization" takes on a different meaning within the design process.

Design, or redesign, occurs more often than generally recognized. Every indication is that the need for an organization to change will increase, and that the ability to continually redesign may be one of the most important attributes for future survival. Continual change, in-so-far as it inhibits the development of well thought through procedures and places an increasing burden on training, will be an important factor in safety. The methods for redesign and change implementation are therefore of interest in regard to accident causation.

One concept within Cherns' "design process" principle has interesting implications for safety; that people who will have to live with a design should participate in its creation. Our interests here are toward the continual, local redesigns related to product or process change or personal reorganization, for example. Participation by the shop floor workers in the redesign process leads to three possible results, all of interest to safety: 1) an increased understanding of how the system works, 2) increased motivation, especially toward implementing the new design successfully, and 3) a better design, in that expertise gained from direct, operating experience is automatically brought into consideration. The first result helps workers to avoid errors due to ignorance of the system "just beyond" their particular task and to cope with unforeseen contingencies. The author has investigated a number of accidents wherein the machine was not shut down, or was inadvertantly restarted, due to ignorance of total machine functioning.

The minimum critical specification principle comes into play here again, in suggesting that designers tend to produce designs with three characteristics, all possibly detrimental to the proper working of the social system, and thus potentially relevant to accidents: 1) designs completed as early as possible, often with inadequate considerations of the social system or implementation issues; 2) designs considering only the technical system — with the social system meant to "fill in", somehow; and 3) designs complete in levels of detail that rather than help, actually inhibit "local" adaptations to circumstances unforeseen by the designer. Participation by the effected workers would seem to be a potent countermeasure on all three of these points.

A second concept in Cherns' "design process" principle is that the design should be "middle-out", starting with the "core technology". In the underground mine, for example, the design began with the coal cutting machine, its complimentary coal delivery systems and the human tasks and roles necessary for these to function. It then expanded to include both specific jobs and training needs and to include the new role for the foreman. A design which had started at the "bottom" would, most probably, have linked men to specific jobs, and one starting at the "top" might well have started with the group as it had been, and missed the issues of cooperation between shifts and relocation of maintenance people. Safety could avoid its "add-on" problems if it were immediately one of the effectiveness measures for the core technology system and design decisions, including task allocation and training, were made to reflect safety along with the production and cost decisions. This procedure might help to avoid the problems of safety "programs" that tend to die out in a few months or with a change in personnel.

Cherns' principle on "traditional organization" points to the need for an explicit implementation organization with any sizeable change. For our purposes here, this translates largely into training and related supervision during early periods of a new design, when accident potential is usually higher. Cherns' principle on "completion" notes that design is really a continuous process. As noted earlier, this problem seems to becoming more acute, as organizations find it necessary to continually adapt to imposed change. Participative design from the shop floor appears as a useful strategy here, in that both the identification of needed redesign and the implementation problems are heightened at that organization level.

Quality of Working Life. This principle, or set of principles, within sociotechnical theory is an attempt to operationalize the motivational needs of the worker that relate to performance on the job. It is an explicit recognition that it is not adequate to consider people as simply machines or machine extensions if we desire their best work performance. Jobs designed under prevalent "scientific management" theory, fractionalized and with layers of supervision, are built on a totally machine-like view of the worker, with no decision-making or other discretionary behavior. Even modern human factors or ergonomics considerations usually ignore motivational issues.

The problem here, from the standpoint of safety, and quite aside from the main sociotechnical arguments for quality of working life, is that people often have accidents <u>because</u> of their discretionary acts. They recognize that they must attempt tasks that they have had little or no training for, and without the opportunity of supervisory advice. These acts are taken because the worker takes on responsibility for the effective performance of the job; responsibility usually not assumed in the design of his job. He is, in effect, in a double-bind, being punished for a failure to "keep things going", and punished if the methods he adopts lead to an accident.

Sociotechnical theory starts with a very different set of assumptions. It assumes that people are required in the system largely for their discretionary, decision-making abilities, and that they will take the necessary responsibility if given the correct organization and support. (It further notes that simple, repetitive jobs, which can be completely prescribed, should be examined for possible automation, being ideally suited for machines and not for people.) Motivation toward good work performance thus becomes essential. Since sociotechnical theory focuses on the workers discretionary acts, and how to support their effective occurrence, it speaks directly to the accident problem.

The quality of working life principles are (Davis, 1977a; Cherns, 1977): 1) the need for the content of the job to be reasonably demanding, with some minimum variety; 2) the need to be able to learn on the job, and to continue relevant learning; 3) the need for some decision-making authority or discretionary activity as part of the explicit job; 4) the need for social support from co-workers and supervisors; 5) the need for recognition of contributions; 6) the need to be able to relate what one does and what one produces to friends and family; 7) the need to feel that the job leads to some desirable future (not necessarily promotion); and 8) the need for consideration of individual differences in needs and abilities in all of the above.

Two outcomes of attention to these quality of working life principles are relevant to safety. The first is the increased attention to worker discretion and decision-making, which, when coupled with related training and organizational support, will place the worker in a better position to take on the "keep it running" tasks. Secondly, the increased motivation toward the work in general promises increased attention to the work, decreased turnover and absenteeism, and less alcohol and drug abuse, for example. In the mine, the reforming of the work into autonomous work groups, with members having a variety of skills and minimal direct supervision led the participating workers to express the fact that their own "quality of working life" had improved. Several of the principles outlined above can be seen in the redesigned mine.

REFERENCES

Cherns, A.B. "Can behavioral science help design organizations?" Organizational Dynamics. Spring 1977, 44–64.

Cherns, A.B. "Is there such a thing as accident proneness?" Loughborough, UK: University of Technology, 1975.

Cherns, A.B. and Wacker, G.J. "Analyzing social systems: An application of Parson's microsystem model to the organizational level and the sociotechnical perspective." Human Relations, 1978, 31, 823–841.

Cohen, A. "Factors in successful occupational safety programs." J. of Safety Research, 1977, 9, 168–178.

Cohen, A, Smith, M.J., and Anger, W.K. "Self-protective measures against work place hazards." J. of Safety Research, 1979, 11, 121–131.

Davis, L.E. "Evolving alternative organization designs: Their sociotechnical bases." Human Relations, 1977a, 30, 261–273.

Davis, L.E. "Job design: Overview and future direction," J. of Contempory Business, Spring, 1977b, 85–102.

Davis, L.E. "The coming crisis for production management: Technology and organization," Intern J. of Production Research, 1971, 9, 65–82.

Davis, L.E. and Engelstad, Per H. "Unit operations in socio-technical systems: Analysis and design," Readings in Organization Design, Edited by L.E. Davis and A.B. Cherns. Los Angeles: University of California Center for Quality of Working Life, 1977.

Emery, F.E. and Trist, E.L. "The causal texture of organizational environments," Human Relations, 1965, 18, 21–32.

Engelstad, Per H. "Sociotechnical approach to problems of process control," in Design of Jobs, 2nd edition, edited by L.E. Davis and J.C. Taylor. Santa Monica, California: Goodyear, 1979.

Firenze, R.J. The Process of Hazard Control, Dubuque, Iowa: Kendell/Hunt. 1978.

Gyllenhammer, P.G. People at Work, Reading, Mass: Addison-Wesley, 1977.

Hammer, W. Occupational Safety Management and Engineering, Englewood Cliffs, New Jersey: Prentice-Hall, 1976.

Herbst, P.G. Socio-Technical Design and Strategies in Multidisciplinary Research, London: Tavistock, 1974.

Hill, P. Towards a New Philosophy of Management, London: Tavistock, 1971.

Jones, D.F. "Effectiveness of different types of occupational health and safety programs." Ontario (Canada) Ministry of Labor, January 1979.

Malasky, S.W. System Safety, Rochell Park, New Jersey: Hayden, 1974.

Powell, P.I., Hale, M., Martin, J. and Simon, M. 2000 Accidents: A Shop Floor Study of Their Causes, London: National Institute of Industrial Psychology, 1971.

Proceedings, "System Safety Society 4th International Meeting," San Francisco, California, 1979. Newport Beach, California: System Safety Society, 1979.

Shafai-Sahrai, Y. Determinants of Occupational Injury Experience: A Study of Matched Pairs of Companies, East Lansing: Michigan State University, 1973.

Smith, K.U. Self-Governed Behavioral Safety Codes for Industry; Human Factors of Optimal Performance Safety Standards in Control of Operational Hazards, Madison, Wisconsin: Department of Labor, Industry and Human Relations, 1975.

Swain, A.D. The Human Element in System Safety, and Design Techniques for Improving Human Performance in Production, Surrey, U.K.: In Com Tec. 1974.

Trist, E. "A sociotechnical critique of scientific management," in Meaning and Control, Edited by D.O. Edge and J.N. Wolfe, London: Tavistock, 1973.

Trist, E.L., Susman, G.I. and Brown, G.R. "An experiment in autonomous working in an American underground coal mine," Human Relations, 1977, 30, 201-236.

Tuttle, T.C., Dachler, H.P., and Schneider, B. "Organizational Psychology," The Human Side of Accident Prevention, edited by Margolis, B.L. and Kroes, W.H., Springfield, Illinois: Thomas, 1975.

Mattison, P.C. [illegible] Technical [illegible] and Strategies in [illegible] Research. London: Tavistock, 1972.

[illegible] The New Philosophy of Management. London: [illegible], 197[illegible].

Jones, [illegible] Effectiveness of [illegible] of occupational health and safety programs [illegible] (Canada) [illegible], January 197[illegible].

[illegible] Safety. [illegible] New Jersey: [illegible], [illegible].

Powell, P. [illegible], M., Martin, J. [illegible] 2000 Accidents: [illegible] Study of [illegible] Causes. [illegible] National [illegible] of Industrial Psychology, 197[illegible].

[illegible] Safety Society, [illegible] Meeting, San Francisco, California [illegible] Newport Beach, [illegible] Safety Society, 197[illegible].

[illegible] Determinants of [illegible] Injury Experience: A Study of [illegible] Companies. East Lansing: Michigan State University, 197[illegible].

Smith, [illegible] Governed Ben[illegible] Causes for [illegible] Human Factors [illegible] Performance [illegible] Council of Occupational Hazards. [illegible] Department [illegible] and Human Relations, 1975.

[illegible] Human Element [illegible] Safety, and [illegible] Techniques for [illegible] Performance in [illegible], 197[illegible].

[illegible] statistical [illegible] management in Mining and [illegible] U.O. [illegible], 197[illegible].

[illegible] and [illegible] working in [illegible] coal [illegible], 197[illegible], [illegible].

[illegible] H.P., and [illegible] B. "[illegible] Psychology." The [illegible] Accident Prevention. [illegible] Springfield, Ill.: Thomas, 197[illegible].

ERGONOMICS IN OCCUPATIONAL SAFETY

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INTRODUCTION

I am delighted to be here to discuss the needs and resources necessary for the development of occupational safety as a respected field in science and practice. The speakers and papers that follow these introductory remarks will illustrate how ergonomics has been used and can continue to be used as the basis for a disciplined approach to occupational safety problem solving.

I will attempt in my comments to emphasize the complementary role that ergonomics and injury epidemiology must play to build a more respected occupational safety field in the future. I will also attempt to emphasize the need to integrate and reference existing ergonomic principles in occupational safety problem recognition and control. Further, I will attempt to illustrate the complexity of safety hazard recognition and control from an ergonomist's perspective, which supports the need for a greatly enlarged research effort in this country. My illustration will involve the accident category often referred to as Falls from Elevated Work Surfaces. As such I will also be commenting on the deficiencies that I perceive exist in existing Occupational Safety and Health safety standards, and the challenge that such deficiencies present to the occupational safety field and, in particular, to ergonomists in the future.

THE EMERGING DISCIPLINE OF OCCUPATIONAL SAFETY

It clearly is acknowledged by many authorities in the field of occupational safety that the problems confronting the professional are very complex and involve a multitude of human and process related factors and their interactions. To study such a complex phenomenon requires a highly disciplined approach. To develop such a disciplined approach three specific developments are necessary. These are:

1. Data acquisition methodologies and the application of these methodologies to develop easily accessible data sources.

2. Accident models or hypothetical constructs which allow the meaningful analysis and interpretation of data about the accident phenomenon.

3. Methods and opportunities to validate specific accident intervention and control strategies appropriate for specific hazards.

THE ROLE OF ERGONOMICS IN PROVIDING A DISCIPLINE

I propose that ergonomics can provide a basis for a disciplined approach. It, in particular, combines the knowledge and behavior with engineering concepts about production processes. These models and theories are necessary to the understanding of the injury and illness data which are being generated by improved epidemiological methodologies. This leads to the insights necessary in the field to develop innovative control strategies.

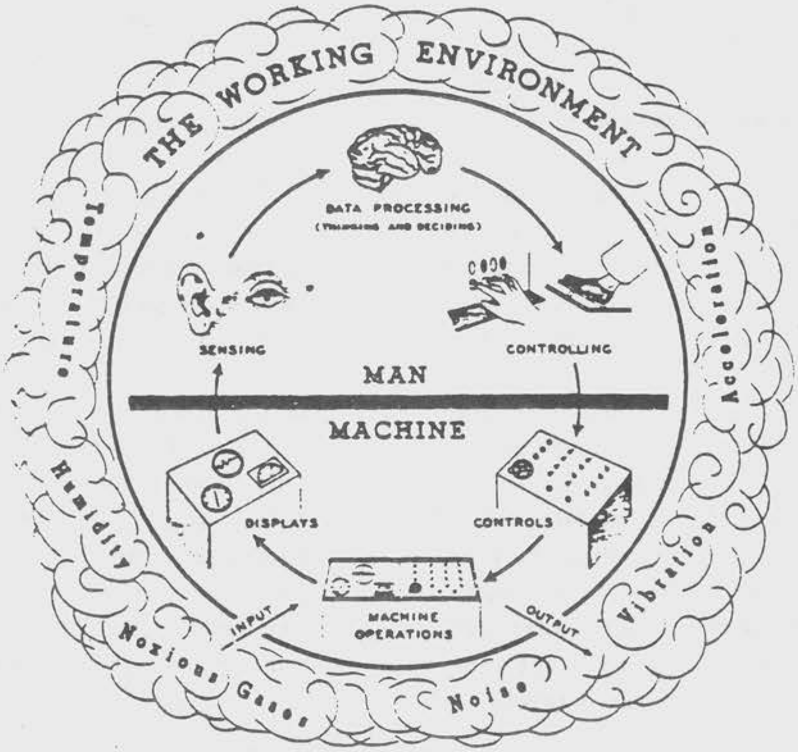
ERGONOMICS IN PERSPECTIVE

Ergonomics recognizes and attempts to deal with the complexity of a person, a task and the environment. In its literal Greek interpretation, it means "the study of work," where work is defined as an organized effort by people to produce products or services. Though there are many different ways to illustrate what this type of a definition implies, I have chosen a common illustration in Figure 1.

This figure illustrates that there is a system of complex interactions in the workplace. In the United States we have defined a specific professional field to study the interactions of people with the health related hazards in what Dr. Chapanis calls "The Working Environment." This profession we now refer to as industrial hygiene. To anticipate those conditions and work methods which could result in accidental situations resulting often in acute injury, we rely on another type of professional known now as the safety professional. Further, we have developed a set of knowledge about how people work with machines, tools and work methods to establish performance or productivity norms in industry. This latter expertise we have largely delegated to the industrial engineer.

Figure 1

SIMPLIFIED MODEL OF A MAN-MACHINE SYSTEM*



*From Chapanis, A., 1965, Man-Machine Engineering, Wadsworth Publishing Company, Inc., Belmont, California.

What the ergonomist would claim, however, is that the interaction between the person and the process or operation is too complex to be adequately dealt with by the current split in professional disciplines concerned with either performance capability alone or acute injury. Rather we must be concerned with the total interaction that occurs between the person, the task, and the working environment, and the resulting harm or limitations that may result. Ergonomics has chosen to deal with these complexities as a basic science. As such, it relies on the basic knowledge of how various types of interactions can not only limit performance of the system to meet some organizational objective, but also result in harm to the individual worker or groups of workers in the system in chronic or acute ways.

Ergonomics then has a unique direction. It focuses on the combinations of interactions of people with machines, operations, tools, work methods, and the working environment. It has a unique role in that it concentrates its attention on understanding people who are at work, and how such people can be provided with improved work environments, tasks, machines, and operations.

Historically, very extensive ergonomics-type literature began to be developed in the 40's regarding such things as the design of aircraft controls and displays, the training of individuals for combat assignments, the anticipation of heat stress conditions in desert warfare, the data on the size of pilots, and the time and motion data developed to predict the performance capability of manual production systems. These all recognize both the variability of human behavior and the resulting human tolerances which occur under many different operating conditions. Such extensive data are useful today in that they do provide insight into how people interact with civil and military oriented tasks.

In the 50's there were enough people involved in ergonomic problem solving that the discipline became more organized with the founding of The Ergonomics Research Society in Great Britain and the Human Factors Society in the United States. At the same time, journals were developed which emphasized the nature and complexities of the ergonomics-type problems.

By the 60's the Ergonomics Research Society of Great Britain enlarged its scope of activities, from an organizational standpoint, and provided a basis for what is known as the International Ergonomics Society. Additional degree programs were begun, particularly in Sweden, England, and other European countries. These programs emphasized the need to have specialists who understood the great variety of human responses to varied work conditions. In parallel in the United States, industrial hygiene as a discipline continued to grow, with an emphasis on toxicological hazard recognition.

With the advent of OSHA in 1970 the safety professional was greatly stressed to understand and interpret the voluminous legal safety regulations developed to supposedly control hazards. The emphasis of OSHA regulations on engineering hazards out of the workplace resulted in additional industrial engineering programs emphasizing the application of human factors or ergonomic principles in the design of work situations.

The combined emphasis on ergonomics in the United States and throughout the world has resulted in over 5,000 members being associated with the International Ergonomics Society today. This has gradually stimulated the life sciences, behavioral sciences and engineering sciences to integrate research and academic programs in efforts to solve workplace-oriented problems. Figure 2 illustrates this concept further.

ERGONOMICS IN THE SAFETY PROFESSION

Despite these developments, it must be conceded that we have a limited number of people available in the United States who are familiar with contemporary ergonomic principles. In fact, I propose that a great deal of the knowledge we need to control harm exists, but is not in journals commonly read by even those few safety professionals who are in the best position to control such harm. I suggest that the human physical and mental responses that must be anticipated to design a work setting free of hazards are to a large extent predictable but are not commonly considered in the work design process. This knowledge I speak of is often presented in the Human Factors Journal, or the Ergonomics Journal, or Applied Ergonomics Journal and text books on ergonomics subjects.

These and other specialty journals which discuss appropriate human responses under both physical and mental stresses are claimed by some "professionals" to be scientific journals, but I would argue that to develop a discipline necessary to establish a professional field of endeavor requires that the professional be conversant with the latest scientific developments, especially when dealing with health and safety matters.

This lack of awareness of scientific information on the part of the safety professional, I conclude, is one reason safety research has not developed at the rate that health research has in the occupational setting. The complexities they are dealing with and the necessity, therefore, for establishing a good science to understand such complexities has not been recognized by this group of practicing professionals.

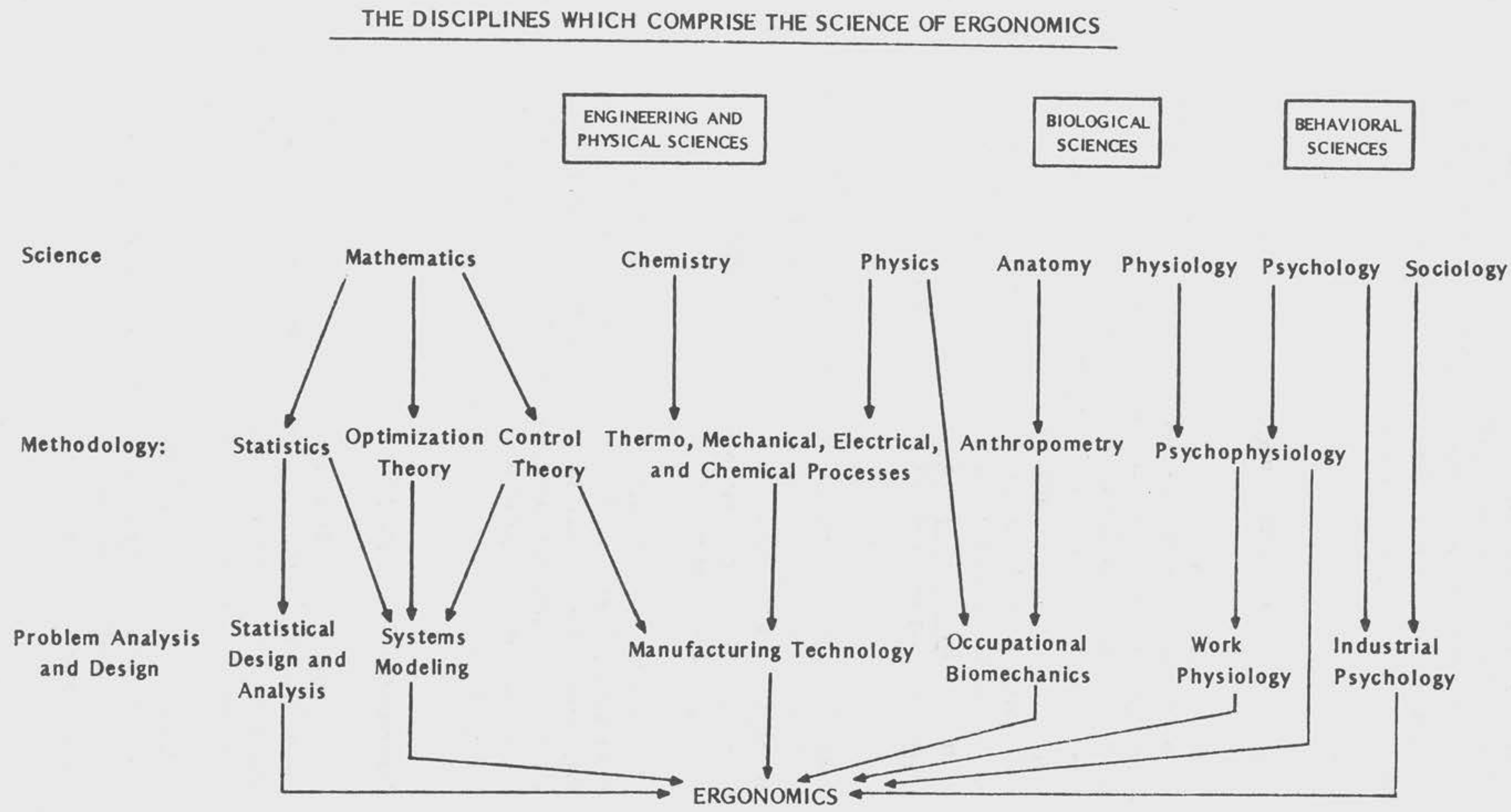
ERGONOMICS AND NIOSH SAFETY NEEDS

The problem that faces all of us on a national scale is to develop a plan for safety research which takes full advantage of the existing bodies of knowledge regarding people and their interactions in the workplace. This plan of action must be widely circulated and discussed.

Two years ago, in an attempt to develop such a plan of action, NIOSH wrote what they refer to as a 5-Year Occupational Safety Research Document—A NIOSH Strategy. This document was developed in consultation with outside experts and represents a 5-year plan for occupational safety research. As such, the document

Figure 2

ERGONOMIC DISCIPLINES



emphasizes the need for research to be carefully planned in occupational safety, due to the complexities of the conditions that create harm in the workplace. The priorities for research were established by reviewing varied injury statistics and workers' compensation reports as well as reviewing available knowledge necessary to develop control strategies. Five types of accidents were identified by this procedure as predominant in the field of occupational safety. Table I gives an approximate breakdown of the high priority accident areas identified in the NIOSH safety strategy document. This table illustrates that there are a number of high priority areas wherein both the science of hazard recognition and perhaps more importantly, the science necessary for effective control, has not been well developed.

The NIOSH Safety Strategy Document also contained a proposed budget for 5 years to fund such research. Table II indicates the suggested level of funding for the five high priority areas described in Table I. At first the dollar values, which include in-house and extramural funding of research, appear to be quite adequate. Upon more close scrutiny and contemplation regarding the complexities in each category, however, one is led to the inevitable conclusion that the funding levels are quite insufficient to meet the discipline requirements. What these budget figures represent are approximately 3% of NIOSH's total operating budgets. Last January and February (1980) the National Advisory Committee for Occupational Safety and Health (NACOSH) publicly reviewed the strategy document and unanimously agreed that it was very conservative in its recognition of the complexities of occupational safety problems, and that NIOSH had to give much greater attention to safety research than it had since its conception. Such research, if prorated over U.S. workers, would amount to a safety research expenditure of about $.02 (2 cents) per worker per year.

To illustrate the point still further I have chosen the category of accident entitled "falls from elevations." This category is one that many feel is the most complex accident situation to control. In varied work situations the control strategies are highly elusive. In other words the challenge to the safety scientist is great, requiring (1) a varied approach to describe the associated problems in all of their complexities, (2) epidemiological data to understand the causal factors involved in injuries resulting from falls from evaluation, and (3) a basic knowledge necessary to develop innovative and effective control strategies in many different situations involving work on elevated surfaces.

Table III is my attempt to give some examples of what could be titled "Ergonomic Oriented Investigations Necessary to Prevent Falls from Elevations." I've had the opportunity along with several of my colleagues in the last couple of years to work with OSHA to explore some of the studies suggested in Table III. This meager effort has given me a great appreciation for the extent of original thinking necessary to develop effective control means. I would estimate from this experience that each one of the topical areas indicated in Table III could substantiate research outlays of a minimum of half a million dollars. Such funding would provide the stimulus and incentive necessary for researchers in occupational biomechanics, work physiology, anthropometry, psychomotor skills, psychophysics, injury epidemiology, industrial psychology, industrial engineering and many other allied fields supportive of ergonomics to concentrate their capabilities on this very important problem area.

Table I

PRIORITIES FOR RESEARCH BY TYPE OF NIOSH ACCIDENT*

Accident Type	Index of Importance	Rank Order
Falls from elevations	17	1
Caught in, under or between	17	1
Overexertion	16	2
Struck by	16	2
Falls on same level	9	3
Struck against	3	4
Contact with extreme temperature	2	5
Contact with electric current	2	5
Contact with radiation	0	--
Motor vehicle accidents	0	--
Bodily reaction	0	--

Table II

NIOSH RESEARCH FUNDING PLANS
(Totals for Five Years)*

Accident Types	Five Year Total	Per Annum
Falls from elevations	$2.82 million	$564,000
Caught in, under, between	$1.93 million	$386,200
Overexertion	$1.50 million	$300,000
Struck-by**	$3.40 million	$680,000
Falls on same level	$0.55 million	$110,000

*From Five-Year Safety Strategy Document.

**Struck-by research is largely funded by Safety Equipment Section of NIOSH.

Table III

EXAMPLE ERGONOMIC ORIENTED INVESTIGATIONS TO UNDERSTAND AND PREVENT FALLS FROM ELEVATIONS

1. Tethering and Tie-off Studies, involving
   - A. Lanyard and harness biomechanics
   - B. Hook-up procedures in various jobs
2. Safety Net Studies, involving
   - A. Placement effectiveness
   - B. Biomechanical tolerances
3. Ladder Studies, involving the effectiveness of
   - A. Location and configuration
   - B. Rung/stringer configuration
   - C. Portability
   - D. Wind loading limitations
4. Guardrail Studies, involving the effectiveness of
   - A. Location and configuration
   - B. Alternative barriers
   - C. Special uses on scaffolds
5. Handrail Studies, involving
   - A. Stairs
   - B. Ladders
   - C. Scaffolds
6. Fall Warning Device Studies
7. Climber Training Program Studies

ERGONOMICS AND OSHA NEEDS

As presented by Dr. Purswell earlier in this proceedings, one strategy for controlling unsafe work conditions is to develop more effective safety standards. We certainly must concede that federal and state safety standards are voluminous. However, I would propose that these standards have two types of major deficiencies which have greatly curtailed their effectiveness. The deficiencies are:

1. Most of the safety standards that exist today do not deal with the types of hazards that often create the greatest amount of harm in the workplace.

2. The standards that exist don't rely on the contemporary knowledge that has developed in the general field of ergonomics.

The types of hazards that aren't recognized are usually complex hazards. Some illustrations of these are hazards related to (1) handling of heavy loads, (2) worker fatigue, (3) postural stress, (4) vibration stress, and (5) heat and cold stress. The second deficiency, that is the general exclusion of ergonomic principles in safety standards, is probably a natural result of the problem I discussed earlier (i.e., the lack of concern for establishing a science in safety matters). The individuals that wrote the early consensus standards upon which OSHA developed its current safety standards were not conversant with the scientific ergonomic oriented literature, nor were they involved in ergonomic studies in their industries when the early standards were developed. The unfortunate point is that OSHA was forced by Congress to these consensus standards without time for critical, scientific review.

CONCLUSION

In conclusion, I would support the rapid expansion of increased epidemiological investigations in the safety areas. This effort would clearly meet two of the disciplinary requirements that I stated in the beginning of this paper. First, epidemiological data is necessary to provide the objective basis for hazard recognition in industry. Second, epidemiological methodologies are necessary to validate particular intervention control strategies.

I would caution, however, that epidemiology is not enough. It is extremely important to have fundamental laboratory and field studies of the complex interactions of people in various work situations. These I have referred to as ergonomic studies. They are as necessary in the safety field as toxicology is in the health field. Only through such fundamental investigations can we develop the basic understanding and prescriptive knowledge necessary to develop innovative and hopefully effective safety control strategies.

I would emphasize that the NIOSH Five Year Strategy Document for Safety has identified areas of need for concerted study. I hope, however, that these and areas identified by future epidemiology will have increased funding, since the harmful conditions in the workplace are highly complex, and not easily generalized across industries and processes.

Clearly, the challenge is great to all of us. We are discussing the knowledge necessary to save many thousands of lives each year, but perhaps more importantly we are discussing the knowledge necessary to provide the protection needed to maintain the quality of life for millions of individuals in the United States each year. Thank you!

Acknowledgement

I wish to thank Professor James Miller and Edith Baise for their kind assistance in preparing this paper for publication.

OCCUPATIONAL INJURIES AND WORKER CAPABILITIES

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No theory in the field of occupational safety has had the impact of Heinrich's (1959) "domino theory." To most safety practitioners the third domino, the so called "unsafe act" or "unsafe condition" is probably the most familiar. Along with the theory came the premise that 88 percent of all accidents were preceded by an unsafe act. This developed into the popular 90–10 theory of accident causation. This theory persists today in spite of the fact that little supporting published research exists. The influence of the theory is most evident at the worksite itself, although it certainly persists at other levels as well, particularly in state and local government safety agencies. Most significant is the fact that the theory has done very little in the way of providing useful methods for reducing the incidence of occupational injuries. In some cases it must be concluded it has actually been detrimental. For example, it is a common practice for industry safety personnel to lump injuries and illness together (e.g., in calculating total lost work days, medical costs, workers compensation costs, etc.) Since most occupational diseases go unreported (Ashford, 1975), it is not uncommon to find that some form of unsafe action played a part in most reported cases. The logical conclusion to be drawn is that one must concentrate major resources on the "person" aspects of the problem by attempting to reduce errors, mistakes, inattentiveness, carelessness, etc. While this may lead to positive efforts such as improved training, the unfortunate consequence often is seen in the neglect of serious unsafe conditions such as noise, air contaminants, temperature extremes, and other physical stresses, as well as a variety of safety hazards. This type of thinking typified much of the early criticism of OSHA standards and inspections activities.

The "unsafe act" or "person" approach has generally been characterized by motivational and educational campaigns, movies, contests, posters, and slogans. One of the most popular has been the no-lost-time contest. One study indicated 65 percent of all businesses surveyed attempted to identify "accident prone" individuals, 85% used posters to promote safety, 35% used slogans, 26% used contests, and 35% gave out awards (BNA, 1977).

Finally the philosophy underlying unsafe acts, accident proneness, motivational campaigns, etc., certainly has affected the course of professional education and research. It has undoubtably detracted significantly from research and education efforts aimed at redesigning jobs and workplaces to make them fit the worker.

ERGONOMICS AND SYSTEMS SAFETY TECHNIQUES

The concept of fitting the job to the worker is not new. It is the basis of the ergonomics approach and plays an integral part in any systems approach to hazard reduction. Gordon (1950) first advocated the use of the epidemiological approach for analysis of accidents, which is the basis for systems safety engineering techniques. Swain (1974) has emphasized the futility of attempts to change the worker instead of looking at what he refers to as accident prone situations. Haddon (1964), in his book Accident Research expanded these concepts with his set of 10 counter measures, placing particular emphasis on analyzing hazards rather than accidents. Firenze (1978) has an excellent summary in his chapter on "Application of Ergonomics to Hazard Control." Shealy (1979) described a systems approach to analyzing accident investigation techniques. So, as Shealy stated, "Many of you are probably saying at this point 'I've heard all this before'." The important point is in Shealy's next question, "But what have we done about it?"

Anyone who believes in a systems approach or an ergonomics approach or simply fitting the job to the worker ought to be stimulated to action by that question, because he obviously has not done enough. Apparently everyone has not heard it before, or they haven't been convinced. Personal observations indicate that both may be significant factors. It is obvious that at any forum on safety, someone should be up arguing the case. Unfortunately, there has never been a great debate. Suprisingly little dialogue expressing viewpoints has taken place on this issue, if there are indeed opposing viewpoints. The reasons for this are not entirely clear.

It is certainly true that a significant number of safety practitioners (specifically those directly responsible for safety in industry) have not been introduced to ergonomics or systems safety engineering. Unfortunately it may take awhile longer since many of these people learn safety techniques through traditional safety council meetings, technical schools, insurance companies, and safety equipment dealers. All of these groups will have to be reached first.

Convincing people to look at accidents in a different light faces a number of obstacles. In addition to the general problem of resistance to change, other pressures exist including, taking the easy way out and holding down costs (not to imply that ergonomics and systems safety are not easy and economical). Furthermore, in many cases, even the most basic ergonomics data does not exist. For example, which is the best industrial truck, or what type of controls should a crane have?

WORKER CAPABILITIES

The primary purpose of this paper is to emphasize the fact that many accidents which have traditionally been labeled as "unsafe acts" may have occurred because the capability of the worker was exceeded. Anytime a job includes features which require the worker to adapt or change to meet the demands of that job, the worker is put into a situation where an accident is more likely to occur. Efforts to select people who have the capabilities to meet the demands of a poorly designed job as well as attempts to overcome these effects through training can only have limited success. A good example which contrasts the different approaches to hazard reduction is provided by examination of the back injury problem. For years the emphasis has been on training workers to lift properly. Recent evidence has, however, pointed out the futility of such an approach (Snook et al., 1978). There are simply too many reasons for workers not to use that training, including inadequate or cramped workspace, bulky loads, awkward working positions, and production rates or incentive systems. It accomplishes nothing to label these as unsafe acts. Instead, each must be considered as a contributing factor in the determination of worker capabilities. Likewise, other determinants of behavior including financial rewards, fear, recklessness, experience, and age must all be considered as the capabilities of the work force are evaluated.

WORKER CAPABILITIES AND PRESS INJURIES

Results of a study of nearly 1,000 press injuries in Wisconsin provides some interesting data related to this subject. The data was taken from the results of accident investigation reports completed by State safety inspectors. In each case where an injury occurred, the hand(s) was in such a position that when the ram descended, some part of the upper extremities was contacted directly by the ram or indirectly through a force transmitted by a work piece. Thus each incident included, involved the ram descending when it shouldn't have since the hand was in or near the point of operation. The analysis included a determination of why this occurred. Eight mutually exclusive categories were established:

(a) Timing error by operator—operator normally was required to remove and/or place parts in the point of operation. The incident occurred when the operator put his hands in at the wrong time or tripped the press too early.

(b) Accidentally tripped—operator tripped press when he hadn't intended to.

(c) Machine malfunction (other than repeats)—bad switch, broken parts in flywheel or ram.

(d) Probable machine malfunction including repeats—best available evidence indicates that ram descended by itself; no other explanation.

(e) Machine recycled or repeated—operator indicated that machine had cycled a second time without reactivation.

(f) Second person tripped the press—either during set up, more than one operator, or passerby.

(g) Other operator erros—including reaching back in to clear jam, or hand slipped, etc.

(h) Beat the press—after tripping the press, the hands were put into the point of operation before ram had descended (typically on 2-hand control).

(i) Unknown—there was not enough information available to definitely determine why the ram had descended or why the hands were in the point of operation when the ram descended.

Table 1 presents results of the analysis.

The label "unsafe acts" was attached to the first five categories since these are the types of problems usually described as such. The next three categories were labeled "unsafe conditions" using the same reasoning. Seventy-five percent of the incidents which could be classified were "unsafe acts" versus 25 percent "unsafe conditions." Ten percent of these unsafe acts were timing errors. In each of these cases, it was normal procedure to put the piece into the point of operation and trip the press, usually with the other hand or a foot. Thirty-seven percent of these unsafe acts were classified as other operator errors. Common examples were removing or adjusting pieces or reaching back to adjust. Again the machine allowed the operator to have the hands in the point of operation during activation. The worker was expected to keep the hands out of the way, never reacting spontaneously to a jammed or defective piece. Forty-one percent of the unsafe acts were classified as accidental trips, i.e., the operator tripped the press when they had no intention of doing so. Once again nothing prohibited the hands from being in the point of operation during activation. Almost 8 percent occurred when another individual activated the press. Four percent occurred on 2-hand control presses when operators were able to get the hands to the point of operation after activation. It can be seen that each of these accidents could have been prevented "theoretically" had the operator acted safely, been alert, or been more attentive. Only 25 percent were beyond operator control in that they were unpredictable mechanical failures.

Table 1

RESULTS OF ANALYSIS

	Classification of Causes for Ram Descent		
	Reason	**Percentage of Total**	
"Unsafe Acts"	Timing Errors	5.4	
	Accidental Trip	21.8	
	Other Operator Error	19.9	
	Second Person Tripped	4.0	
	Beat Press	1.9	
	SUBTOTAL		53.0
"Unsafe Conditions"	Machine Malfunction	3.5	
	Probable Machine Malfunction	5.8	
	Repeats or Recycles	8.3	
	SUBTOTAL		17.6
Unknown		29.3	
	SUBTOTAL		29.3

This type of analysis would certainly seem to lead one to the conclusion that the proper way to deal with these problems is by training or motivating the worker to overcome these human inadequacies in some fashion. This all seems very logical until two other considerations are made: (1) What are the limits of humans? and, (2) Do motivational or training programs work?

There is little direct evidence to tell the safety director how many successive times one can place his hands in a point of operation without committing some sort of error. But, sheer numbers should provide some insight. Press operators can expect to have standards of production totalling 5,000 pieces per day. An operator who produces 5,000 pieces in a day is asked to put his hand in front of a ram once every 5 seconds or 25,000 times a week or 1,200,000 times per year without overtime and with 4 weeks vacation. Is this beyond the limits of human capabilities?

Then we must add all of those personal, physical, and environmental effects which affect that capability. If the magic number is 10 million, how much is it reduced by fatigue, overtime, psychological stress, heat, chemicals, etc.? What about the stress of the wage incentive system? It would seem to push the operator beyond the normal pace, indeed to his limits in many cases.

While studies have been conducted to evaluate these factors, very little has been done in the United States. One of the most interesting points is that knowledge of these effects may have an underlying effect on a variety of other types of accidents.

EFFECTIVENESS OF MOTIVATION

Finally, the second point mentioned above must be considered. How effective are motivation and training programs? Once again there is very little recent evidence either way concerning the effectiveness of such programs. There have not been any well controlled studies evaluating motivational campaigns, awareness programs, slogans, contests, or even training. If one were to borrow data from the traffic safety field, not too much faith would be put into the future of these approaches. The effectiveness of training programs in preventing back injuries have not been encouraging either. A point must be reached where the potential of traditional approaches in reducing injuries is compared with alternate approaches.

Again the results from the press study described above may provide some insights. Table 2 provides a breakdown of the unsafe acts and conditions by type of activation device. The most significant point to note is the shift in distribution for presses activated by 2-hand controls. In other words, if two-hand controls are used, the cause shifts to the condition or machine side. The assumption would be that a good number of "unsafe acts" have been eliminated. Table 3 lends support to this assumption. As can be seen, the 2-hand controls appear to have been effective in keeping the hands out of the point of operation during the cycling of the

Table 2

PERCENTAGE OF UNSAFE ACTS VERSUS UNSAFE CONDITIONS FOR DIFFERENT METHODS OF PRESS ACTIVATION

Type of Activation	Reason Hands Were in Point of Operation When Ram Descended		
	Unsafe Act	Unsafe Condition	Undetermined
Foot Pedal	62.6	11.9	25.5
1-Hand Control	69.1	13.2	17.7
2-Hand Control	34.6	54.2	11.2
Automatic or Semiautomatic	61.5	17.3	21.2

Table 3

PERCENTAGE OF ACCIDENTS OCCURRING DURING DIFFERENT ACTIVITIES BY TYPE OF ACTIVATION

Method of Activation	Activity					
	Feeding	Holding	Removing	Removing Stuck Piece	Adjustments or Maintenance	Other
Foot Pedal	30.7	10.9	11.2	8.4	4.0	34.8
1-Hand Control	26.2	10.7	9.5	7.1	7.1	39.4
2-Hand Control	16.5	2.3	36.1	6.8	2.3	36.0
Automatic or Semiautomatic	13.5	1.9	5.8	26.9	19.2	32.7

machine. Now a greater percentage of the accidents are occurring during removal of parts, due to machine malfunctions (repeats etc.).[1] The data appear to indicate the effectiveness of an ergonomics approach in reducing punch press hazards.

RESEARCH NEEDS

Unfortunately, research related to the limitations or capabilities of workers usually surfaces only in the case of accident investigations of major catastrophes such as explosions, air crashes, or radiation leaks, often precipitated by concerns over liability.

Research needs to be done to establish basic data on capabilities, frequency of errors, and normal variations. Standardized tests of job related abilities which reflect changes in worker capabilities are necessary to determine the effects of relevant personal variables such as physical strength, endurance, manual dexterity, perceptual motor coordination, reaction time, attention, and sensory capacity; as well as relevant physical variables such as noise, chemicals, fatigue, heat, and psychological stress.

One of the reasons for the lack of this type of basic well directed research in this country is the lack of clear leadership. As mentioned, this subject would typically be described as Ergonomics or Human Factors Engineering—fitting the job to the worker. The Human Factors Society which would be the natural choice for this leadership unfortunately lists only 80 of its 2,200 members as members of the technical group on Industrial Ergonomics. The interest is simply not there.

Finally, safety professionals must be educated to look for design factors which can lead to hazardous situations, how to use established ergonomic principles, and the health and economic benefits of the ergonomics approach.

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1 Data does not allow comparisons of the relative hazards of different types of controls since the total number of each type of control was not available.

REFERENCES

1. Heinrich, H. W. Industrial Accident Prevention, 1959, McGraw-Hill, New York.

2. Ashford, Nicholas A. Crisis in the Workplace: Occupational Disease and Injury, 1975, Report to the Ford Foundation.

3. Bureau of National Affairs, Safety Policies and The Impact of OSHA, Bureau of National Affairs, Inc., Washington, D.C.

4. Gordon, J. E. The Epidemiology of Accidents, in Accident Research by Haddon, Suchman and Klein, 1964, Harper and Row, New York.

5. Swain, A. D. The Human Element in Systems Safety, 1974, Industrial Techniques Ltd., London.

6. Haddon, W. Jr., E. A. Suchman, and D. Klein. Accident Research, Methods and Approaches, Harper and Row, 1964.

7. Firenze, Robert J. The Process of Hazard Control, 1978, Kendall Hunt Publishing, Dubuque, Iowa.

8. Shealy, J. E. Impact of Theory of Accident Causation on Intervention Strategies, 1979, In Proceeding of the Human Factors Society - 23rd Annual Meeting, 1979, pp. 225-229.

9. Snook, S. H., R. A., Campanelli, and J. W. Hart. A study of Three Preventive Approaches to Low Back Injury. J. of Occup. Med., 20(7), July 1978, pp. 478-481.

ERGONOMICS AT PUNCH PRESSES

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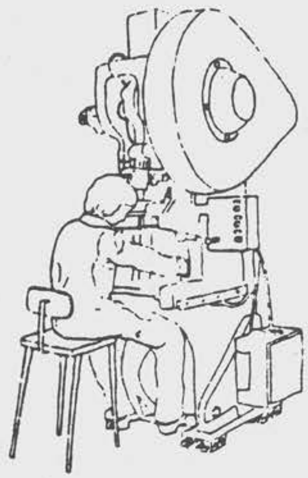
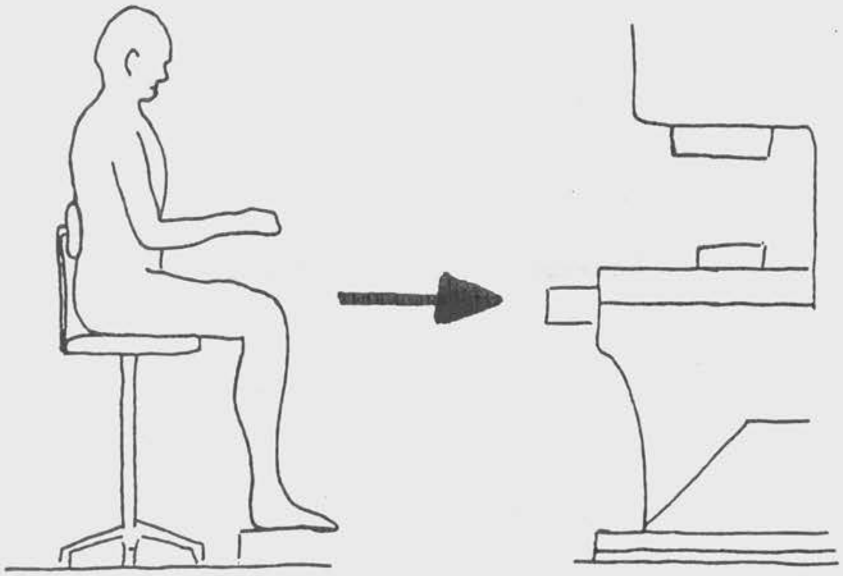
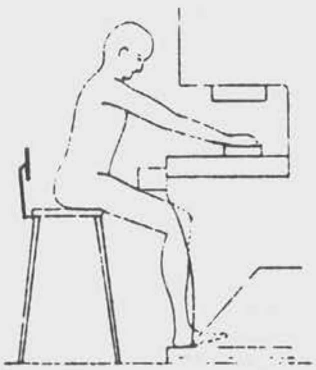
This report is the result of an investigation of 32 pressworking places for presses less than 630 kN press capacity.





The most desirable upright sitting posture at this type of picking and placing job is achieved with a compromise of seeing distance, height of the tool, and reach to the tool.

The mechanical presses are not designed on ergonomic criteria.



Lack of space for legs and feet forces the operator to sit at a distance from the press. Consequently the operator has to lean forward to reach the tool. This forward bending with straight arms often causes arm trouble.

Background

There is no doubt about the fact that the coming decade will not result in an automation that will eliminate manual work at punch presses. Press operators are working today under very hard conditions. The noise level is usually very high, leading to isolation from other colleagues. The work is very monotonous, and the operators are forced to look at the work pieces and tools all the time, as the work demands both sight and touch control.

Sitting Posture

The most convenient working posture is impossible to define exactly. There is always a compromise between seeing distance, working height, reach, and leg room. Those are the critical ergonomic materials. In this survey, an attempt to make observations as objective as possible has resulted in a measuring method where the difference is measured between the operator's optimal sitting posture and his posture while at press working. The result is shown in Figures 1, 2, and 3.

Seeing

Orienting a work piece and placing it in a tool is precision work that should be done at close to ordinary reading distance for the operator. When the work piece is placed in the tool directly by hand, the work position is a combination between the seeing and feeling positions. As can be seen, the seeing distance is better for smaller persons when working in small presses.

It is important to be able to see into the tool, but this is often hampered by safety guards, parts of the tool, poor lighting, or reflections.

Height

If possible, the work should not be done above elbow height. Otherwise, this will lead to movement of the shoulders or static bending of the elbows, which will, in turn, lead fairly quickly to muscle problems.

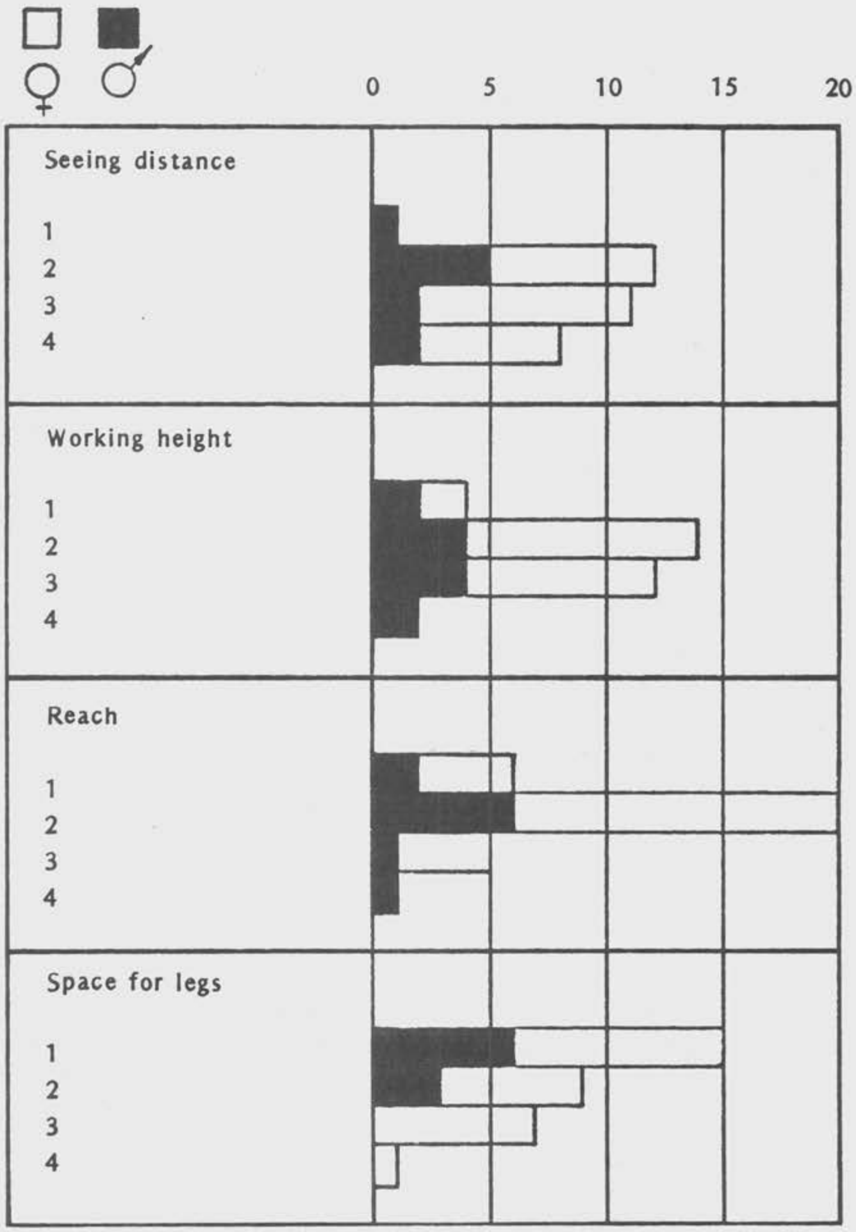
Operators prefer a correct seeing distance and working height, rather than a good position for the legs, when choosing a sitting posture at the press. The critical factor at presses is the thick bed plate. Figure 4 shows the correlation between the bed plate thickness and the distance between the elbow and upper leg of the operators. This illustrates effectively the bad situation at press work.

Reach

It is important to describe problems with working height when the tool is placed at a great distance from the body. The working pieces are not often very heavy, but the weight of the arms themselves is sufficient to result in fatigue during long work periods.

Figure 1

RESULTS OF ERGONOMIC MEASUREMENTS ON PRESS OPERATORS



1 = Very bad

2 = Bad

3 = Satisfactory

4 = Ideal

Figure 2

ERGONOMICS RELATED TO PRESS CAPACITY

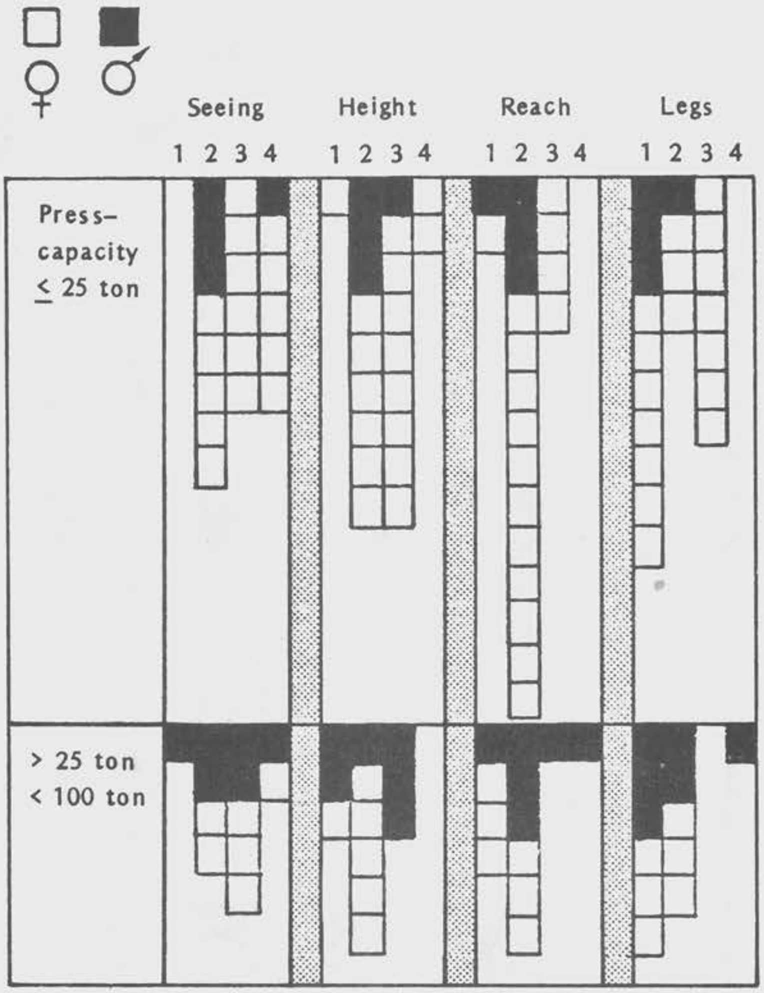


Figure 3

ERGONOMICS RELATED TO THE OPERATOR'S BODY LENGTH

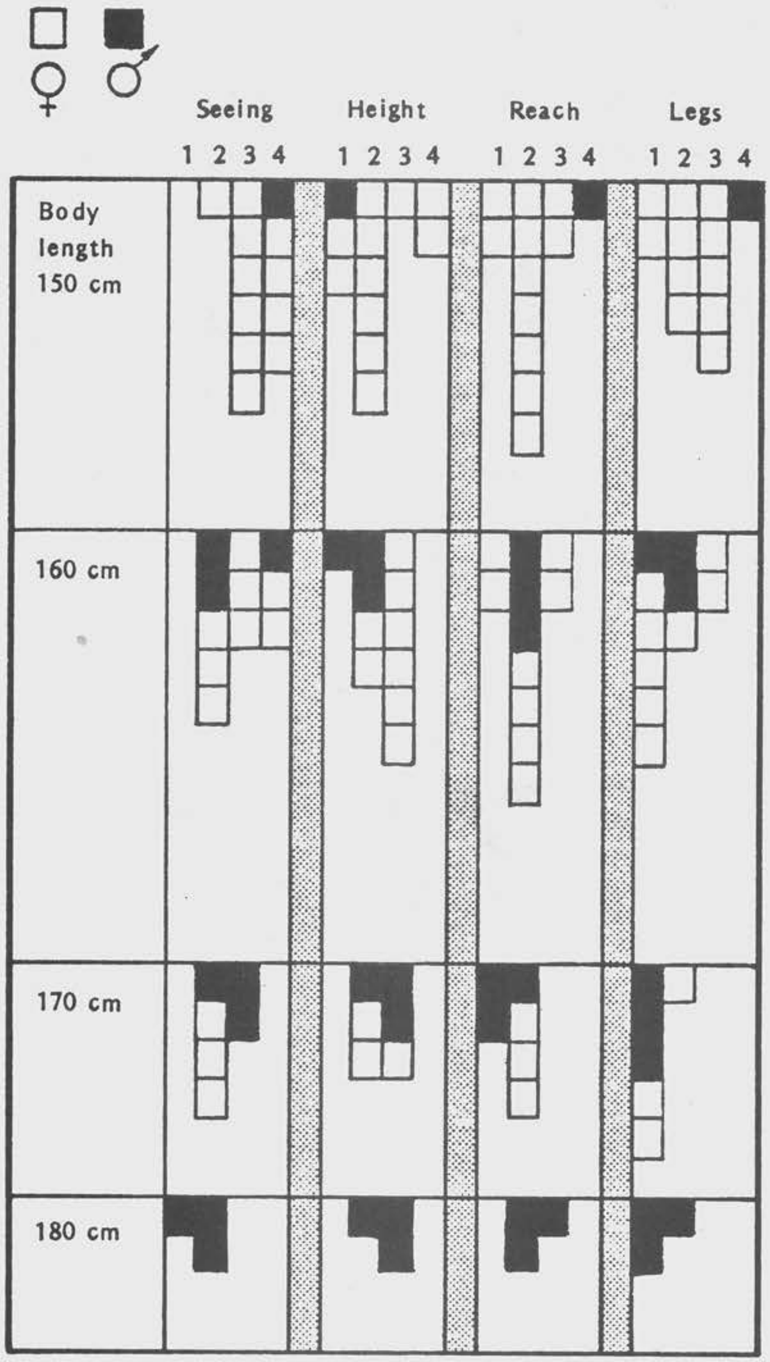
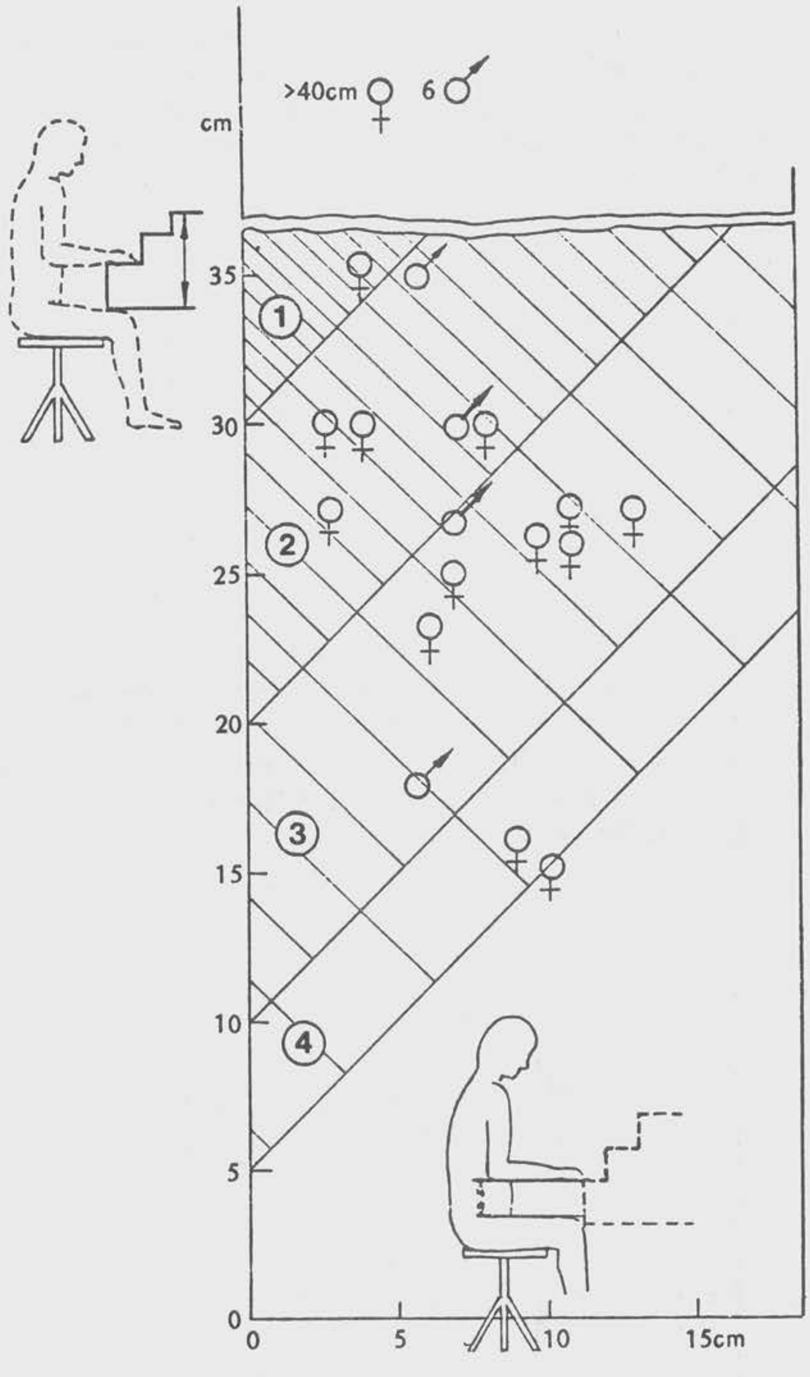


Figure 4

CORRELATION BETWEEN BED PLATE THICKNESS AND DISTANCE BETWEEN OPERATOR'S ELBOW AND UPPER LEG

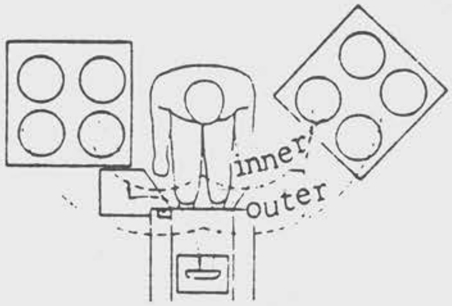


The dimensions of the presses and the operators do not fit together very well. The numbers in the circles indicate:

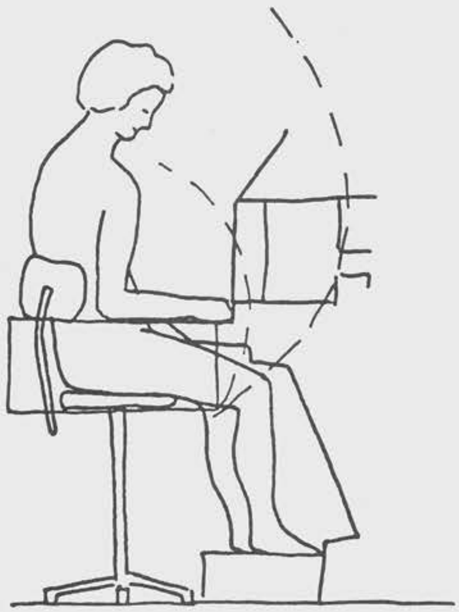
(1) very bad; (2) bad; (3) satisfactory; (4) ideal.

To increase reach, hand tools of different types may be used. Many of those types are not of optimal handgrip and weight, which only serves to move the problems from the shoulders to the lower arms and fingers.

Reach may be divided into two areas: inner reach and outer reach. As placing work is a precise activity, the tool should optimally be located in the inner reach zone. However, this is not the case. Lack of leg room forces the operators to move away from the press, resulting in the distance of the tool sometimes being outside even the outer reach zone.



When using the hands in the die, a safe distance is chosen based upon the brake time of the press. Light guards placed on older presses result in very long distances and asymmetric seating, which also increases the reach. This is not to be recommended. The light guards are otherwise very useful, however, as they permit free arm motion during the cycle.



The Legs

As can be seen from the measurements, leg room is very poor for all types of presses. On many presses it is impossible to place the knees under the bed plate, thus forcing the operators to sit in a half-standing posture. Clearly, small persons at small presses is the best combination, while tall people will always have problems with leg room.

The legs are often in a fixed position, and must often be kept separated because of the press construction. This makes flexible sitting postures impossible during a working period, and causes circulation problems and irritation in the legs.

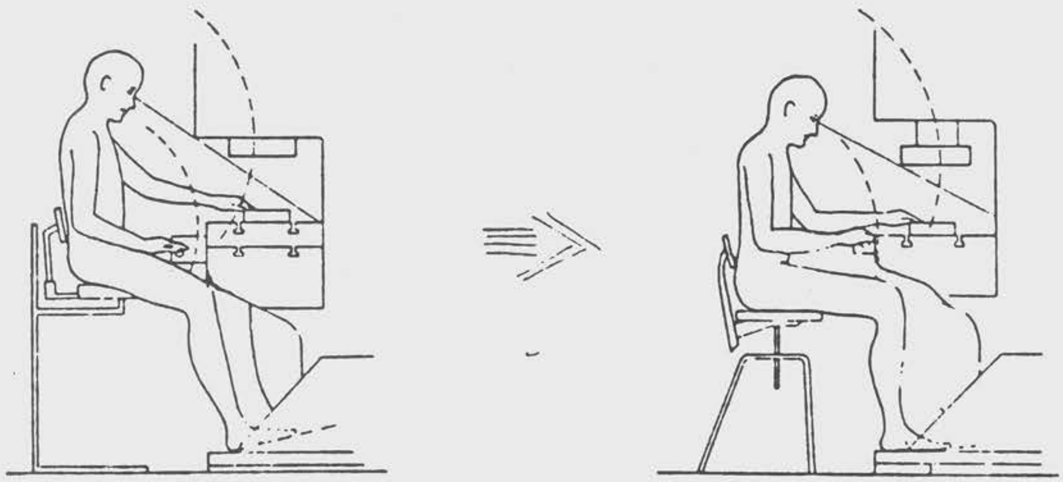
Arm Motions

The working tempo is very high at this pick-and-place work. The average value is around 25 work pieces/minute. When using light guards, some operators can manage 60 work pieces/minute. Use of a pedal to punch strips can result in even higher frequencies. Most of the presses are equipped with two-hand controls, many of which are poorly designed, causing finger problems.

Because the motions are very repetitious, it is essential that the operators be conscious of how to move so as to minimize the energy needed for the work and to vary their motions, if possible, to produce an all-round motion.

Summary

To solve these problems for the future, major work must be started, including development of a completely new press design and an arrangement around the press that will minimize the energy needed by the operator for each work piece cycle. The introduction of flexible sitting postures and motions for the operator is the main guideline in this development, and will minimize both static loads and dynamic muscle problems.



LITERATURE REFERENCES

T. S. Clark
Ergonomics; Better Design
Engineering, November 1978, p. 1198

E. N. Corlett
Ergonomic Design is a Pressing Matter
Metalworking Production, November 1974

E. Grandjean and W. Hunting
Ergonomics of Posture
Applied Ergonomics, September 1977

Bengt Jonsson m fl
Sittande arbetsställningar
ASS Arbetsfysiologiska enheten i Umea 1978
Utbildning 1978:12

Tove Kling
Ergonomiska studier av arbetsplatser med daligt benutrymme
LME Företagshälsovarden 1977

Ake C Mandal
Work-chair Tilting Seat
Ergonomics, March 1976

R. W. Tomlinson, E. N. Corlett
The Ergonomics of Open-fronted Presses
Applied Ergonomics, March 1975

D. J. Mercel
Toolsetting and Maintenance on Small Power Presses
Applied Ergonomics, June 1975

STRENGTH TESTING/EMPLOYEE PLACEMENT ON PHYSICALLY STRENUOUS JOBS

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ABSTRACT

This study was performed to develop and evaluate a system for matching the strength of workers to the strength demands of physically stressful jobs. A cross section of volunteers assigned to production jobs in an aluminum smelting facility received nine strength tests which simulated job activities. They were then monitored for medical incidents during a period of over two years. Significant relationships were found among job demands, worker strengths, and medical incidents. Workers with strength abilities less than job strength requirements suffered a higher rate of accidents and injuries than workers whose strengths matched or exceeded job demands. It was concluded that strength testing can be used to identify workers who would be at high risk of suffering medical incidents if placed on jobs which exceeded their strength abilities.

(Note: This work was performed to fulfill Ph.D. degree requirements at the University of Michigan Center for Ergonomics. The author wishes to acknowledge the support of the ALCOA Foundation, The Firestone Tire and Rubber Company, NIOSH, and the Department of Industrial and Operations Engineering at the University of Michigan.)

INTRODUCTION

Manual materials handling is recognized as the leading cause of occupational illnesses and injuries in the United States and accounts for approximately twenty-five percent of all workers' compensation payments.[1,2] Most of these costs are due to the long periods of incapacitation and rehabilitation which result from injuries to the lower back. Studies conducted over the past two decades have shown an increased incidence and severity of low back pain in occupations which require the lifting and moving of heavy loads.[3–6] In addition to the low back problem, positive relationships have been found between the occurrence of common occupational injuries (bruises, abrasions, lacerations, sprains, etc.) and overexertion in manual handling activities.[7] All of these injuries may be compensable under recent legal interpretations of cumulative injury.[8]

It is apparent from the above discussion that manual materials handling activities present a serious problem to today's occupational health professional. Several solutions have been suggested to alleviate the problem, but they have been generally ineffective. In a recent survey of workers' compensation policy holders, it is reported that neither employee training programs in safe lifting techniques nor traditional medical screening programs (based on medical histories or low back X-rays) have resulted in any reduction in low back injuries.[9] This finding is consis–

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[1]National Safety Council. Accident Facts. Chicago, Illinois, 1974.

[2]Snook, S. H., Irvine H., and Bass, S. F. "Maximum Weights and Work Loads Acceptable to Male Industrial Workers." Journal of American Industrial Hygiene Associations, 3:579, 1970.

[3]Wickstrom, G. "Affect of Work on Degenerative Back Disease: A Review," Scand. Journal of Work, Environment, and Health, 4:1–12, Suppl. 1, 1978.

[4]Kosiak, M., Aurelius, J. R., and Harfiel, W. F. "The Low Back Problem: an Evaluation." JOM, 11:161–169, 1969.

[5]Rowe, L. M. "Low Back Pain in Industry." JOM, 11:161–169, 1969.

[6]Magora, A. "Investigation of the Relation Between Low Back Pain and Occupation." Ind. Med. and Surg., 39(12):28–34, 1970.

[7]Chaffin, D. V., Herrin, G. D., Keyserling, W. M., and Foulke, J. A. Pre–Employment Strength Testing in Selecting Workers for Materials Handling Jobs. Cincinnati, Ohio: NIOSH Physiology and Ergonomics Branch, Contract No. CDC–99–74–62, 1977.

[8]Hershenson, J. D. "Cumulative Injury: A National Problem." JOM, 21(10):674–676, 1979.

[9]Snook, S. H., Campanelli, R. A., and Hart, J. W. "A Study of Three Preventive Approaches to Low Back Injury." JOM, 20:478–481, 1978.

tent with other studies.[10–12] The survey concludes that the most effective method of controlling injuries is to design jobs to fit the workers and that such a policy could reduce overexertion injuries by as much as 67 percent.[9]

Job redesign is the ideal solution to the manual materials handling problem. The weights of loads which are lifted and carried should be reduced to accommodate the strength abilities of workers, or mechanical assistance should be provided to reduce stresses on the musculo-skeletal system. Criteria establishing maximum acceptable loads for materials handling jobs are available to assist engineers and job designers in developing job requirements which are safe for most workers.[13] Managers of occupational safety programs should encourage compliance with these recommendations as a method of controlling accidents and reducing injuries.

The reduction of physical requirements often calls for extensive engineering changes and may not always be feasible in existing plants. In these situations, an alternative and interim solution is to establish a program for selecting workers based on their ability to perform the strength requirements of their jobs.

This investigation was undertaken to develop and evaluate a system for assessing workers' abilities to perform strenuous job elements. The specific objectives of this study were:

1. To use isometric strength tests to measure workers' strengths in simulations of strenuous job elements, and

2. To determine the relationships among worker strength attributes, job requirements, and medical incidents.

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[9]Snook, S. H., Campanelli, R. A., and Hart, J. W. "A Study of Three Preventive Approaches to Low Back Injury." JOM, 20:478–481, 1978.

[10]Montgomery, C. H. "Pre-Employment Back X-Rays." JOM, 18(12):495–498, 1976.

[11]Brown, J. R. Manual Lifting and Related Fields: An Annotated Bibliography. Toronto: Ontario Ministry of Labour, 1972.

[12]Dehlin, O., Henderud, B., and Horal, J. "Back Symptoms in Nursing Aides in a Geriatric Hospital." Scand. J. Med., 8:47–53, 1976.

[13]Snook, S. H. "The Design of Manual Handling Tasks." International Ergonomics Society Lecture – 1978. Bedfordshire, England, 1978.

METHODOLOGY

This investigation was a field study performed in an aluminum reduction plant where a sample of employees assigned to entry level production jobs volunteered to participate. These jobs included the most physically demanding tasks found anywhere in the plant. The study was initiated in early 1977 and the data reported herein are current through summer 1979.[14]

A longitudinal design was used to collect required data. Major phases of the investigation are described below:

Biomechanical Job Analysis – The first step in data collection was to evaluate biomechanically the strength requirements of the jobs under investigation. To do this, a three-dimensional strength prediction model developed at the Ergonomics Laboratory of the University of Michigan was used. Complete details on this computerized model are available elsewhere.[15–17]

Job analyses were performed by a trained engineer from the participating plant. During the analysis, each job was systematically broken down into strenuous task elements. For each of these elements, the following variables were measured:

- A basic description of the task (e.g., lift, push, pull).
- A description of the body posture maintained while performing the task (e.g., stand, sit, squat).
- The force (in pounds) which must be exerted in order to perform the task.
- The location of the hands in space (with respect to the feet).

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[14] Keyserling, W. M., Herrin, G. D., Chaffin, D. B., Armstrong, T. J., and Foss, M. L. "Establishing an Industrial Strength Testing Program." Am. Ind. Hyg. Assoc. J. (in press).

[15] Chaffin, D. B. "A Computerized Biomechanical Model: Development of and Use in Studying Gross Body Actions." J. of Biomechanics, 2:429–441, 1969.

[16] Schanne, F. J., Jr. A Three-Dimensional Hand Force Capability Model for a Seated Person. Ph.D. Thesis, The University of Michigan, Ann Arbor, 1972.

[17] Garg, A., and Chaffin, D. B. "A Biomechanical Computerized Simulation of Human Strength." AIIE Transactions, 7(11):1–15, 1974.

These data were collected for both task origin and destination, and at points judged to be most stressful during the trajectory of motion. Additional job analysis procedures have been described elsewhere.[18]

Design of Strength Tests – Following the analysis of the entry level jobs, the strength demands of several hundred tasks had been documented. Of these, nine tasks were found to be of critical importance in terms of required strength.[19] Strength tests were developed to simulate the postures and forces required to perform these tasks. These tests are illustrated in Figure 1, and the corresponding jobs requirements are summarized in Table I.

Strength Testing – Strength tests were administered to a cross-section of incumbent and new employees. Volunteers for the study were approved by the plant physician prior to taking the tests. All subjects performed a sustained (five second) maximum voluntary isometric exertion simulating each of the nine critical task elements given earlier in Table I. The final three seconds of the exertion were measured, and an average of this period was used to score performance. These procedures were consistent with AIHA Ergonomics Guide recommendations.[20] In addition to strength measurements, employment and medical histories were recorded for each participant.

Medical Monitoring – At the time of strength testing, the medical record of each volunteer was tagged to indicate participation in the study. From this date forward, all visits to the medical department for job related illness or injury were reported by the plant physician or the duty nurse.

RESULTS

Three hundred forty-four workers (309 males, 35 females) participated in the study.[14] Descriptive statistics (means, ranges, and standard deviations) computed on anthropologic measures (height, weight, and age) and strength scores for males and females are presented in Table II.

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[18]Chaffin, D. B., Herrin, G. D., Keyserling, W. M., and Garg, A. "A Method for Evaluating the Biomechanical Stresses Resulting from Manual Materials Handling Jobs." Am. Ind. Hyg. Assoc. J., 38(12):662-675, 1977.

[19]Keyserling, W. M., Isometric Strength Testing in Selecting Workers for Strenuous Jobs. Ph.D. Dissertation, The University of Michigan, Ann Arbor, MI: University Microfilms International, 1979.

[20]Chaffin, D.B. "Ergonomics Guide for the Assessment of Human Strength". Am. Ind. Hyg. Assoc. J., 36:505-510, 1975.

[14]Keyserling, W. M., Herrin, G. D., Chaffin, D. B., Armstrong, T. J., and Foss, M. L. "Establishing an Industrial Strength Testing Program". Am. Ind. Hyg. Assoc. J. (in press).

Figure 1

STRENGTH TEST POSTURES

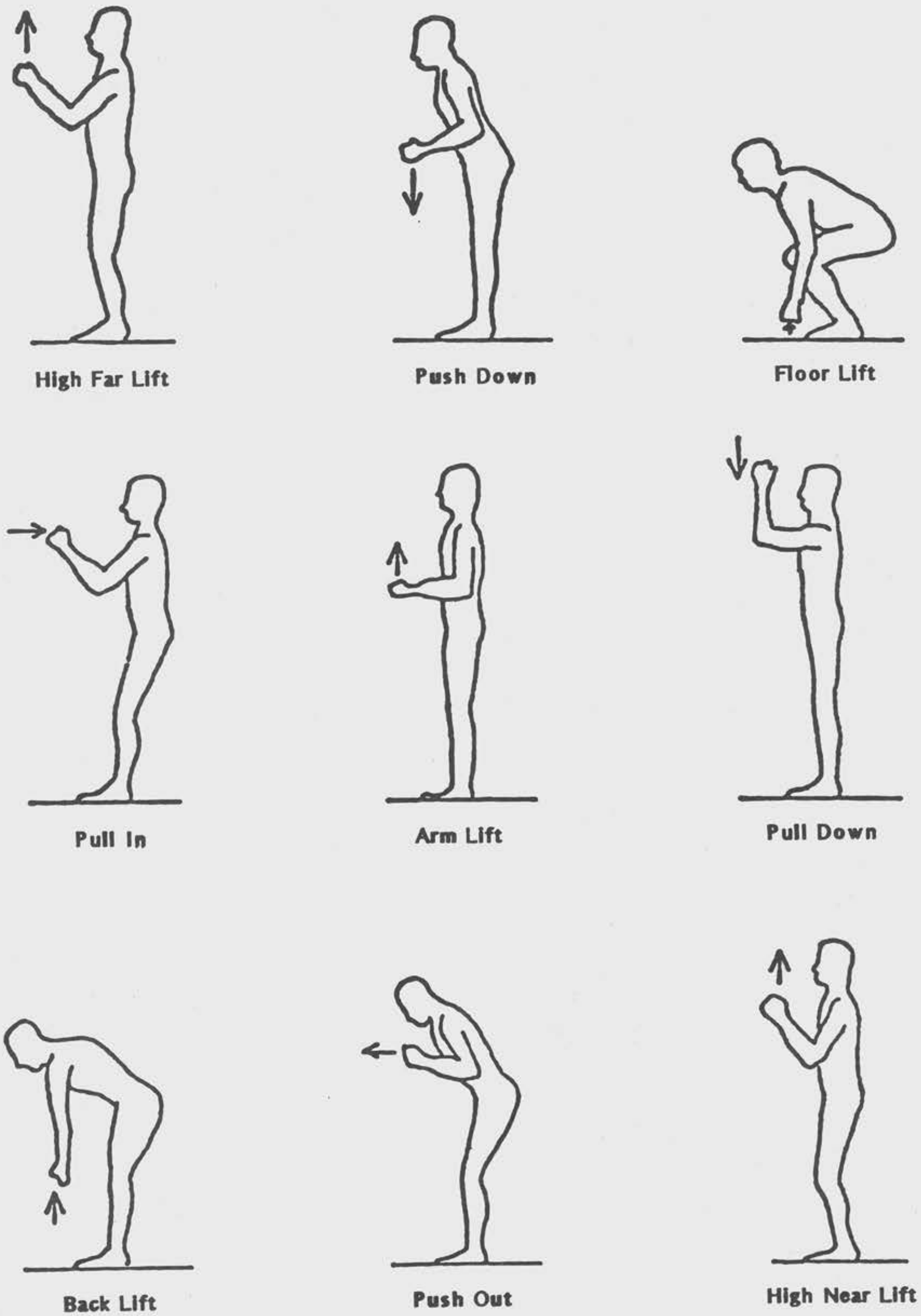

Table 1

DESCRIPTION OF CRITICAL STRENGTH ELEMENTS[14]

Test	Hand Coordinates (cm) Vertical	Horizontal	Critical Element	Req. Force (Newtons)
High Far Lift	152	51	Lift Pneu. Hammer	150
Push Down	112	38	Handle Pot Rake	400
Floor Lift	15	25	Lift Lining	540
Pull In	157	33	Handle Pot Rake	310
Arm Lift	*	*	Lift TFR Wheel	290
Pull Down	**	**	Handle Hand Jack	550
Back Lift	38	38	Lift Steel Hook	360
Push Out	124	36	Handle Pot Rake	270
High Near Lift	152	25	Lift Huck Gun	230

*Elbow at 90 degrees, lower arm horizontal (see Figure 1).
**Elbow at 90 degrees, lower arm vertical (see Figure 1).

Table II

DESCRIPTIVE STATISTICS—ANTHROPOMETRY AND STRENGTH[14]

Measure	Males (n=309)			Females (n=35)		
	Mean	Range	Std. Dev.	Mean	Range	Std. Dev.
Height (cm)	180	152–201	6.6	168	152–180	6.9
Weight (kg)	83.5	57–132	12.4	71.9	54–100	10.7
Age	27.7	18–61	9.5	29.3	18–49	8.3
High Far Lift (N)	234	71–556	72	133	71–200	37
Push Down (N)	444	213–778	92	334	222–484	71
Floor Lift (N)	894	324–1689	243	552	191–1089	183
Pull In (N)	322	156–871	80	252	156–396	56
Arm Lift (N)	400	151–702	85	260	89–413	67
Pull Down (N)	608	382–925	101	452	253–649	105
Back Lift (N)	445	160–1360	154	316	178–636	113
Push Out (N)	315	142–707	75	221	156–365	48
High Near Lift (N)	543	160–1138	156	282	133–596	100

See Table I and Figure 1 for a description of test postures.

During a monitoring period of approximately twenty-six months, 322 visits to the medical department were recorded. Table III presents a summary of incidents, days lost, and days restricted for each complaint type.

To investigate the relationships among medical incidents, strength ability, and job demands, it was necessary to develop a simple quantitative relationship between strength test performance and job strength requirements. This was done by defining a new variable, called the Ability Ratio (AR). It was calculated by dividing the force exerted on each strength test by the force required to perform the job:

$$\text{Ability Ratio (AR)} = \frac{\text{Strength (Newtons)}}{\text{Job Requirement (Newtons)}}$$

Ability Ratios were computed on each of the nine strength tests for the 344 participants in the study. Job Requirements, used in the denominator of the AR, were taken as the critical job element simulated by the strength test. These requirements were presented earlier in Table I.

Following the determination of ability ratios, employees were classified into the following three groups based on how well their strength abilities matched job demands:

1. Weak - Those workers whose strength abilities were less than job strength demands (AR less than 0.75).

2. Matched - Those workers whose strength abilities were matched to job demands (0.75 less than AR less than 1.25).

3. Strong - Those workers whose strength abilities exceeded job demands (AR is greater than 1.25).

While the above classification scheme was somewhat arbitrary, it was nonetheless consistent across all nine strength tests. In addition, it yielded adequate sample sizes for most of the analyses presented below.

Incidence rates (computed as the number of incidents per 200,000 hours of job exposure) were determined for the weak, matched, and strong groups on each of the nine strength tests. These rates, which are presented in Table IV, were computed for all medical incidents and for only those incidents classified as musculo-skeletal. (Note: 200,000 hours is equivalent to 100 man years.)

Table III

SUMMARY OF MEDICAL INCIDENTS[14]

Complaint Type	Incident Count	Days Lost	Days Restricted
Non-specific	66	22	3
Skin contact	206	7	44
Musculo-skeletal	50	7	18
Total	322	36	65

Table IV

INCIDENCE RATES BY STRENGTH CLASSIFICATION (14)

Test	Group	N	Exposure Hours (x1000)	All Medical Visits				Musculo-Skeletal Visits			
				Obs.	Exp.	Rate	Test Stat. (Sig.)	Obs.	Exp.	Rate	Test Stat. (Sig.)
High Far Lift	Weak	16	71	21	15.2	59.2	2.42	4	2.4	11.3	2.66
	Matched	88	383	78	82.1	40.7	(n.s.)	16	12.7	8.4	(n.s.)
	Strong	240	1049	223	224.7	42.5		30	34.9	5.7	
Push Down	Weak	21	93	29	19.9	62.4	4.53	4	3.1	8.6	0.72
	Matched	245	1071	220	229.4	41.1	(n.s.)	33	35.6	6.2	(n.s.)
	Strong	78	339	73	72.6	43.1		13	11.3	7.7	
Floor Lift	Weak	12	53	15	11.4	56.6	1.18	2	1.8	7.5	*
	Matched	78	343	73	73.5	42.5	(n.s.)	15	11.4	8.7	
	Strong	254	1107	234	237.2	42.3		33	36.8	6.0	
Pull In	Weak	49	216	68	46.3	63.0	12.75	13	7.2	12.0	6.35
	Matched	236	1029	197	220.5	38.3	(.005)	32	34.2	6.2	(.05)
	Strong	59	258	57	55.3	44.2		5	8.6	3.9	
Arm Lift	Weak	17	75	17	16.1	45.3	4.42	3	2.5	8.0	3.88
	Matched	115	508	126	108.8	49.6	(n.s.)	23	16.9	9.1	(n.s.)
	Strong	212	920	179	197.1	38.9		24	30.6	5.2	
Pull Down	Weak	18	80	19	17.1	47.5	0.23	6	2.7	15.0	4.52
	Matched	260	1137	243	243.6	42.7	(n.s.)	36	37.8	6.3	(n.s.)
	Strong	66	286	60	61.3	42.0		8	9.5	5.6	

*Expected Value Too Small To Compute X^2 Statistic

Table IV (Continued)

INCIDENCE RATES BY STRENGTH CLASSIFICATION (14)

Test	Group	N	Exposure Hours (x1000)	All Medical Visits				Musculo-Skeletal Visits			
				Obs.	Exp.	Rate	Test Stat. (Sig.)	Obs.	Exp.	Rate	Test Stat. (Sig.)
Back Lift	Weak	31	136	44	29.1	64.7	19.43	9	4.5	13.2	8.14
	Matched	198	863	148	184.9	34.3	(.001)	20	28.7	4.6	(.125)
	Strong	115	504	130	108.0	51.6		21	16.8	8.3	
Push Out	Weak	21	94	40	20.1	85.1	21.12	5	3.1	10.6	1.26
	Matched	210	914	179	195.8	39.2	(.001)	30	30.4	6.6	(n.s.)
	Strong	113	495	103	106.0	41.6		15	16.5	6.7	
High Near Lift	Weak	6	27	15	5.8	111.1	16.46	1	0.9	7.4	*
	Matched	26	116	30	24.9	51.7	(.001)	9	3.9	15.6	
	Strong	312	1360	277	291.4	40.7		40	45.2	5.9	
Total		**344**	**1503**	**322**	—	**42.8**	—	**50**	—	**6.65**	—

*Expected Value Too Small To Compute X^2 Statistic

To test for differences in the rates experienced by the groups, a Chi-Square test described elsewhere was used.[19,21] The results of the Chi-Square analyses are presented along with the computed incidence rates for the three groups in Table IV. Considering all medical visits, employees in the weak group suffered the highest incidence rates for eight of the nine strength test categories. Significant differences in rates were observed on four of the tests (the Pull In, Back Lift, Push Out, and High Near Lift). On these tests, the weak group experienced between 1.25 and 2.71 times the incidence rates suffered by the matched and strong groups. Note that no consistent differences were found when comparing the incidence rates experienced by the matched and strong groups.

A similar analysis was performed on the 50 musculo-skeletal incidents and is presented in the right hand side of Table IV. For these complaints employees in the weak group experienced the highest incidence rate on six of the nine tests. Significant differences were observed on two tests (the Pull In and Back Lift). On these tests, weak employees suffered between 1.6 and 3.1 times the musculo-skeletal incidence rates of the other two groups. Test statistics could not be determined for either the Floor Lift or High Near Lift because the expected number of incidents (E_i) was insufficient.

DISCUSSION

In this study, a system was developed for identifying strenuous job elements and strength testing workers in simulations of these elements. A cross section of employees in an aluminum smelting plant was administered strength tests and monitored for medical incidents.

Significant relationships were found among worker strength, job demands, and medical incidents on four of nine tests. Workers whose strength abilities were less than job requirements suffered higher incidence rates than workers whose strength matched or exceeded job demands. Snook and his co-workers report that up to two out of three overrexertion injuries could be prevented by matching job strength demands to population strength abilities.[9] The findings of this study indicate that similar reductions in medical incidents can be accomplished through a strength testing program which matches an individual's strength ability to the strength demands of a job.

19Keyserling, W. M. Isometric Strength Testing in Selecting Workers for Strenuous Jobs. Ph.D. Dissertation, The University of Mighican, Ann Arbor, MI: University Microfilms International, 1979.

21Duncan, A. J. Quality Control and Industrial Statistics. Homewood, Illinois, Richard D. Irwin, Inc., 1965.

9Snook, S. H., Campanelli, R. A., and Hart, J. W. "A Study of Three Preventive Approaches to Low Back Injury". JOM, 20:478-481, 1978.

Significant relationships between strength and medical risk were found on four tests. Similar trends (i.e., weak workers suffering the highest incidence rates) were observed on four of the remaining five tests. The Arm Lift, however, proved to be an exception. Here, matched workers experienced the highest incident rate. This finding should serve as a caution to those comtemplating the use of strength tests; a pilot study should always be performed using incumbent employees. This will assure the validity of the tests before they are used for selection of new employees.

The data reported herein reflect a relatively short monitoring period for medical incidents (only twenty-six months). Trauma on the musculo-skeletal system from the performance of strength demanding jobs may have cumulative effects which do not produce symptoms during early years of exposure. Only through long term monitoring will these effects become apparent, and extended studies of this type are needed.

CONCLUSIONS

As stated in the Introduction, the desirable solution to the manual materials handling problem is to redesign stressful jobs in order that they will accommodate the physical capabilities of the workforce. When this is done, selection procedures will not be needed as it would be reasonable to assume that practically all applicants could safely and effectively perform all jobs. In the near future, however, this goal may not be technologically or economically feasible in all industries. Based on the findings of this and earlier studies,[7,22] isometric strength testing is an effective and valid tool which can be used by industry as part of an employee selection and placement program.

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[7]Chaffin, D. V., Herrin, G. D., Keyserling, W. M., and Foulke, J. A. Pre-Employment Strength Testing in Selecting Workers for Materials Handling Jobs. Cincinnati, Ohio: NIOSH Physiology and Ergonomics Branch, Contract No. CDC-99-74-62, 1977.

[22]Chaffin, D. B. "Human Strength Capability and Low Back Pain". JOM, 16(4):248-254, 1974.

STRESS-RELATED RISK FACTORS[1]

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ABSTRACT

The theory of stress is briefly reviewed and its impact on job design and the allocation of people to jobs discussed. Recommendations for future research are made, the findings from which could significantly decrease the rate of accidents at the work place.

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(1) Much of the research reported here was supported by National Science Foundation Grant Number APR7718695.

BACKGROUND INFORMATION

The phenomenon of stress is illustrated in Figure 1; a model of stress at work is outlined in Figure 2 while Figure 3 illustrates the relationship between job demand and job decision latitude. It can be seen from Figure 3 that the highest stress level is present for a task having high demand and low decision latitude while the lowest stress level is present for those tasks having the lowest job demand and highest job decision latitude.

MANAGEMENT OF STRESS

Stress may be measured by biochemical, physiological and psychometric methods. Since each of the above categories of measurements have specific areas in which they are most applicable, stress may be operationally defined by the method utilized. In the present studies, physiological and psychometric methods were utilized to measure stress. For the physiological measures, sinus arrhythmia (S.A.) was the method selected. S.A. is a measure of the variability of the interbeat intervals of the heart; usually the larger this measure is the smaller is the mental load involved in task performance. Because of this relationship, S.A. has also been utilized as a measure of stress at work.

STRESS AND PACED PERFORMANCE

In a series of statistically balanced design of experiments operators were required to perform the same task at both machine-paced (M/P) and self-paced (S/P) rate of work. Studies by Salvendy and Humphrey (1979) illustrate in Table 1 that in high perceptual tasks the stress level in M/P work is significantly lower than at S/P work but the quality of work performance is higher at the more stressful S/P work than at the M/P work (Table 2). These findings appear to have occurred because in the S/P tasks the operator had to maintain an additional timing (which was not necessary at the M/P work) to ensure that the work was completed on time. This lack of performance feedback imposed additional mental load on the operator which caused an increase in the stress level at the S/P work. However, when knowledge of results is provided at the S/P work, the stress level of operators is being significantly reduced (Table 3 – Knight, Salvendy, and Howells, 1979).

The effects of financial incentives and different types of attentional requirements of a task on operator stress were examined by Sharit and Salvendy (1980). It is concluded (Table 4) that during a 4 to 6 second rest period between work cycles, S/P work at the external attentional task has the greatest deceleration of the heart rate. This has broad implications for reducing the stress in work situations through the manipulation of job design variables. Figure 4 illustrates that in shop floor work situations lower non-work related movements (NWRM) occur in S/P than in M/P work and these NWRM are higher the more complex the task is. Changes in NWRM may reflect changes in anxiety levels associated with task performance.

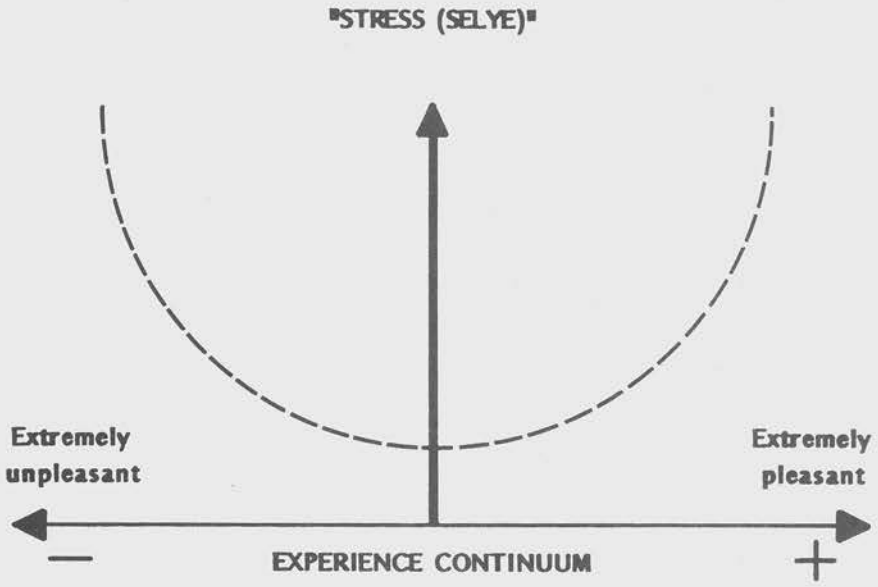
When continuous unobtrusive physiological measures were collected (Figure 5) on industrial operators during a period of one year the results tentatively indicate that no differences exist in rate of breathing, blood pressure and heart rate measures between S/P and M/P work.

STRESS AND ACCIDENTS

Currently no documented relationship exists between stress and accidents. However, it can be hypothesized that such a relationship may indeed exist as illustrated in Figure 6. Research is needed to determine the optimal level of stress needed for minimizing the occurrence of accidents. Also, it may be hypothesized that as a result of improved physical fitness, the decision making process may be improved and thus the rate of accidents at the work place will decrease.

Figure 1

"STRESS (SELYE)"
(After Levi, 1972)



Theoretical model regarding the relation between physiological stress as defined by Selye and pleasant, indifferent, and unpleasant experiences of various environmental stimuli, e.g., "life change." Note that the physiological stress level is lowest during indifference but never goes down to zero. Pleasant as well as unpleasant emotional arousal is accompanied by an increase in physiological stress (but not necessarily in distress).

Figure 2

A MODEL OF STRESS AT WORK
(After Cooper and Marshall, 1976)

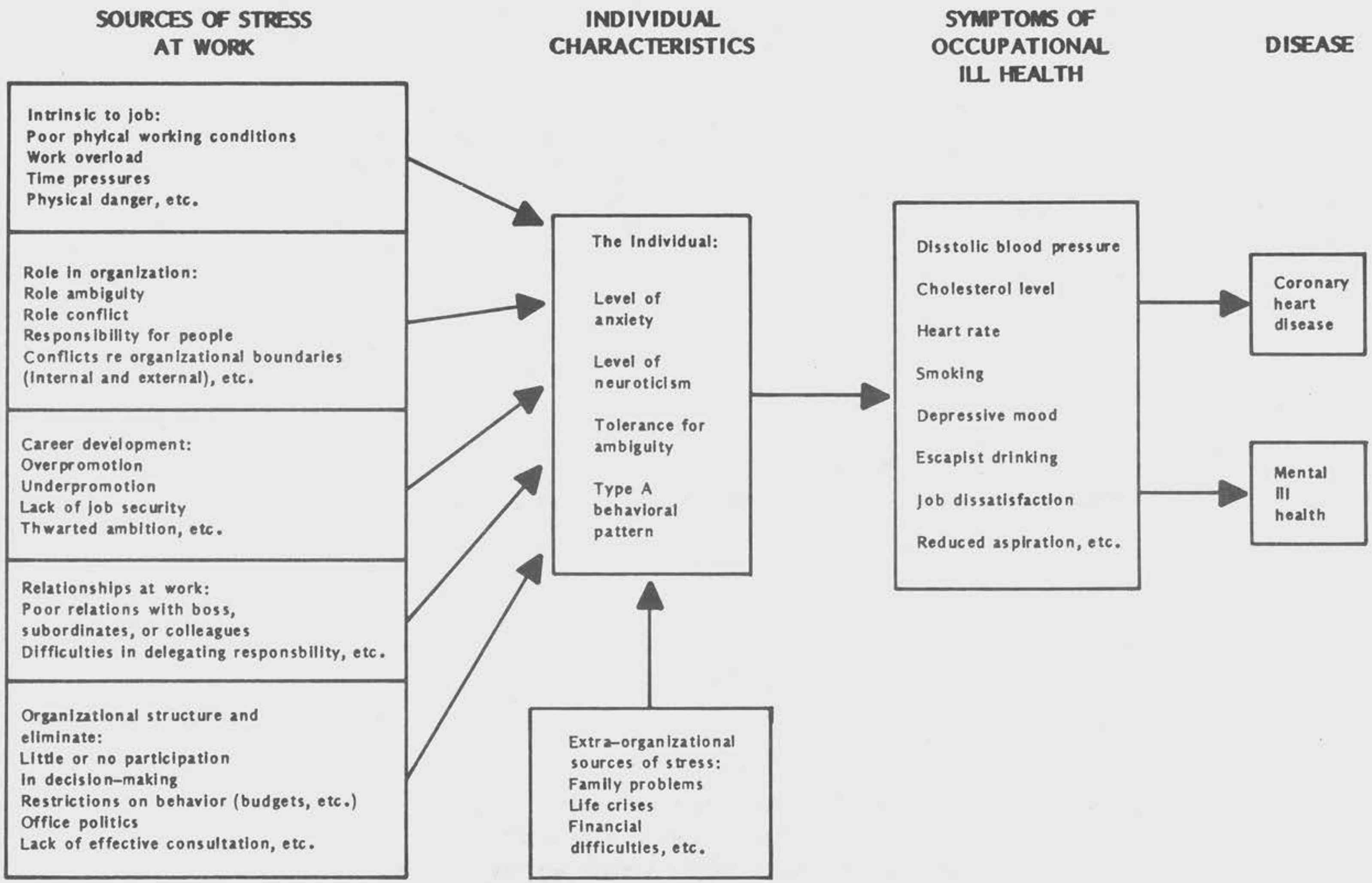


Figure 3

TEST OF THE JOB STRAIN MODEL WITH SYMPTOMS OF EXHAUSTION AND DEPRESSION
(After Karasek, 1979)

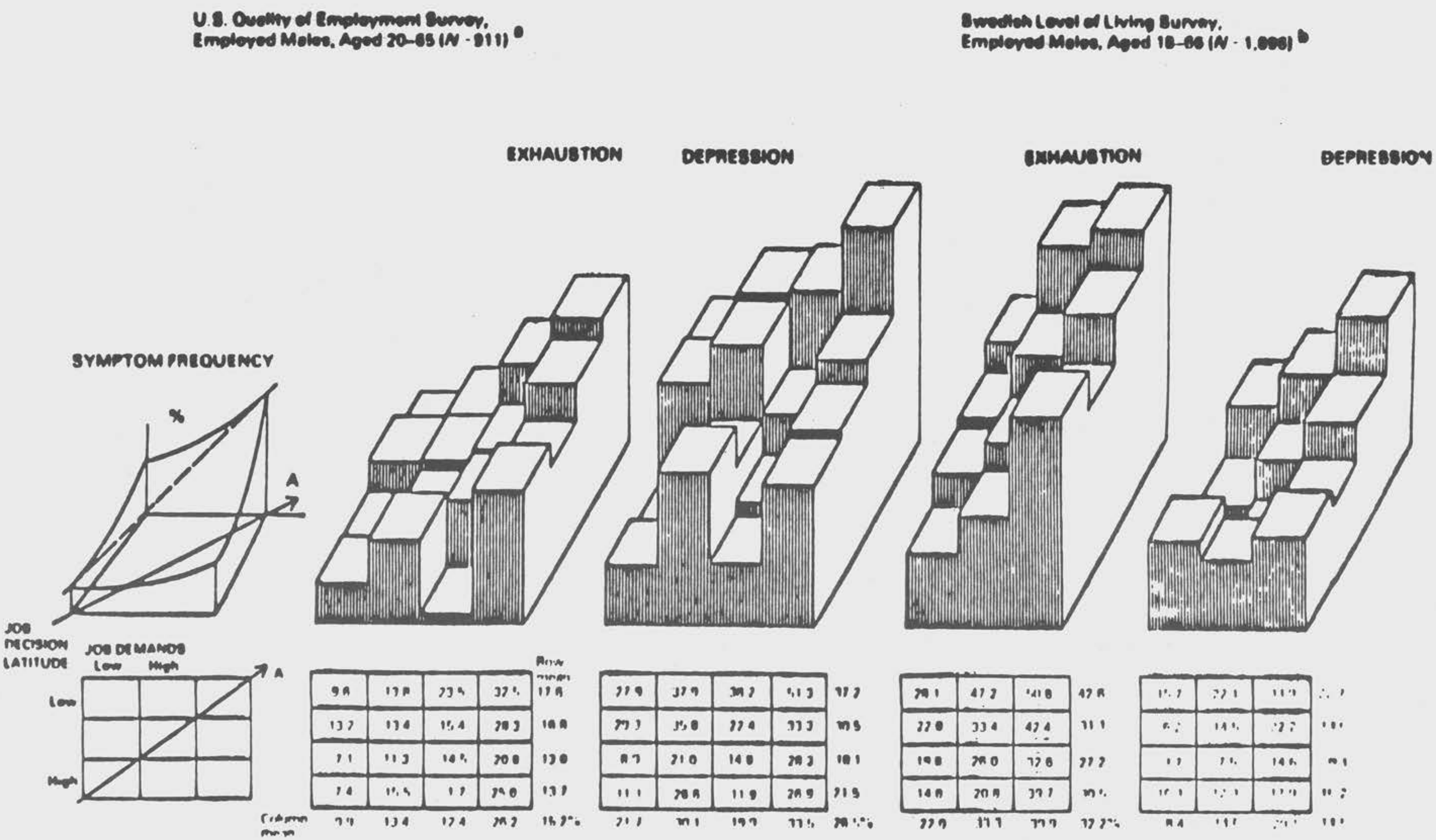


Table 1

EFFECTS OF PACED WORK AND PERCEPTUAL LOAD ON SINUS ARRHYTHMIA SCORES (After Salvendy and Humphrey, 1979)

	SINUS ARRHYTHMIA			
	Task with Low Perceptual Load		Task with High Perceptual Load	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Machine-paced	.66	.15	.90	.18
Self-paced	.69	.15	.55	.16

Table 2

SINUS ARRHYTHMIA AND QUALITY PERFORMANCE ON A TASK WITH HIGH COGNITIVE LOAD (After Salvendy and Humphrey, 1979)

	Self-Paced		Machine-Paced	
	x	S.D.	x	S.D.
Sinus Arrhythmia	.55	.16	.90	.18
Number of Errors	12.0	5.0	44.7	7.6

Table 3

EFFECTS OF PERFORMANCE FEEDBACK ON THE REDUCTION OF STRESS IN SELF-PACED WORK
(After Knight, Salvendy and Howells, 1979)

Work Condition	Sinus Arrhythmia
Machine-paced	162
Self-paced	
No Feedback	101
Time Feedback	118
Cycle Feedback	112
Time and Cycle Feedback	178

Table 4

EFFECTS OF WORK PACING, ATTENTIONAL REQUIREMENTS OF THE TASKS AND MODE OF INCENTIVE ON HEART RATE ACCELERATION AND DECELERATION
(After Sharit and Salvendy, 1979)

	Heart Rate Acceleration and Deceleration			
	External Attention		Internal Attention	
	Machine-paced	Self-paced	Machine-paced	Self-paced
No Incentive	66	63	71	69
Financial Incentive	68	62	75	72

Mean starting heart beat 72 beats per minute.

Figure 4

EFFECTS OF WORK–PACING AND TASK COMPLEXITY ON THE FREQUENCY OF NON–WORK RELATED MOVEMENTS (After Suarurenan, Basila, Salvendy, and McCabe, 1980)

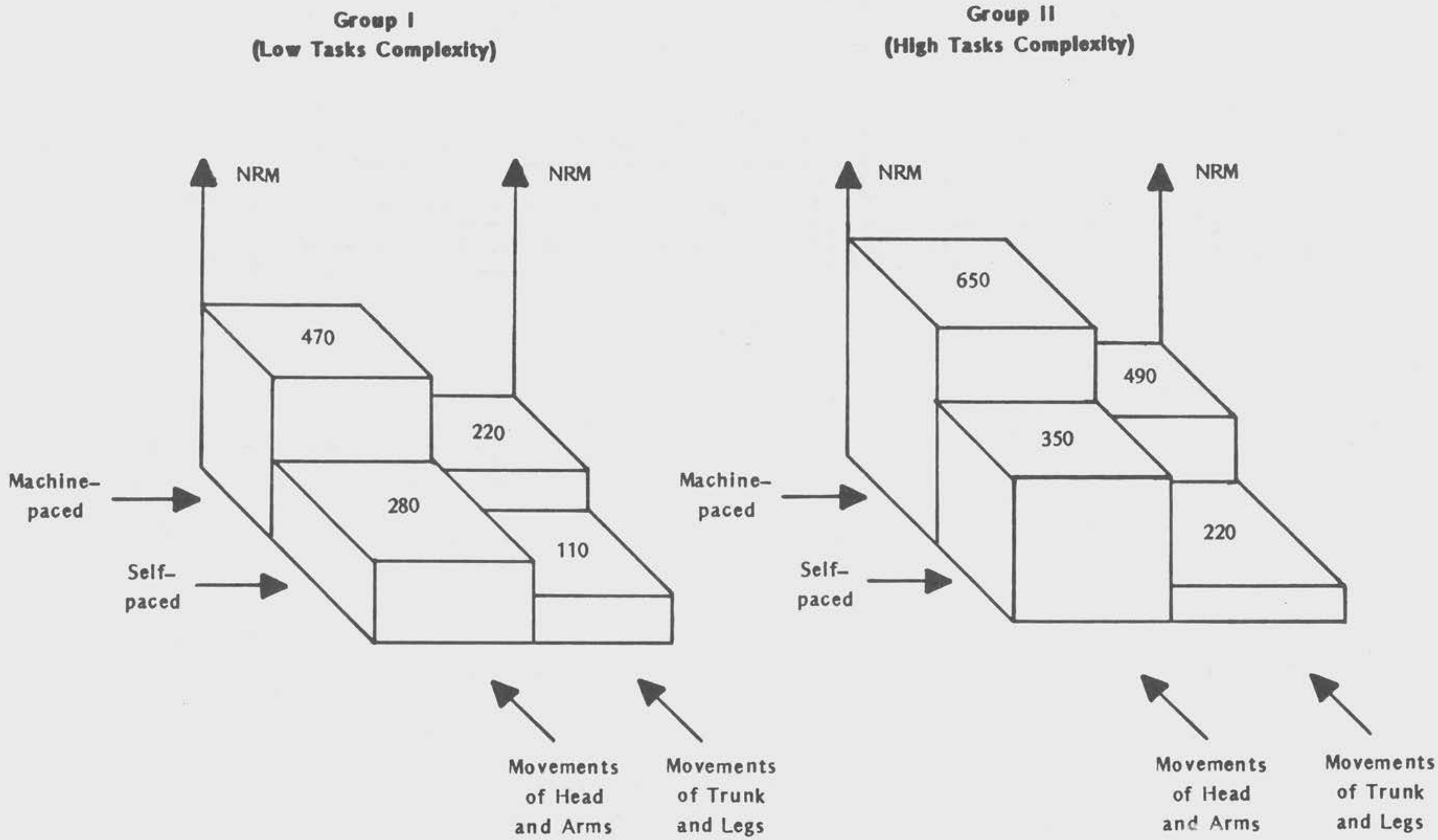


Figure 5

SYSTEMS BLOCK DIAGRAM FOR CONTINUOUS, UNOBTRUSIVE PERFORMANCE AND PHYSIOLOGICAL MONITORING OF INDUSTRIAL WORKERS
(After Knight, Geddes, and Salvendy, 1980)

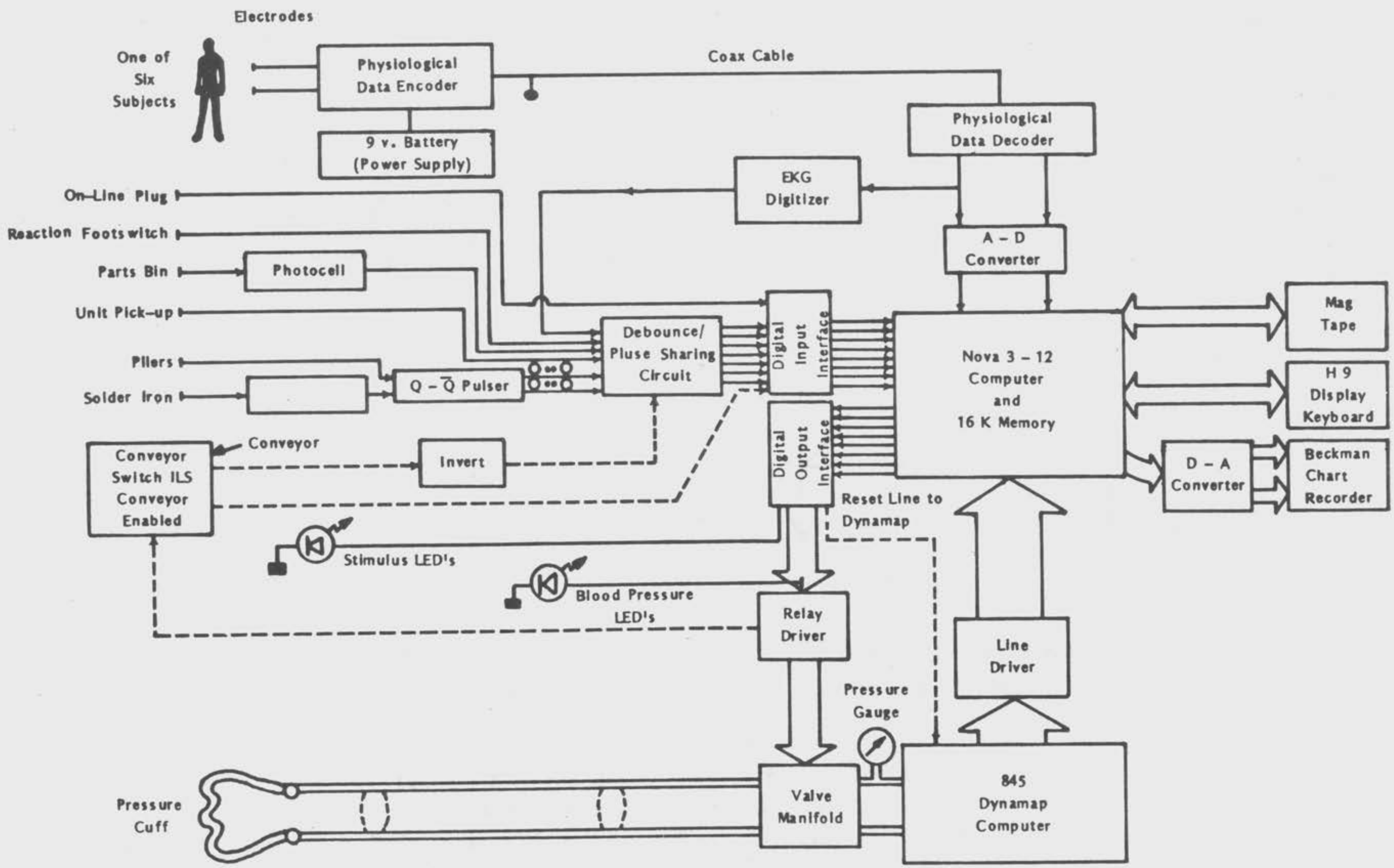
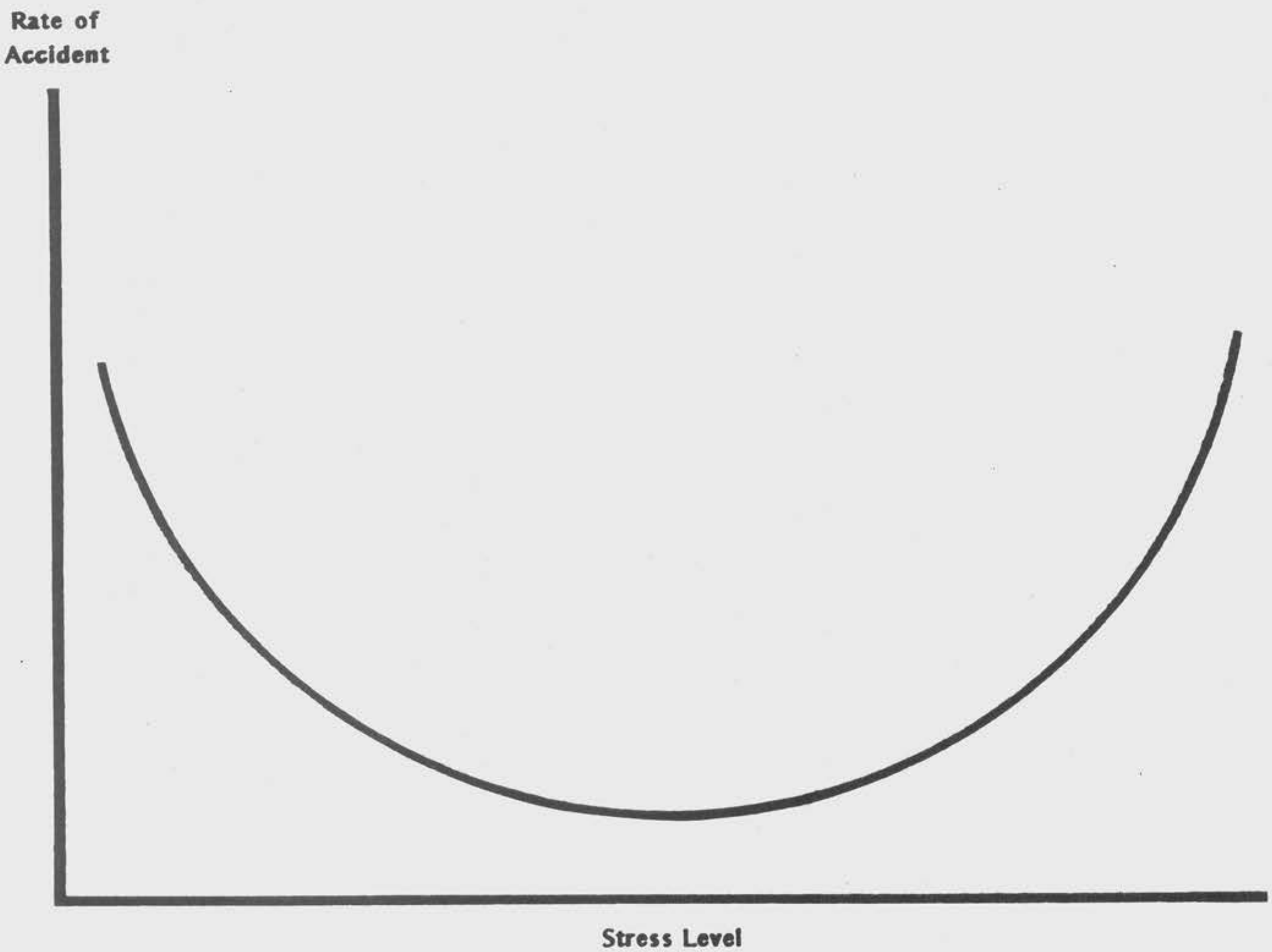


Figure 6

HYPOTHESIZED RELATIONSHIP BETWEEN THE LEVEL OF STRESS AT THE WORK PLACE AND THE RATE OF ACCIDENTS



Note that both high and low stress levels may increase the rate of accidents.

REFERENCES

1. Cooper, C. L., and Marshall, J., "Occupational Sources of Stress: A Review of Literature Relating to Coronary Heart Disease and Mental Ill Health", Journal of Occupational Psychology, 1976, 49, pp. 11-28.

2. Karasek, R. A., "Job Decision Latitude, and Mental Strain: Implications for Job Redesign", Administrative Science Quarterly, 1979, 24, pp. 285-308.

3. Knight, J. L., Geddes, L. A., and Salvendy, G., "Continuous Unobtrusive Performance and Physiological Monitoring of Industrial Workers", Ergonomics, 1979, in press.

4. Knight, J. L., Salvendy, G., and Howells, R., "Reducing Cognitive Load in Man-Machine Interaction Involving Psychomotor Skills", Proceedings of the III International Symposium on Man-Machine Systems and Environments, Dubrovnik, Yugoslavia, 3-5 September, 1979.

5. Levi, L., "Introduction: Psychosocial Stimuli, Psychophysiological Reactions, and Disease", Acta Media Scandinavica, 1972a, Supplement 528, 191, pp. 11-27.

6. Salvendy, G., and Humphreys, A. P., "Effects of Personality, Perceptual Difficulty, and Pacing of a Task on Productivity, Job Satisfaction and Perceptual Stress", Perceptual and Motor Skills, 1979, Vol. 49, pp. 219-222.

7. Sharit, J., and Salvendy, G., "Effects of Work Pacing and Attentional Requirements", Unpublished Report, School of Industrial Engineering, Purdue University, 1979.

8. Suaurenan, S., Basila, B., Salvendy, G., and McCabe, G. P., "Effects of Conveyor Operation on Posture and Body Movements of Industrial Operators", Unpublished Report, School of Industrial Engineering, Purdue University, 1980.

PERSONAL PROTECTIVE EQUIPMENT

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For a presentation on personal protective equipment it is first necessary to put the subject in perspective.

The economic perspective in Canada is that twenty (20) percent of the total compensation payments of about one billion dollars (Canadian) were for parts of the body for which protection is alleged to exist. Some protection!

For the professional perspective of protective equipment in the accident process, there are two conceptual models which give considerable insight for further study and development.

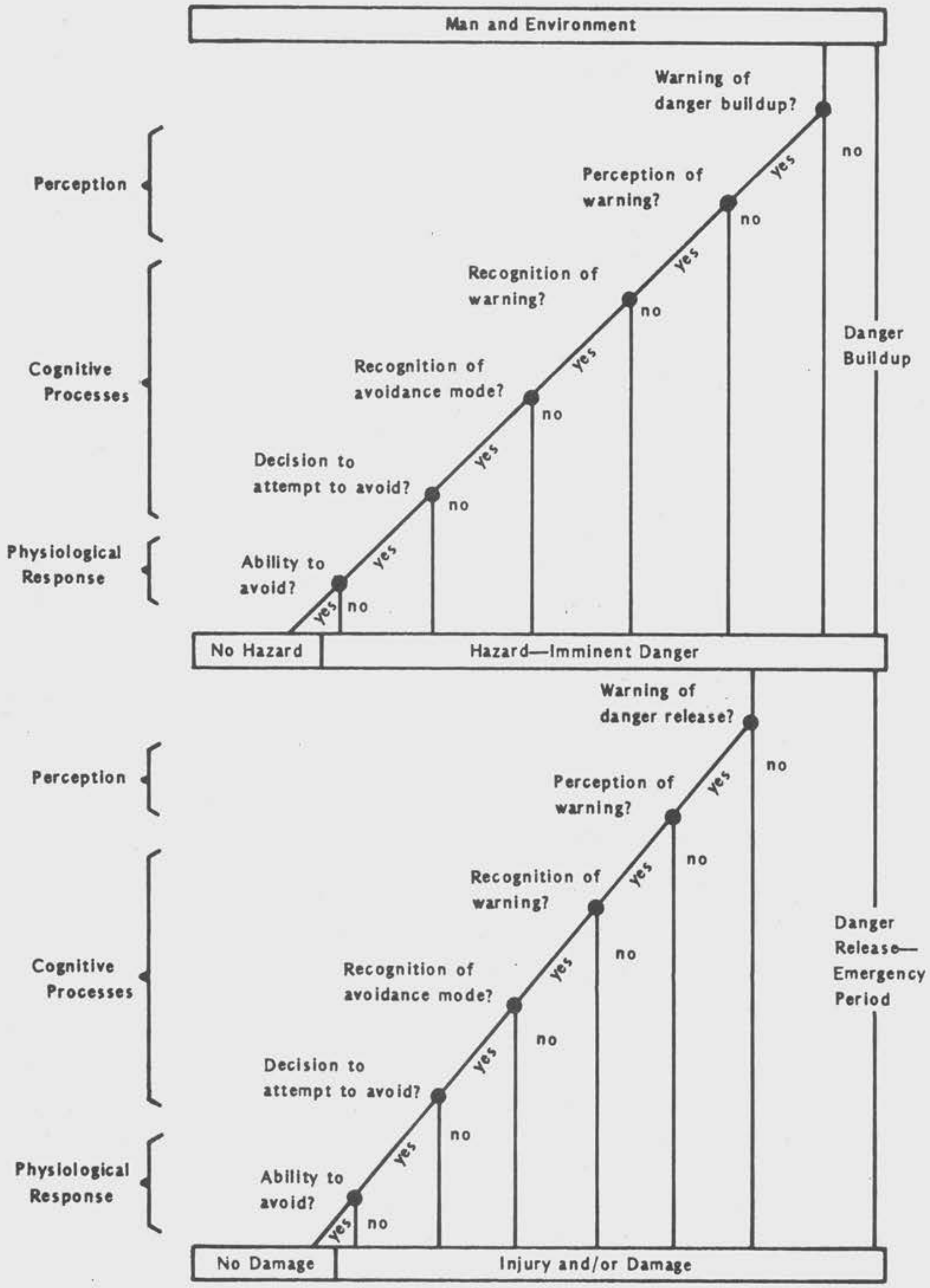
Exhibit 1 is a model of men's passive response or decision model in the accident/injury process, showing three principal stages with two similar cycles linking them. In sequence, from top to bottom there is the secure man and environment stage moving through danger build-up cycle to a possible imminent danger stage and then through an energy release cycle to a possible injury and/or damage stage.

Men often court danger by taking risk in the face of probable danger growth. In that first cycle, a negative decision or response to the questions representing man's perceptive, cognitive and physiological capabilities will lead to imminent danger.

Imminent danger coincides with initiation of energy release and the same series of questions applies in the danger release, or energy release cycle, possibly leading to the injury and/or damage stage.

Exhibit 1

MAN AND ENVIRONMENT



It is in this second cycle that protection is the vital consideration. In the first cycle, "prevention" of the occurrence so that no energy is released is the consideration.

The first cycle is that period of time (which could be days, weeks or even longer) where "accident prevention" must be practiced.

Interviews with many injured workers at the Ontario Workmens' Compensation Board Rehabilitation Centre made it very clear that in the second cycle "it all happened so fast"——that virtually all of those interviewed had to agree that appropriate personal protective equipment, if available and worn was the only certain safeguard.

This leads to an interesting consideration of the method of recording basic facts relating to the nature and occurrence of work injuries as used in the United States.

The "accident type" classification identifies the <u>event</u> which directly resulted in the <u>injury</u>.

Typical events are "struck by," "caught between," "falls from one level to another," etc. all of which imply energy is already released. This classification in practice is unquestionably related to the second cycle – the part associated with protection against injury. In fact, the appropriate title would be <u>"injury event"</u> rather than "accident type". Conditioning created by the use of the words "accident type" over the years has associated this classification with the second cycle. Accident prevention (defined as ensuring that energy is not released) and therefore all accident factors must be considered in the first cycle. This confusion of the words accident vs injury (cause vs effect) has inhibited investigation into the myriad of root causes of accidents.

However, the emphasis of this paper is on personal protective equipment, related conceptually to the second cycle.

The second conceptual model of the injury process is the energy exchange model. This is based on the fact that injuries to a living organism can be produced only by some energy interchange.

In other words, by technical definition an injury is an abnormal energy exchange. Energy exchanges resulting in injury can be mechanical, chemical, thermal, electrical, etc. but are of a limited number, permitting a reduction of classification of agents. Furthermore, there is then significant potential for quantifying. The eminent British Scientist Lord Kelvin wrote: "When you can measure what you are speaking about, and express it in numbers, you know something about that subject. But when you cannot measure it in numbers, your knowledge is of a meagre and unsatisfactory kind."

Applying these concepts to personal protective equipment, and at this time considering very briefly only head and foot protection, we will start with the necessary basic principles for protection:

Match the Protection to:

Type of Hazard

Part of Body at Risk

Size of Hazard

In a Manner Acceptable to the Wearer

We could start with head protection which will provide protection for "strike against" and "struck by". (Note this is the second phase of the accident injury process - energy is already released.)

In Canada our efforts in considering the basic principles for head protection concentrated on,

- The "struck by" type of hazard
- The five regions of the head top, front, back, right and left
- The energy exchange of falling objects as determined in a Canadian survey related to both foot and head injuries.

The locations of object impact on hard hats were as follows:

Location	Percentage of Impacts
Top 20% Hat Area	33%
Right Hat Area	15%
Left Hat Area	10%
Front Hat Area	12%
Back Hat Area	7%
Multiple Locations	23%

The important issue here is that only 1/3 of the impacts were at a location coinciding with the impact test location in the test requirement of standards (both in U.S.A. and Canada).

One series of tests performed by a consultant at Ottawa showed that the turban of a sikh, while not meeting the impact performance requirements of the standards, was better than some certified hard hats for impact at the back of the hat.

A study of potential energy of objects which fall on Canadian industrial workers (excluding certain claims of potential energy in excess of 1,000 ft. lbs.) is shown on the distribution chart in Exhibit 2.

This study suggested sizes of the problem in terms of total potential energy available for conversion to kinetic energy and ultimately available for "abnormal energy exchange" on contact with a foot or a head.

Responses to the question as to the nature of the falling object, and bearing in mind that not all energy is transmitted to a person, led to the arbitrary assumption that energy transmitted to a person was half (1/2) of the total potential energy available. This assumption provided quantities which could be conservatively low but were values which manufacturers of protective equipment could use to set their sights in protecting even larger populations from the actual hazard. Much more intensive investigation would be required to develop accurate energy exchange information.

In Canada, there are still 20,000 head and neck occupational injuries a year costing $40 million (Canadian) through workers compensation boards. This would suggest that one consideration in reducing this loss could be improved head protection, and there are well informed professionals who are convinced this is possible without overwhelming change to present design concepts.

Following basic principles in a study of foot injuries, Canadian efforts for such injuries in all industries and all provinces concentrated on:

- The "struck by" type of hazard
- The five regions of the foot: toe, metatarsal, sole, ankle and heel
- The energy exchange of falling objects as determined in a Canadian survey related to both head and foot injuries.

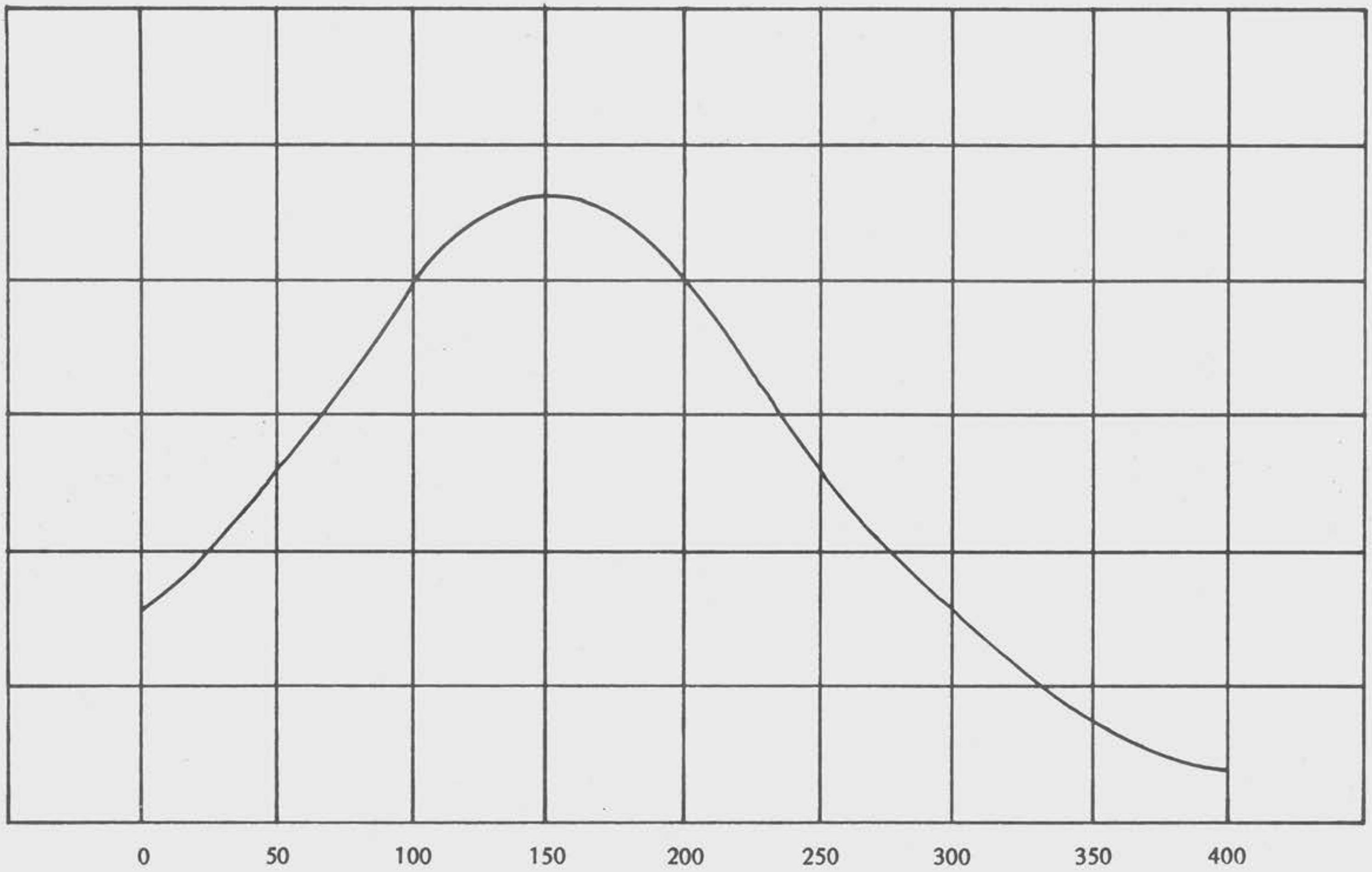
The locations of impact to the foot were as follows:

Location	Percentage of Impacts
Toe	25%
Metatarsal	31%
Sole	6%
Ankle	32%
Heel	6%

For the "struck by" hazard, the assumed energy exchange taken from the distribution chart of potential energy and applying the 50% factor had an average value of 75 ft. lbs. with a standard deviation of 50 ft. lbs.

Exhibit 2

IDEALIZED DISTRIBUTION OF POTENTIAL ENERGY OF OBJECTS WHICH FALL ON CANADIAN WORKERS



When the construction industry of Ontario started a very successful program for better foot protection in 1968, there was an injury frequency rate of 7.5 per million man-hours at that time. This frequency rate equates approximately to the fact that 3 out of 4 construction workers spending an entire working lifetime in construction would receive a disabling injury to the foot.

At that time, as manifest in the safety regulations of the day, legal requirements were to wear "safe footwear" with a steel box toe, but not in the winter when protection against cold was the alleged greater hazard. In virtue of these requirements, and noting the percentage of injuries to different parts of the foot, the overall effectiveness of foot protection at that time for all parts of the foot was very low:

- Only the 25% protection for the toe was required

- This protection required only about 1/2 the time

- The protection available but not in general use at that time was 75 ft. lbs. energy absorbtion at the toe, which could cater for less than 1/2 of the energy exchanges.

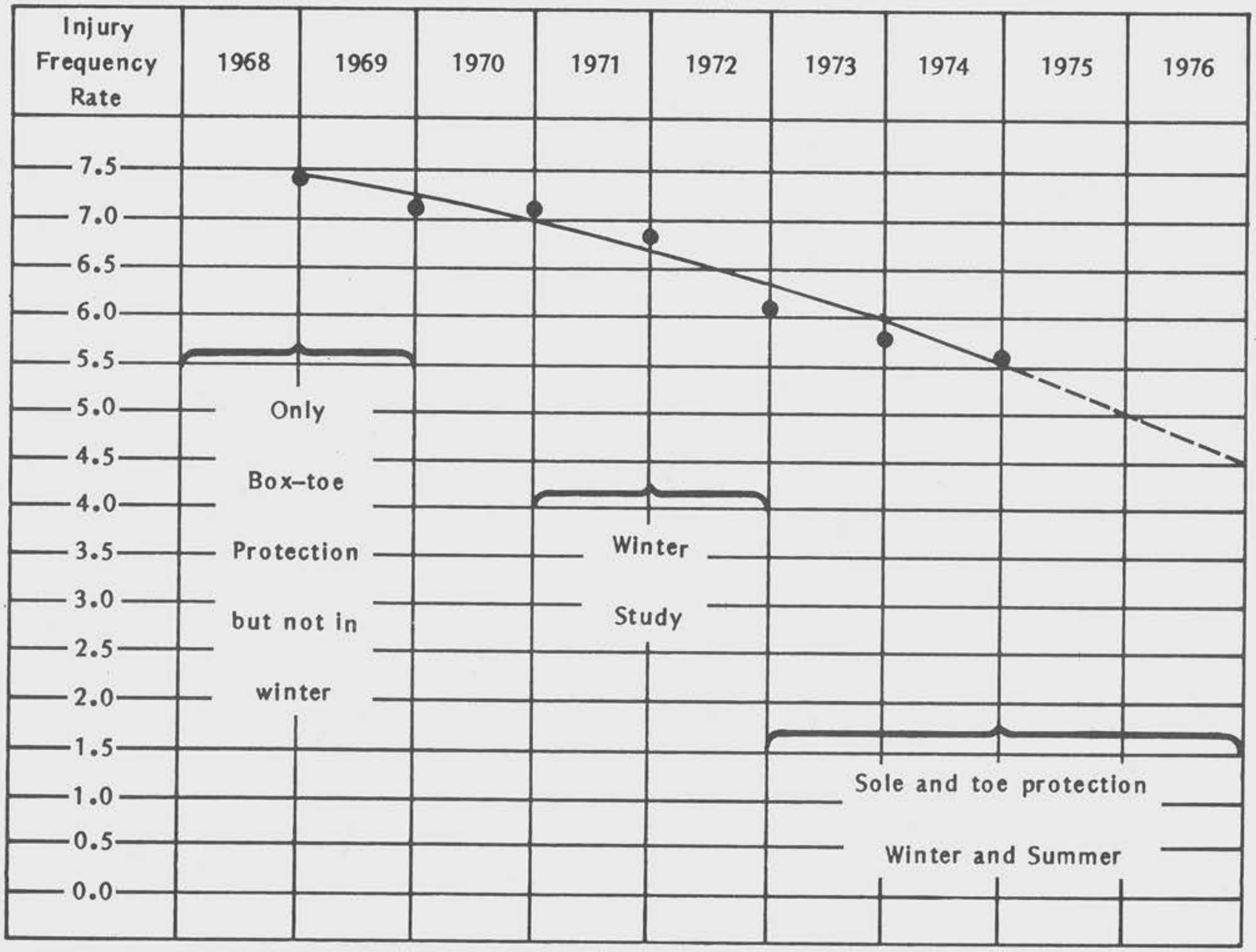
Considering those facts alone, the overall potential for safe footwear was only 6% and that ignores the large percentage who did not wear any kind of safety boot. The potential for some support and therefore some reduction in injuries to the ankle (32% of total) was negated by the fact that very few construction workers laced up their safety boots to the top.

The United States could well question their present overall potential for protecting the feet of their construction workers. Does it exceed 6%?

In dealing with this problem, (see graph in Exhibit 3) the first step was the question of winter work. Why permit non-safety footwear? The answer to dealing with the problem was an approach which combined elements of research, communication and involvement of construction workers. Twenty-eight construction workers actively engaged in outside construction work in northern cities of Ontario volunteered for the test program. Each volunteer was presented with two pairs of boots of their own choice, identical in appearance, but one pair was certified safety footwear (to a C.S.A. standard) and the other pair was non-safety footwear. The workers were asked to wear odd boots during the winter months, the safety boot on one foot, the non-safety on the other. This was reversed the next day. The results of records of how their feet actually felt indicated that there was very little difference in their perception of relative coldness. Where some difference was noted, the safety boot was warmer. These results convinced the volunteers and labor force and ultimately convinced the government in August, 1973 that safety footwear could and should be worn in winter and summer. These results were confirmed by closely controlled laboratory tests in 1977.

Exhibit 3

FOOT INJURIES REDUCED



In 1968, the percentage of injuries to the soles of construction workers in Ontario was significantly greater than the average value of 6% for all industry today. This fact motivated the Canadian Standards Association to develop standards, tests and certification programs for minimizing sole injuries; in 1973 the government included this protection as a legal requirement. Also at the Canadian Standards Association, work was initiated for even higher standards of energy transfer and only 3 grades of toe protection:

- 93 ft. lbs. (125 joules)
- 61 ft. lbs. (90 joules)
- 45 ft. lbs. (60 joules)

Lobbying continues for an even higher grade of 120 ft. lbs. (160 joules).

The following chart, based on a computerized survey of Canadian workers was completed by the Canadian Standards Association in 1977 for injured workers in different industry classifications. The energy levels relate to impacts at the toe and metatarsal areas. Many industries need the grade of protection now available to them.

This special effort for better foot protection in one industry of one province resulted in direct savings for that province in direct costs of compensation as follows:

Year	Frequency of Foot Injury	Annual Savings $ by Reduction from 1968 Frequency
1968	7.42	–
1969	7.07	210,000
1970	7.24	108,000
1971	6.85	342,000
1972	6.06	816,000
1973	5.80	972,000
1974	5.67	1,050,000

In 1976, the direct cost of foot injuries and associated compensation to injured workers of all industries in Canada was $50 million. We still have a long way to go, but a course has been charted, and our next major emphasis will be on metatarsal protection. The Canadian experiences in respiratory, hearing, fall arresting and eye protection have equally interesting and unique considerations, but that must wait for another occasion.

However, since the next speaker on our panel is my good friend Allan Sherr, I will make one comment about eye protection. In the Canadian survey of eye injuries, it was determined that 60% of those sustaining an eye injury were not wearing any type of eye protection.

Among the reasons that workers have for not wearing "zero power" safety glass is the distortion which the spectacles create. Indeed, if one were to look at a wall, say 10 feet away, with a grid pattern on it with lines spaced at 2 feet intervals, one would see the lines as in the illustration, Exhibit 4.

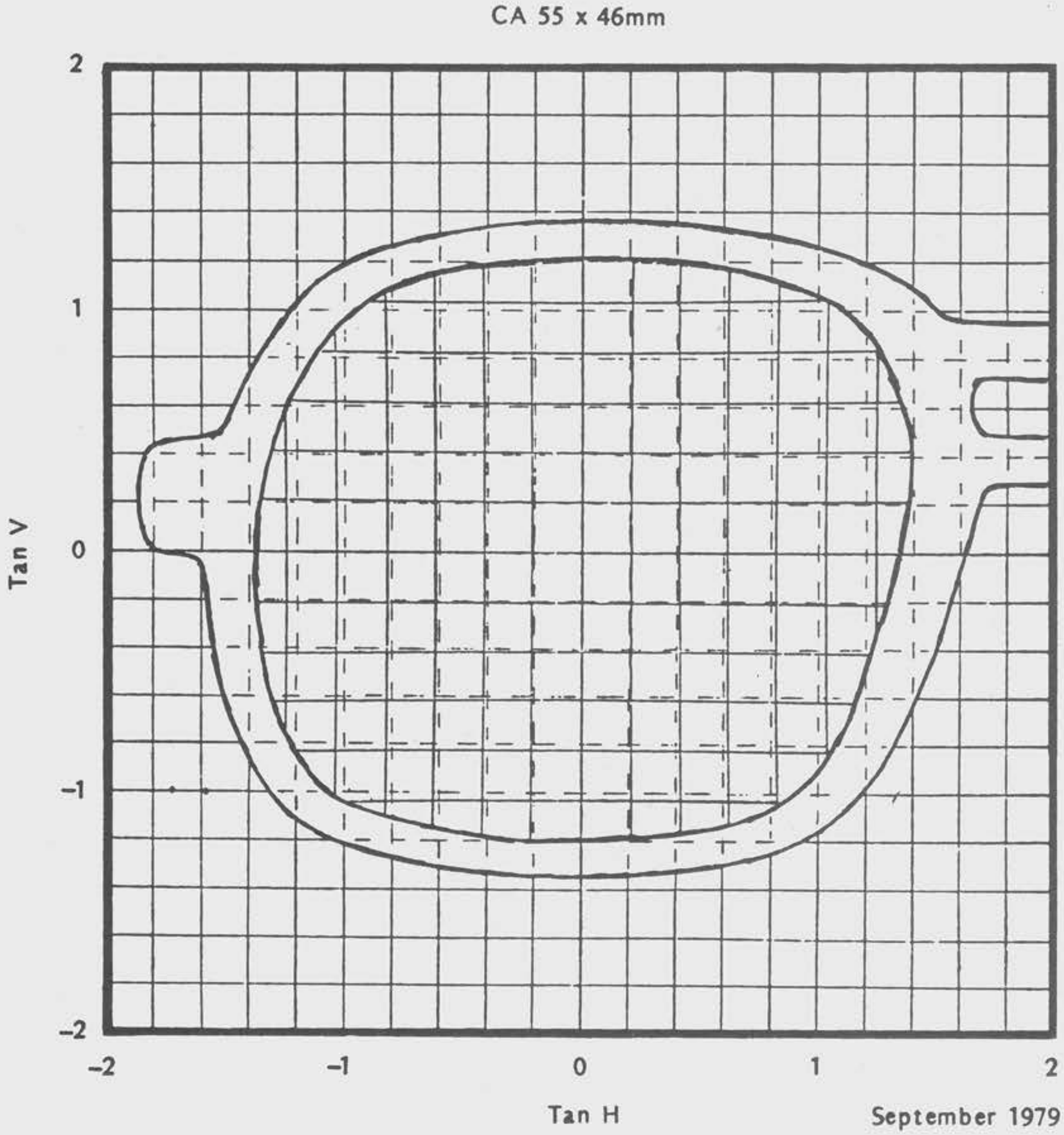
The solid lines show what you see: the dashed lines show the real grid pattern. There really is distortion which can be extremely disturbing to some workers.

We do need a light comfortable protector which will not limit or impair direct and peripheral vision and with less distortion than in the conventional "6 base" spectacle lenses. Wrap around spectacles are an interesting possibility, and I would ask Allan to comment on these ideas in his presentation.

Thank you for your kind attention to my presentation.

Exhibit 4

DISTORTION PRODUCED BY "ZERO POWER" SAFETY GLASS



STATUS OF EYE PROTECTIVE EQUIPMENT

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INTRODUCTION

In the last few years significant changes have occurred regarding industrial safety eyewear. This paper will briefly review some of the developments in materials, applications and standards. Emphasis will be on the new plastic materials and the needs for protection in the ultra-violet and near-infrared portions of the electromagnetic spectrum. Needs for improved products and areas of research will be presented.

Polycarbonate Lenses

The most recent improvement in eye protection products in the last five years has been the development of polycarbonate safety lenses with a mar resistant coating applied to both surfaces of the lens. The polycarbonate acceptance is based on several factors.

Impact Resistance

Foremost is the impact resistance of polycarbonate compared to glass and other optical plastics. Table 1 compares the impact resistance of several plastic lens materials.

---

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Table 1

IMPACT RESISTANCE CLEAR PLASTICS

Test	Polycarbonate	Acrylic	Impact Acrylic	Butyrate
Drop Ball[a]				
73°F (22.7°C)	Greater than 20	1.6	27.0	
0°F (–17.7°C)	Greater than 20	1.6	11.0	30
–20°F (–28.8°C)	No breaks	1.6	2.5	8
Impact Strength				
Notched Izod	16	0.4	1.4	0.8–6.3
Ft–lb/in of notch[b]				

[a] 5 lb dart, 25mm diameter tip, 3mm thick specimen.

[b] 3mm thick specimen at 73°F (22.7°C).

The polycarbonate is significantly better in terms of impact resistance than the other three plastics. Similarly, polycarbonate is superior to glass in terms of impact resistance. A 3mm polycarbonate lens can withstand the impact of a six-ounce steel ball dropped from a height of 127 cm. This is a force much in excess of the minimum required for a safety lens under the current ANSI standards.[1,2]

Table 2 gives physical properties of several lens materials including glass. The superior impact resistance of polycarbonate to glass is shown.

J.H. King, R. K. Larkin and W. E. Newcomb[3] have recently compared glass and polycarbonate safety lenses for impact resistance. They report that polycarbonate lenses required energy levels of several orders of magnitude greater than glass lenses to cause any significant damage. Polycarbonate lenses were found to be capable of absorbing energy levels of substantial proportions before yielding to a point where lens failure may occur. King reports that although tempered glass is a very strong material and well suited to optical applications, it is extremely brittle and readily reduces to fragments. Even at extremely low temperatures, such as -46°C, the energy requirement for failures of polycarbonate lenses (with either a needle missle or a steel ball) remained considerably higher than the energy required to cause glass to fracture under any circumstances.

Penetration Resistance

King used a needle missile in his study, as noted above. The ANSI Z-87.1 Standard[1,2] has a requirement that a plastic lens withstand the penetration of a pointed projective consisting of a new Singer No. 25 needle fastened to a 44.2-gram (1.56 ounces) holder dropped from a height of 127 cm (50 inches) into the lens. Glass lenses are not subjected to such a test, and, in general, cannot withstand the penetration tests without breakage.

Optical Properties

As shown in Table 2, polycarbonate lenses have optical transmittance comparable to glass and other optical plastics. The application of the mar resistant coatings appears to improve the transmittance of the polycarbonate lenses.

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[1]American National Standard Institute Z-87.1-1968 Practice for Occupational and Educational Eye and Face Protection, New York, American National Standards Institute, 1968.

[2]American National Standards Institute Z-87.1-1979 Practice for Occupational and Educational Eye and Face Protection. New York, American National Standards Institute, 1979.

[3]J. H. King, R. K. Larkin, W. E. Newcomb: A Comparison of Glass and Polycarbonate Safety Lenses Relative to Impact Resistance. American Industrial Hygiene Conference, May 22, 1980, Houston, Texas.

Table 2

PHYSICAL PROPERTIES OF LENS MATERIALS

	Tensile Strength 10^3 psi	**Impact Strength ft–lb/in of Notch**	**Heat Resistance (Continuous) °F**	**Light Transmittance %**
Mar Resistant Polycarbonate Lens	9–10.5	12–16	250–270	90–92
Glass, Heat-treated		0.3–0.4	300+	89–92
CR-39	5–6	0.2–0.4	212	89–92
Polycarbonate	9–10.5	12–16	250–270	85–91
Poly(methyl methacrylate)	5.5–10.5	0.4–0.5	150–225	92

Ultraviolet and Infrared Protection

Most plastics do not provide the required infrared protection. Many do not even provide the required ultraviolet protection. The danger is that this lack of protection cannot be recognized by the human eye observing only the visible spectral range. The eye is damaged, as by ultraviolet, with the feeling of sand in the eye or a burning sensation.

Until recently, it had been believed that cumulative damage to the eye was caused by near-infrared radiation. Pitts[4] has just reported that in acute exposures, primary occular lesions resulting from exposure to infrared were corneal, iris and lenticular. The corneal damage varied from ephitheal haze to erosion and usually healed within 24 hours. The iris showed stromal haze and swelling in the region of infrared exposure. Lenticular opacities appeared as small white dots. Pitts believes that infrared ocular damage is a single process, and that heat is the process responsible. He further believes that the eye should be protected from ultraviolet, visible and near-infrared radiation.

Figure 1 illustrates the spectral curves of a green acetate visor and a face shield made with the IREX® infrared absorbers. Note the absense of protection from 700–2000 nm for the green acetate visor, while both have about the same visible transmittance and about the same color.

Welding Eye Protection

The filter glasses used for the observations of welding processes have three main functions, as follows:

A. Reduction of visible light to a comfortable level,

B. Mechanical protection of the welder's eyes from weld spatter, and

C. Reduction of ultraviolet, visible and infrared radiation emitted during the welding process, to a level at which harmful physiological effects on the eyes are negligible.

Up to quite recently, these objectives could be achieved by only using glass filter plates. Early in 1968, plastic filter plates were introduced which were capable of fabrication into a variety of forms, shapes, configurations, etc. Generally speaking, for the same thickness, plastic materials are about one-half the weight of glass. The plastics will not break or crack under the conditions of normal welding exposures and use. The plastic welding filters may function by absorption or reflection.

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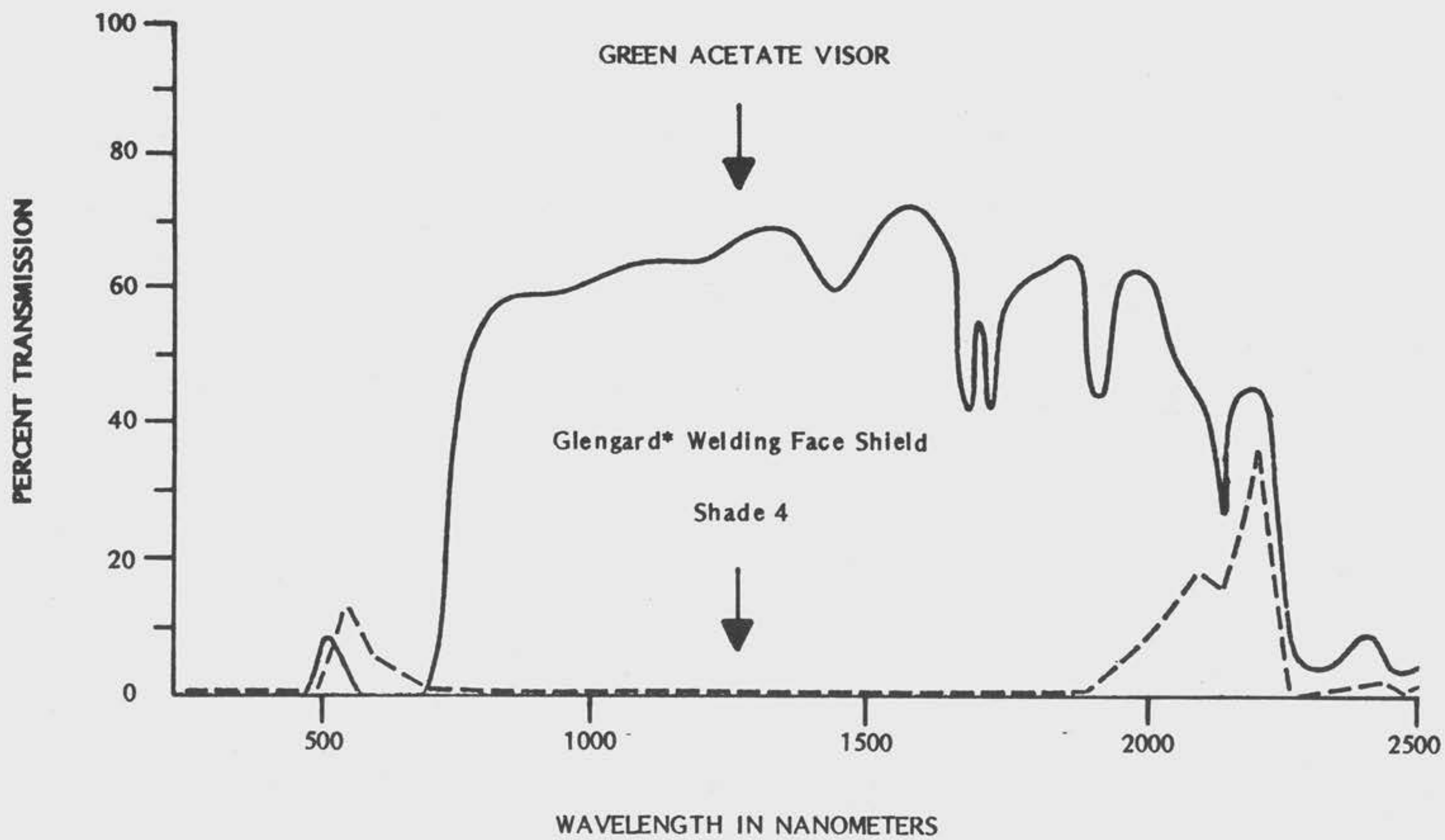
[4] D. G. Pitts, A. P. Cullen and P. Dayhaw-Barker: Determination of Ocular Threshold Levels for Infrared Radiation Cataractogenesis. American Industrial Hygiene Conference, May 22, 1980, Houston, Texas.

Figure 1

GREEN ACETATE VISOR



*Trademark

In the United States, filters designed to protect against the radiation from the welding arc must meet the ANSI Z-87 requirements.[2]

For the last several years this hazard has received more attention. The three major spectral bands of concern are the ultraviolet, visible and infrared. Worldwide consensus is that major eye damage can occur from both near-infrared radiation (the recent work of Pitts, Sutter in Germany and Slucki in France) and ultraviolet radiation. In recognition of this, the ISO Standard (Table 3) has put tighter specifications into the near- and mid-infrared wave lengths. It should be emphasized that near-infrared is difficult to measure in the laboratory and even more so in field conditions. Fortunately, the glass and plastic lenses sold by the major reputable concerns in the United States, meet both the ANSI and ISO requirements. It should be pointed out that the plastic absorptive lenses made from the IREX® infrared absorbing compounds have the fortunate virtue of having their strongest absorption in the near-infrared wavelengths as shown in Figure 2.

Up to 1980, the required spectral protection could be found in plastic lenses of two types, the absorptive lenses made with IREX infrared absorbing compound in cellulosic, acrylic and vinyl polymers or reflective polycarbonate lenses.

Absorptive Polycarbonate Lenses

The newest absorptive protective plastic lens is one made using polycarbonate. Up to now, ultraviolet and visible absorbers could be incorporated into polycarbonate, but the polycarbonate and infrared absorbers were incompatible. Recently introduced was their IR/PC* lens which combines the protective spectral properties of ultraviolet, visible and near infrared absorbers with the light weight and impact resistance of polycarbonate. In addition, the lenses have a special TEMA II® mar resistant resin coating to resist spatter and superficial surface damage.

Mar Resistance

The current mar resistance coatings are of two basic chemical types: polyurethane or polysiloxane.

Spectacle lenses may be damaged by scratching, indentations, pitting, chipping, wearing away of the material, development of haze or loss of gloss. Resistance to such damage is generally called "hardness" or "abrasion resistance." These terms are often difficult to define.

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[2]American National Standards Institute Z-87-1979 Practice for Occupational and Educational Eye and Face Protection. New York, American National Standards Institute, 1979.

*Trademark American Cyanamid Company

Table 3

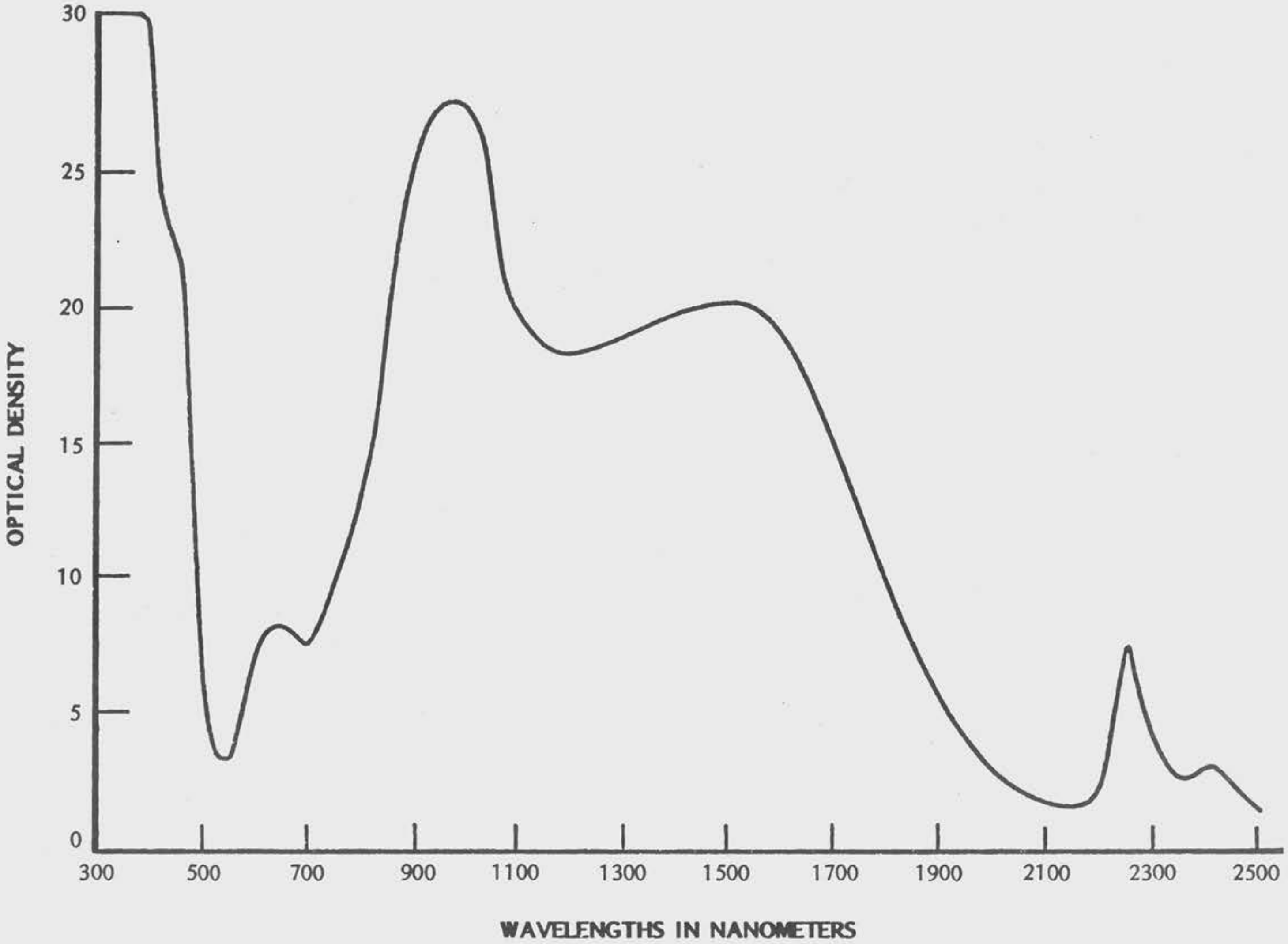
ISO STANDARD – WELDING FILTERS

Shade Number	Luminous Transmittance		Infrared Transmittance		Z-87.1 (U.S.A.) 700–4000 nm %
	Allowed %	Range %	NIR, 1300–780 nm %	NIR, 2000–1300 nm %	
1.2	100–74.4	134	37	37	—
1.4	74.4–58.1	128	33	33	
1.7	58.1–43.2	134	26	26	20
2.0	43.2–29.1	148	21	13	15
2.5	29.1–17.8	163	15	9.6	12
3	17.8–8.5	209	12	8.5	9
4	8.5–3.2	266	6.4	5.4	5.0
5	3.2–1.2	267	3.2	3.2	2.5
6	1.2–0.45	267	1.7	1.9	1.5
7	0.45–0.17	265	0.81	1.2	1.3
8	0.17–0.06	283	0.43	0.68	1.0
9	0.06–0.023	261	0.2	0.39	0.8
10	0.023–0.0085	271	0.1	0.25	0.6
11	0.0085–0.0032	266	0.05	0.15	0.5
12	0.0032–0.0012	267	0.027	0.096	0.5
13	0.0012–0.00045	267	0.014	0.06	0.4
14	0.00045–0.00017	265	0.007	0.04	0.3

Figure 2

WAVELENGTHS IN NANOMETERS

GLENGARD® lens with IREX® infrared absorbers



The new coatings for polycarbonate spectacle lenses make the lenses resistant to superficial surface damage causing changes in the reflection or transmission of light. We refer to this retention of optical quality as "mar resistance." We define marring as the development of up to 6% haze, or loss in transmission of the lens of up to 6%. By covering the very impact resistant polycarbonate plastic with the new mar resistant coatings, spectacle lenses of a high level of safety and durability result.

There are many techniques for measuring mar resistance. Among these are the Taber abraser described in the American Society of Testing Material's Procedure D-1044-73,[5] the Falling Carborundum Test (ASTM D-672-70),[6] the Armstrong Test (Method B of ASTM D-1242),[7] The Steel Wool Test,[8] Cleaning Tests[8] and the Cyanamid Mar Test.[9] For rapid qualitative evaluation of the mar resistance of plastics, we use the Cyanamid test. Typical results from the Cyanamid test and the Taber procedure are shown in Table 4. It can be seen that only glass is superior to the coated polycarbonate lenses in terms of mar resistance.

I might comment that while a steel wool mar test can be done most readily, its correlation with the real world is most questionable. Certainly spectacles have been and are cleaned with many things, but how often does a person clean his spectacles with steel wool?

Configurations

The polycarbonate lenses just described are available in many configurations. Both plano and prescription spectacles are available which have the mar coatings. These coated polycarbonate lenses have improved ultraviolet protection compared with clear glass lenses as shown in Figure 3.

This is an added benefit of the plastic compositions. The coated lenses not only protect against UV-C light at 100-280 nm, but also against UV-B light at 280-315 nm and some of the UV-A light at 315-400 nm.

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[5]American Society for Testing and Materials, 1976 Annual Book of ASTM Standards, Part 35: 409-410.

[6]American Society for Testing and Materials, 1976 Annual Book of ASTM Standards, Part 35: 234-237.

[7]American Society for Testing and Materials, 1976 Annual Book of ASTM Standards, Part 35: 441-448.

[8]Mock, J. A.: Lightweight, Transparent Plastics Have Excellent Inpact Resistance. Materials Engineering 80: 42-44, 1975.

[9]Sherr, A. E. Deichert, W. E., Webb, R. L.: A New Mar Resistance Tester for Plastics. Plastics Design and Processing 10: 24-26, March 1970.

Table 4

LENSES COATED WITH TEMA II MAR RESISTANT RESIN COATING

A. Cyanamid Mar Test[5]

Material	No of Rings[a]	Rating
TEMA II Mar Resistant Resin	1–3	Excellent
Abcite[b] Abrasion Resistant Sheet (on Polycarbonate)	1–3	Excellent
Glass	0–1	Excellent
CR-39	5–7	Good
Polycarbonate	28–30	Poor
Poly(Methyl Methacrylate)	30+	Very Poor
Cellulose Acetate	30+	Very Poor

B. Taber Mar Test

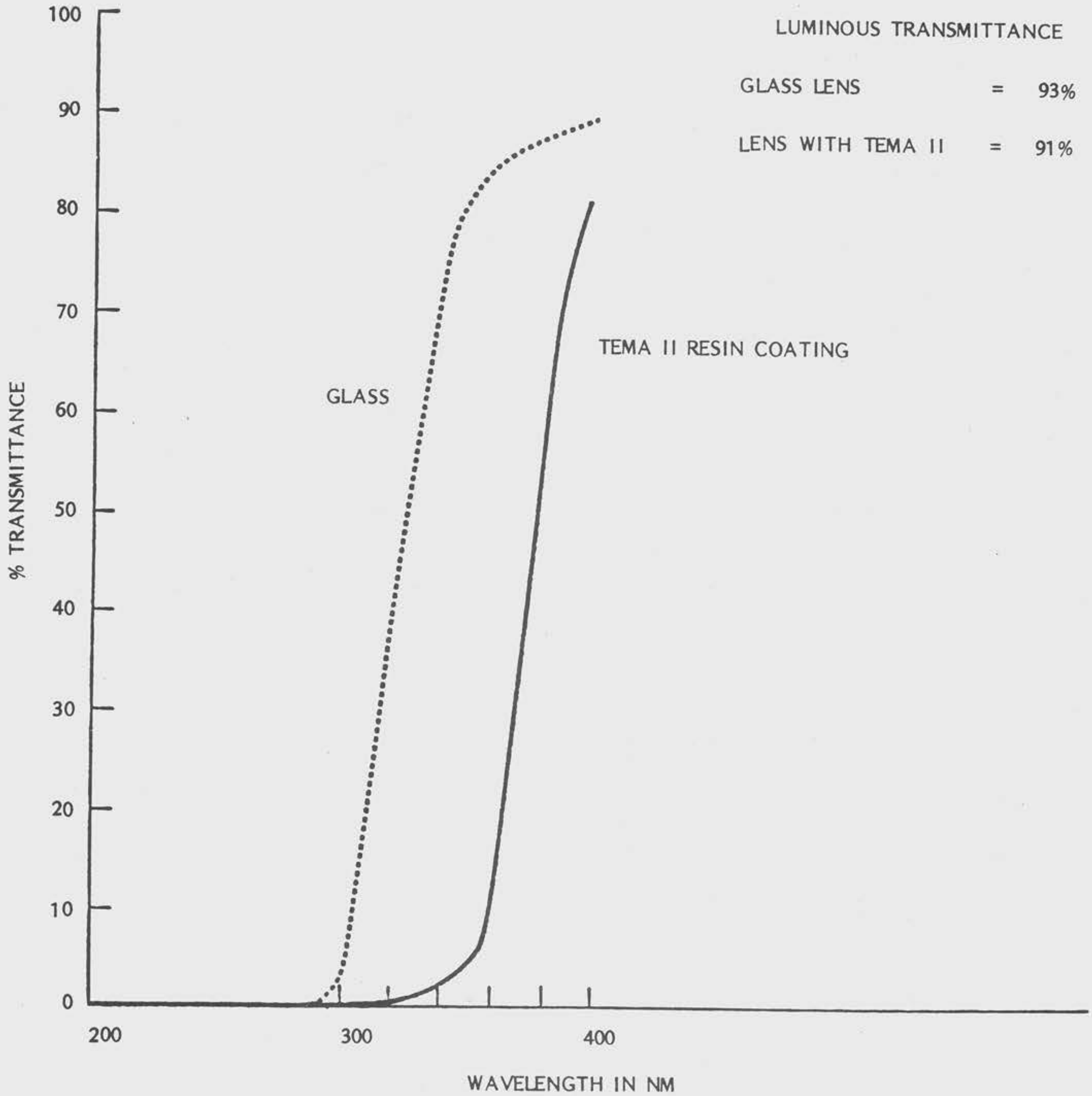
Material	Haze
TEMA II Mar Resistant Resin	5%
Abcite Abrasion Resistant Sheet (on Polycarbonate)	5%
Abcite Abrasion Resistant Sheet [on Poly(Methyl Methacrylate)]	3%
Glass	0.2%
CR-39	12%
Polycarbonate	38%
MR-4000 Polycarbonate	7%
Poly(Methyl Methacrylate)	24%

[a]0–3 rings = excellent; 4–7 rings = good; 8–15 rings = fair; 16–29 rings = poor; 30+ rings = very poor.

[b]Product of E. I. duPont de Nemours and Company.

Figure 3

ULTRAVIOLET TRANSMITTANCE OF GLASS LENS AND LENS COATED WITH TEMA II RESIN COATING



Polycarbonate face shields are available as are the previously mentioned welding filters. In addition, some laser protective goggles with polycarbonate lenses are available.

Laser Protection

Lasers are increasingly being utilized for welding operations and other industrial applications. These new devices require specialized eye protection for the specific wavelengths of concern. There are three major types of devices: the modified welding goggle, the spectacle and the soft side goggle.

Protection is accomplished by three major techniques: absorptive plastics, absorptive glass and reflective glass. As I mentioned earlier, I prefer the absorptive method over the reflective. Particularly with lasers, I have this opinion. When scratched, the reflective lens loses protection, an absorptive does not. A reflective lens has its maximum protection only for laser beams at right angles to the reflective surface. This is not true for absorptive lenses. With reflective lenses, there is the possibility of reflecting the potent laser beam into the eyes of people in the area.

The major laser wavelengths in commercial use now are:

Neon–Nitrogen	at 332 and 337 nm (ultraviolet)
Argon	at 488 and 514.5 nm (visible)
Helium Neon	at 632.8 nm (visible)
Ruby	at 694.3 nm (visible)
Neodymium or YAG	at 1.060 nm (near-infrared)
Carbon Dioxide	at 10,600 nm (infrared)

Typical protection against these wavelengths is shown in Figure 4. The current major standards on laser eye protection are the ANSI Z136 Standard,[10] the ISO, the DIN and the British standards.

Standards

The ANSI Z87.1–1979[2] standard has finally been published. Even before it was issued, it badly needed revision. My personal preference is for a performance standard rather than a design standard. I suggest that the Z87.1–1979, while more

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[10]American National Standards Institute Z–136.1–1976 Standard For the Safe Use of Lasers. New York, American National Standards Institute, 1976.

[2]American National Standards Institute Z–87.1–1979 Practice for Occupational and Educational Eye and Face Protection. New York, American National Standards Institute, 1979.

Figure 4

OPTICAL DENSITY VERSUS WAVELENGTH
LASER-GARD GOGGLES

Designed for Laser	Wavelength nm	Optical Density	% Luminous Transmittance
Neon-Nitrogen	332	15	70
	337	16	
Argon	488	15	45
	514.5	11	
Helium-Neon	632.8	6	20
Ruby	694.3	6	20
Gallium Arsenide	840	14	45
Neodymium	1,060	14	45

explicit and less ambiguous than the 1968 issue, still can be greatly improved. It continues to carry too many design criteria, it remains confusing on many issues, and it should be clarified. I strongly urge the U.S. to adopt a standard similar to that being promulgated by ISO which stresses performance over design. There are separate ISO standards on uses of eyewear, on specifications for eyewear and on test procedures. This, to me, seems a far better practice. Let us not hinder development of new concepts and products by continually imposing design restrictions!

Needs

In our concepts, we are still limiting ourselves by tradition. We are all too accustomed to the standard spectacle, faceshield, and filter configurations. Are there not better ways to protect the eye and the face that will provide greater comfort and acceptance, thus insuring more broad and continual use?

We are accustomed to having our eye protective devices attract dust, become foggy and, in the case of plastics, become marred. In the future, we should be able to develop lenses which provide better glare protection and/or have anti-reflection properties. Plastics which have mar protection superior to those currently in use will be developed.

We should be able to put all these improvements into one product to provide protection from spectral energy, fog, dust, glare and physical damage!

Further, as plastics become more widely accepted for eye protection, the consumer needs some method to rapidly ascertain that the product purchased does meet the specifications for the use. For example, a need exists for simple instrumentation to insure spectral protection.

Continuing work to define the occupational hazards by light from the ultra-violet, visible and infrared wavelengths should be performed. There is much to be learned about these hazards. As new applications and processes arise, definitions of the protection needed will be required.

Summary

A review of recent significant developments in industrial eye protection has been presented. The emphasis was on the new plastic eye protective devices. Such products can now provide both infrared and ultraviolet protection in very high impact resistant plastic (polycarbonate). The polycarbonate can be coated to have mar resistance approaching glass. Needs for further improved products and areas of research were discussed.

Acknowledgement

I would like to thank both Glendale Optical Company and Gentex Corporation for supplying material used in some of the figures.

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BEHAVIORAL APPROACHES TO PERSONAL PROTECTIVE EQUIPMENT USAGE[1]

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ABSTRACT

The likelihood of a worker wearing a personal protective device is viewed as a function of the immediacy of the hazard and its consequences, the encumbrance/discomfort imposed by the device, and its perceived effectiveness to the wearer. Various strategies for altering these factors are described as to favor greater use of personal protective equipment. Techniques using early indicators, pre-clinical signs of latent disorders are noted in generating more immediate concern about insidious and remote hazard producing conditions. Behavioral analysis approaches, involving rewards for safe acts such as wearing protective equipment, are recognized for their effectiveness in overcoming the burden imposed by protective equipment use. Providing frequent feedback or knowledge of results to signify the protection offered by the protective equipment is shown to be a potent motivator for its use. NIOSH studies offering empirical support to these ideas are referenced as are other observations in the job hazard control literature.

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[1]The author is indebted to Professor Bill Hopkins, Department of Human Development and Family Life, University of Kansas, Lawrence, Kansas 66045, for some conceptual ideas bearing on the organization of this paper.

INTRODUCTION

Techniques for promoting greater worker use of personal protective equipment[2] against job hazards bring to mind snappy slogans, eye-catching posters, and creative film strips with appropriate appeals. Indeed, the popular safety literature abounds with them. Glancing through some recent issues of safety magazines, there are "one liners" such as, "Give hand and body hazards a dressing down" (1), "Throw the book (the safety one, that is) at the head, eye, and face hazards" (2), or "Stick It In Your Ear" (3), the latter being the title of a film strip on hearing conservation. These approaches through their novelty or other features may have value in reminding workers of potential hazards, and one means for controlling them. That other efforts are needed, however, would seem indicated by a continuing trend for workers to forego using personal protective equipment. A recent survey by the Bureau of Labor Statistics of industrial eye accidents found, for example, that 60% of the workers were not wearing eye protection at the time of the accident (4).

The safety literature contains some new ideas for fostering greater use of personal protective equipment. Several of these will be highlighted below.

Organizational Scheme

The following proposition is set forth as a means of defining issues involved in promoting the use of personal protective equipment:

> "The likelihood of a worker using a personal protective device is a joint function of:
>
> - the immediacy of the hazard and its consequences,
> - the encumbrance/discomfort imposed in using or wearing the protector,
> - its perceived effectiveness to the wearer."

As to the immediacy variable in this formulation, situations can be contrasted where hazards are quite apparent, posing a high risk of acute or traumatic injury versus those involving less detectable agents presenting a more insidious or remote health threat. In more concrete terms, a work site with chipping operations spraying metal fragments in all directions would present a distinct risk of eye or other bodily injury. Such a condition would have a high immediacy rating. On the other hand, one where dust is being generated in a mining operation would pose the possibility of a more remote respiratory problem which has low immediacy. Thus, immediacy can vary with the severity of the exposure and the temporal realization of the expected effects.

[2]As used herein, the expression "personal protective equipment," "Protective devices" or simply "protectors" may refer to a single item or an ensemble and are to be considered as synomymous.

Without question, the use of personal protective equipment places an added burden on the user. Important determinants include the degree of encumbrance, weight, resistance to normal body function and movement, interference with job performance, added stress and need for maintenance (5, 6, 7). Cosmetic factors also contribute to the discomfort of women using these items, as well as loss of masculinity in men.

"Perceived effectiveness" in the above proposition refers to the user's appreciation and knowledge that such equipment, when used, can minimize the danger of injury or illness from known job hazards. Worker safety training is relevant here but so too are the workers' personal experiences reflecting credibility on the hazard control measures in effect.

With this formulation, the level of promotional effort needed to achieve success in a personal protection program aimed at controlling a particular hazard can be gauged. That is, relatively greater promotional efforts would be necessary in dealing with hazards having more subtle and latent effects, where the protective device imposes a significant burden on the user, and where the protective benefits are not immediately obvious to the wearer. Respirators for defense against dust or chemical hazards fall in this category.

Lesser efforts would be needed where the hazards are more obvious and acute, where the protective device is less encumbering, and where the user sees clear evidence of its value. Eye protection or face shields for safeguarding against flying particles, sparks, or chemical splash posing an eye hazard fall in this category.

PROMOTIONAL STRATEGIES

Immediacy Factor

Strategies for promoting increased use of personal protectors can be viewed as efforts at altering the immediacy, encumbrance, and perceived effectiveness terms in favorable ways. Generating more immediate concern among workers at risk to slower acting, and more remote chronic disease hazards has been tried through emphasizing early indicators of such disorders. For example, while it may take years of excessive noise exposure at work to cause a compensable amount of hearing loss, noise hazards to hearing can be detected earlier through evidence of temporary threshold losses in hearing which can occur even after a single work day exposure (8). In one company's hearing conservation program, workers are told to mark the setting of the volume control on their car radios upon coming to work, and to note the difference in audibility when going home (9). This is one way of acknowledging the temporary threshold shift (TTS) due to overexposure to noise. Studies utilizing measurements of TTS before and after the work—with and without ear protectors in personal use—have also been evaluated for their promotional potential. More will be said about this later. More concerted medical screening of workers including neurologic tests as well as biochemical measures are also mentioned in company safety programs as a means for monitoring the effectiveness of their environmental control practices in preventing overexposure to noxious chemicals (10, 11). Recognition then of these temporary or early effects can give immediacy to hazards which otherwise would go unnoticed. While not to be discussed here, training programs should attempt to deal more candidly with data showing the risk of being afflicted by different workplace hazards and the effectiveness of the control measures being used. However, concepts of risk and latency of the adverse health effects remain difficult ones to convey to workers in ways that create and sustain regard for threats which may or may not materialize in the distant future. Of course strict company rules and enforcement policies regarding usage of protectors in known hazardous areas are sometimes the only means to drive the message of danger home.

Encumbrance/Discomfort Factors

Efforts to redesign different types of protective equipment or offer alternative forms for minimizing the encumbrance or discomforting features are beyond the scope of this discussion. With regard to promotional ideas that can further these efforts, the literature notes:

1. Ensure that the protective equipment is readily available especially in areas where it is to be expressly used.

2. Wherever possible, allow the user a range of choices among suitable forms of equipment and ensure adequacy of sizing relative to the population of users. The latter can be an important consideration in light of increasing numbers of women entering non-traditional jobs.

3. Wherever possible, increase its attractiveness or cosmetic appeal. Safety shoes are a success story in this regard.

4. Where particularly encumbering apparel must be worn, increase the frequency of breaks to offset the burden.

5. Identify the use of such equipment with supervisory and other respected persons in the company or other admired figures. This would reflect management's commitment to the practice. To dispel the impression that use of protectors denotes weakness, references could be made to professional risk takers and the protective gear they wear. Football and hockey players, race car drivers, and astronauts offer useful models for conveying a different impression of the user type.

But the major attempt at overcoming the encumbrance factor in using protective equipment has been through incentives or rewards aimed at increasing the benefits in wearing them relative to their burden. For this purpose, techniques of behavioral analysis have been used which involve training sessions with workers where the desired behavior is identified (in this instance using a particular protective device), discussed, and illustrated in terms of its importance in controlling a specified hazard (12, 13). A reward structure is established to reinforce these desired acts among the workers. The rewards may vary from receiving praise and recognition, to special privileges, or gifts. Frequent reinforcement of these acts as they are being performed are critical elements in the process. Usually, this is carried out by the front-line supervisor in the course of routine tours on the workfloor.

NIOSH first used a behavioral analysis approach in a study of shipyard workers, where nearly 60% of dispensary visits were for eye injuries, and fully half of these occurred in 10% of the work crews (14). On-site observations of these crews found 50% to be wearing safety glasses. Recognizing this problem, general safety directives on needs to wear safety glasses were issued by management to all shipyard workers. In addition, supervisors of those crews showing the highest eye injury occurrences were given instructions in using praise and social recognition as reinforcement for motivating workers to wear their eye protection. An increase in the frequency of wearing eye protection was observed to occur in these crews over the 6-month period after this instruction such that their eye injury rate dropped from 11.8 cases to 100 employees to 4.3. Other crews in the shipyard showed a much smaller decline in their eye injury rate over the same period—from 5.8 to 4.7 injuries per 100 workers. Reflecting the specificity of this treatment effect (and arguing against a Hawthorne type explanation of the results),[3] the frequency of non-eye injuries for all of the crews in this study did not appreciably change over the same time period.

In another field demonstration, a token system of rewards was used for reinforcing the use of ear protectors among textile workers exposed to noise levels in excess of 100 dBA (16). In this field trial, token-dispensing tours were conducted daily at random times by shift managers. Each worker observed to be wearing ear protectors during the tour received a token. A variety of inexpensive consumer products were exchangeable for a given number of tokens. The actual monetary value for the maximum number of tokens that could be acquired was equivalent to $15—admittedly a modest cost. Baseline observations of ear protector use were first made in two plant installations, one serving as the experimental or treatment site, the other as a comparison or control site. The experimental site had a 35% use rate, and the control a 50% use rate at the start of the study. This situation prevailed despite several previous promotional campaigns and even disciplinary actions aimed at increasing ear protector use.

The token dispensing system lasted 2 months after which it was terminated, and a 5-month follow-up period began. During the latter period, sampling tours were conducted weekly in both the experimental and control departments.

During the course of the token reinforcement period, the experimental department's use rate increased from 35% to 90% and this was sustained for the 5-month follow-up period. At the same time, the comparison department's usage of ear protection remained at the 50% level.

An important point to note here is that at the end of the follow-up period, over 30% of the work force in the experimental department were new workers who had not participated in the original token reinforcement program—yet all of these workers wore the ear protectors regularly. This suggests that the department's norms included the practice for workers to wear ear protectors. A visit to this facility 12 months later revealed virtually all workers using ear plugs.

In subsequent work with the control group in this field study, a change was introduced in the token-dispensing system designed to generate group pressure toward compliance with wearing the ear protection. It consisted of assigning different values to the issued tokens depending on the total number of workers found to be wearing the ear protectors in unannounced tours of the department. This caused those wearing the ear protectors to get their co-workers to also wear them, and therein increase the value of the received tokens. (Actually, the monetary equivalent did not differ from the $15 limit that was used in the earlier phase of this demonstration study).

The results of this treatment as measured over a 5 month post-period also was found to increase the use rate to the 90% level which was subsequently maintained even though the dispensing program was withdrawn.

To reiterate, some major points of these demonstration studies include:

1. Rewarding the desired act of wearing a personal protective device leads to a substantial increase in their use.

2. There is continued use even when the reward period ends through establishing new norms of expected behavior when working in the department originally subjected to the reinforcement procedures. Indeed, new workers in these departments, which never were involved in the token reward phase, readily accept and wear the protective devices.

Perceived Effectiveness of the Protector:

Given that the performance properties of a protector meet prescribed specifications, how do we convince the user that it is an adequate safeguard against a known job hazard? The safety literature suggests exploiting instances where use of a protector has avoided a severe injury (17). Workers describing to their peers how their protective equipment deflected an object that could have pierced an eye, dented a skull, or crushed a foot can have significant impact, especially where the near shattered equipment is on hand to lend further credance. This is one form of feedback applicable to hazards posing traumatic injury risks. But what of more subtle, insidious risks and means for portraying the effectiveness of the protector in these instances?

NIOSH has recently published a study in which workers were given information about their temporary threshold shifts (TTS) in hearing when they wore and didn't wear ear protectors at their noisy job sites (18). This information proved effective in increasing the extent of ear protector use from 35% to 90% for the workers so exposed. As in the other demonstration with ear protectors, this increased use rate was maintained despite turnover in the department personnel used in the original study—evidently reflecting again new norms for wearing such apparel. The TTS information was a form of feedback, providing knowledge of results which has important motivating properties. One wonders about other applications of this same principle in dramatizing the effectiveness of protective devices against other latent or insidious hazards. For example, differences in breathing zone concentrations, or in body burden measures with and without respirators or other suitable protective devices in place, may be adopted. A NIOSH study (19) took note of the fact that adherence to 20 different work practices, all aimed at reducing worker contact and exposure to a noxious chemical, reduced the body-burden of that agent but not nearly as much as just one--wearing a respirator.[4] Perhaps feeding this information back to the workers could promote greater use of this equipment.

With regard to information feedback and the effectiveness of protectors, one should not forget the need for frequent reporting of protector usage and indications that they are serving the workers at risk. Merely plotting the frequency of safe acts, including use of proper personal protective equipment, has been found sufficient to maintain the safe behaviors observed for a worker group (20, 21). Having the worker group set goals for their use rates also has motivational value (20).

CONCLUDING THOUGHTS

A few added comments are in order in concluding this paper. First, and except for a few occupations (e.g., fire-fighters, emergency rescue workers), personal protective equipment can only be regarded as a secondary or back-up type control measure in coping with workplace hazards. The first emphasis in any hazard control plan must be given to engineering control or job redesign approaches which are inherently more reliable and positive.

Second, any control program utilizing personal protective equipment must include a means for evaluating its use and effectiveness in combating the hazards it is designed to reduce. This means continual tracking of injuries and illnesses, including use of early indicators as may be practical, for which the protector is designed to offer protection. Evidence of reduced injury and illness coupled with increased protector usage has motivational impact on a work force.

Third and last, there are a wide variety of techniques available for promoting increased use of personal protective equipment. The person in charge of such programs should feel free to tailor any one or all of them to the problems at hand. In a sense, he or she should act as an experimentalist trying out ideas, and testing the effectiveness. Any hazard control program and especially those incorporating personal protective equipment will require constant appraisal to ensure the adequacy of the measures in use.

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[4]Personal communication (August 21, 1980) from Professor Bill Hopkins, Department of Human Development and Family Life, University of Kansas, Lawrence, Kansas 66045.

REFERENCES

1. Anon. Occupational Hazards, February 1979, Pg. 33.

2. Anon. Occupational Hazards, February 1979, Pg. 39.

3. Feeney, R. H. and J. P. Nyberg. "Selling the Worker on Hearing Conservation," Occupational Health & Safety, July/Aug. 1976, Pg. 57.

4. Anon. Occupational Hazards, August 1980, Pg. 30.

5. Schulte, H. F. Personal Protective Devices. In the Industrial Environment – Its Evaluation and Control, Cincinnati: National Institute for Occupational Safety and Health, 1973.

6. Pritchard, J. A. A Guide to Industrial Respirator Protection. Cincinnati: National Institute for Occupational Safety and Health. Technical Report No. (NIOSH) 76-189, June 1976.

7. Acton, W. I. Problems Associated With the Use of Hearing Protection. Annals of Occupational Hygiene, 1977, 29, 387-395.

8. U.S. Environmental Protection Agency, Office of Noise Abatement and Control. Public Health and Welfare Criteria for Noise. Washington, D.C., EPA Report No. 550/9-73-002, 1973.

9. Harris, D. Combating Hearing Loss Through Worker Motivation, Occupational Health & Safety, March 1980, Pg. 40.

10. Engel, P. G. Respiratory Protection: Cornerstone of this top-flight industrial program. Occupational Hazards, April 1980, Pg. 73.

11. Vanchuk, J. T. What steps must be taken to establish a respiratory protection program. Occupational Health and Safety, July/August 1978, Pg. 29.

12. Cohen, A., Smith, M. J., and W. K. Anger. Self-protective measures against workplace hazards. Jour. Safety Research, 1979, 11:121-131.

13. Fitch, H. G., Herman, J. & B. L. Hopkins. Safe and unsafe behavior and its modification. Jour. Occup. Medicine, 1976, 18: 618-622.

14. Smith, M. J., Anger, W. K., and S. S. Uslan. Behavior modification applied to occupational safety. Jour. Safety Research, , 1978, 10, 87-88.

15. Kahn, R. L. In search of the Hawthorne Effect. (In Man and Work in Society, Editors: E. L. Cass & F. E. Zinner, Van Nostrand Rinehold, New York, 1975, Chapter 4.)

16. Zohar, D. Promoting the use of personal protective equipment by modification techniques. Jour. Safety Research 1980, 12: 78–85.

17. Anon. How to stamp out foot injuries. Occupational Hazards, march 1977, Pg. 54.

18. Zohar, D., Cohen, A. and N. Azar. Promoting Increased Use of Ear Protectors in Noise Through Information Feedback. Human Factors, 1980, 22:69–79.

19. Conard, R. J., Hopkins, B. L., Fitch, H. G., Smith, M. J., Anger, W. K., and Danzel, R. F. A strategy to validate work practices: An application to reinforced plastics industry. Available from NIOSH, Taft Laboratories, Cincinnati, Ohio 45226.

20. Komaki, J., Barwick, K. D. and L. R. Scott. A behavioral approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant. Jour. Applied Psychol. 1978, 63: 434–445.

21. Komaki, J., Heinzman, A. T., and L. Lawson. Effect of training and feedback: Component analysis of a behavioral safety program. Jour. Applied Psychol. 1980, 65, 261–270.

USING ECONOMIC INCENTIVES TO IMPROVE OCCUPATIONAL SAFETY

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INTRODUCTION

My topic this morning is using economic incentives to improve occupational safety. I'll start with a conceptual model, or theory, of how economic incentives should work. Then I'll give specific examples of ecomonic incentives which have been used successfully in other areas, and some which produced unexpected results. I'll conclude by suggesting some safety research and educational needs applicable to the use of economic incentives, as well as other methods of improving workplace safety. I'd like to note that while what I say this morning draws extensively on my experience as Executive Director of the Interagency Task Force, and subsequently as a consultant to the United States Regulatory Council, these are my own ideas and do not necessarily represent the views of any Federal agency.

THEORY

Turning now to the theory, and with apologies to any "real" economists who may be in the audience, my understanding of the economic theory behind the use of economic incentives is as follows: Given perfect knowledge, rational behavior, and perfect competition, then "the unseen hand" of the private market will result in efficient production, that is, production to the point where the marginal or incremental costs equal the marginal or incremental benefits. Unfortunately, that doesn't always happen.

In the context of this symposium, private markets aren't producing enough of a desired product called safety in the workplace. Theory gives a number of reasons for such a private market failure. One is uncertainty, or information costs. Another one is transaction costs, an example of transaction costs is the cost of collective bargaining. A third reason is what economists call externalities: the person who pays may not be the same person who benefits. An example is worker's compensation insurance. Because it is an insurance mechanism, in a given year a particular company may not bear the total cost of their workers' injuries because other companies who have also paid a premium are helping to pay the cost. A final reason for an imperfect market has been called paternalism. That is, more of a good is desired, for whatever reason, than the marketplace will produce by itself.

Economic theory goes on to say that if one has identified the reason why the free market is not providing enough of a desired product, in this case workplace safety, then what one really wants to do is to design a remedy specifically targeted at the reason that one thinks that the free market has failed. For example, if one thinks there's a lack of information, one can support a program of hazard identification, and of course both OSHA and NIOSH have done exactly that. If one thinks the problem is transaction costs, one can try to encourage the use of worker/management safety committees, and of course OSHA and NIOSH are interested in that also. Or, if one thinks it's externalities, that is the firm who is paying is different from the firm who benefits, then one can consider such things as injury taxes, higher penalties, changes in the worker's compensation system, and other mechanisms whereby more of the true costs of injuries will be borne by the firm whose workers experience them. Lastly, if one thinks the issue is paternalism, or social consciousness, then of course one can issue regulations which go to control points beyond where incremental costs equal incremental benefits.

Now of course the reality is that many or all of these reasons for free market failure contribute to inadequate workplace safety, and so a number of corrective approaches are likely needed. (I'll pass over the fact that theory hypothesizes that rational people will be making these trade-offs, and while economists may be rational people all the time, I suspect that the rest of us aren't.)

If you're interested in more of the background on the theory behind using economic incentives, may I refer you to our Task Force Report titled "Making Prevention Pay" and also to the American Bar Association's report titled "Federal Regulation - Roads to Reform."

Certainly one of the hindrances to using economic incentives to improve workplace safety in the past has been a basic difference of opinion among interested groups. Some interpret the phrase "to the extent feasible" in the preamble to the OSHA Act as a statement of paternalism or social consciousness going beyond economic efficiency. Others interpret it as a call to be sure only that externalities are reduced, and that marginal costs equal marginal benefits. The accompanying rhetoric can run high: from "standards written in blood" to "standards which are destroying what made our country great."

More recently a middle ground has emerged. This middle ground was supported as recently as last Friday by such diverse individuals as Mr. Shapiro, the Chairman of DuPont, and Mr. Kirkland, the head of the International AFL-CIO. This was when the President announced the creation of a committee to advise on revitalization of the economy. The committee's charge included advising on how to achieve workplace safety, health and environmental goals most effectively and at least cost.

My remarks this morning will also be in the context of using economic incentives to achieve regulatory goals more flexibly and at least cost.

EXAMPLES OF THE USE OF ECONOMIC INCENTIVES

Turning from theory to what is being done, many of the examples come from the environmental control field where really quite a bit is being done in the use of economic incentives, both in this country and overseas. In part this reflects the attitudes of the leadership of responsible Federal agencies. For example, Mr. Costle and Mr. Drayton of the EPA have been extremely interested in this topic and have put effort and Budget money into it. But in part it also reflects the fact, I think, that all of us are visibly affected by the environment and there seems to have been more public support for achieving regulatory ends. But only those who work in manufacturing, and a few other industries (less that one half the work force) are severely impacted by workplace safety and health consideration. As a consequence, these considerations seem to directly affect less of the public and have become part of labor/management megotiations, where there is less flexibility. Toward the end of my talk I'll be talking about what I think we can do to help increase flexibility in achieving these regulatory ends.

If you look up "incentives" in the dictionary you'll find that an incentive is something which exhorts to action. Of course there are two basic ways you can exhort to action, some people usually talk about them as being the carrot approach and the stick approach. The carrot approach usually calls for a reward. For example, to incite desired behavior through economic incentives we have an investment tax credit, direct subsidy programs such as farm price supports, and subsidies for employment and training. Then there's also the stick approach. The stick approach is an added cost or a fine or a penalty – for example an increase in the cost of compensating victims, or an emission tax on pollutants. Such added costs are felt to reduce the causes of free market failure by "internalizing the externalities." The effluent tax concept has been used quite a bit overseas. For example in Europe there are several taxes on water pollutants, on sulfur emissions, and even on airport noise. An emission tax on sulfur is also being evaluated in California. There are also new victim compensation laws. For example in Japan, following the severe episode of mercury poisoning, a very strict injured party compensation law was implemented, with the cost levied against specific companies when traceable. Compensation of black lung victims in this country is another example.

One finds however that seldom have these economic incentives been implemented by themselves. That is, they are typically implemented together with some form of regulation, and there may also be a second purpose; for example, revenue raising. The consequence is that it is very difficult to tell the effect of incentives by themselves.

I was also reminded when hearing Dr. Cohen talk about tokens yesterday, that some of the most clearly successful economic incentives have been applied to individuals. For example, in Singapore there was a problem with people riding their bicycles to town at the same time every day resulting in horrendous traffic jams. A tax was imposed upon those taking their bicycles into Singapore at those times. Traffic dropped 40%. In fact it dropped so dramatically that they developed a little "bankable" traffic reduction for the future.

Another example which I think we're more familiar with in this country is beverage container deposits. I happened to be up in Maine recently, and I watched a ferry come into Northeast Harbor from Swans Island. The first things carried off were two enormous plastic bags full of empty beer and soda cans. Apropos of yesterday's comments, we might wonder whether that behavior would still continue if the deposit–refund system stopped. But individual incentives seem to be a fruitful area for more research, although I'm not quite sure yet how we use that information.

REGULATORY REFORM

It should be noted that much of the current interest in the use of economic incentives in the environmental, safety and health areas derives from the ideas in the Godkin lecture which Dr. Charles Schultze gave at Harvard some years ago. It was titled "The Public Use of Private Interest." His remarks were subsequently published by the Brookings Institution and also in Harpers Magazine. Of course Dr. Schultze went on to become the current Chairman of the Council of Economic Advisors. In many ways, his thoughts about using incentives rather than command and control regulation, wherever possible, gave rise to our task force, and were an important part of the administration's regulatory reform program. There is some literature about this program out on the table. Any of you who wants to find you what's going on with regulatory innovations in this and other areas are welcome to pick it up.

While I'm not going to discuss the regulatory reform program extensively this morning, it basically has five parts. The first is to deregulate where possible. That has happened primarily in the economic areas, for example, airlines, trucking, banking, and communication. Next, where it's not possible to deregulate, the approach is to make compliance with regulations more flexible. A third part of the program is to consider differential effects of regulation, that is, for example, the effects on small business. A fourth part is structural reform of the regulatory process, for example, sunset reviews and consideration of regulatory budgets. The last part is better management of the regulatory process. And I might add that better management of the regulatory process often begins with better research data. The use of economic incentives is relevant to many of these reform areas.

Some specific recent examples of regulatory reform includes OSHA's voluntary compliance experiement which is presently going on in San Onofre, California, with the Bechtel Corporation and a number of construction unions. In the Department of Agriculture, the Food Safety and Quality Service has begun a compliance reform program in which their inspectors will increasingly make use of quality control data collected by meat packers and poultry packers themselves rather than replicating the data collection. EPA is implementing a number of fascinating reform concepts. For example, under the bubble concept, a plant or an installation can consider that all sources of a particular air emission are under a "bubble," and the total emission has to meet the standard rather than each source by source. So if it turns out that it's less costly to substantially remove the emissions from one source, and leave another source untouched, this is acceptable so long as the regulated level is achieved. Another portion of the marketable rights program allows a plant which reduced its emissions more than necessary to meet standards to put the excess reduction "in the bank," and draw on it later on, or sell it to another firm. The offset policy permits a firm in a non-attainable area to pay to reduce another firm's air pollution so that the first firm can increase its own effluent, for example, as part of an expansion.

In other area, the FCC in considering allocation of a portion of the communication spectrum used for data transmission, has decided there is no "public interest" to be protected in transmitting data; it's not programming for the public. So instead of hearings, it's been proposed to hold an auction among interested firms. Now this is only a proposal and it's just for a portion of the spectrum, but I think it provides a dramatic example of how far you can go in using economic inccentives in a certain situation.

Before I leave this section of my talk concerning examples of economic incentives and regulatory reforms, I would be remiss if I didn't talk briefly about what I have come to call anomalous results. Sometimes one provides an incentive for behavior, but doesn't get the behavior which was wanted. In fact, sometimes things get worse. For example in the first formulation of black lung compensation, the wording was required that the company which injured the worker would pay the compensation, when the company could be identified. Well perhaps not surprisingly something like 97% of the cases were contested, with the company saying "Who me? I didn't do that." The Federal treasury wound up paying most of these claims. The act was amended, and now a tax levied on each ton of coal mined goes into a fund, and the fund is used to compensate the workers. The contested level of claims has decreased.

Another anomalous result which turns out to be not anomalous after you think about it, is that sometimes when one tries to deregulate, the very industry which is supposed to be in support of free enterprise is against the deregulation. A recent example was when the chairman of a major auto and truck manufacturer came out with a very strong state–

ment against deregulation of the trucking industry. There were a number of reasons given why the trucking industry shouldn't be deregulated, for the public interest. I read that some people think another reason is that there are large fleet sales of trucks, and with deregulation a possible increase in fragmentation might make it more difficult to make these large fleet sales.

As another example, the FDA has tried to use voluntary standards in certain areas of medical device regulation. They found to their surprise that one of the chief opponents was a trade association which took them to court, claiming they had violated the Administrative Procedures Act. Now at first blush that might appear to be an anomalous act. But I've been told that while one consideration was precedent another was concern for possible loss of organized power if a different regulatory mechanism was implemented.

Then, of course, we have the problem of new scientific information. For example, while there are individual regulatory limits on the amount of hydrocarbon, nitrogen oxides, and ozone that can be present in the air, a recent and more detailed look at the chemical reactions involved found that for a given concentration of hydrocarbons, a reduction in nitrogen oxides actually increases ozone. Therefore, the present EPA standards which call for the maximum reduction of all three are scientifically unsound. I'm sure that problem will be resolved because there are some very good people involved, but it makes one a little more humble and cautious in deciding just what behavior to incite.

As many of you know, our task force made several recommendations about the use of economic incentives to complement direct regulation of workplace safety. (Our draft final report titled "Making Prevention Pay" is available from NTIS, #295-284. The three appendix volumes are 295-285, 295-286, 295-287.)

We recommended a combined carrot and stick: changing the worker's compensation system so that a company could deduct as a business expense for tax purposes, the average cost of worker's compensation in their size firm, industry and state, whether the firm's actual cost experience was higher or lower. That approach gives an inter-industry transfer of funds from worse performing companies, and better internalizes the externalities due to worker injury costs within an industry. We became convinced the real issue was intra-industry efforts. For example, while the national average of worker's compensation costs is about 3% of payroll, there are some which run as high as 80%; that is 80 cents per dollar of payroll per week (and somebody told me just yesterday about a situation where the cost was over a dollar on a dollar). Obviously, then some companies are paying a dollar on a dollar, and others 3 cents on a dollar, and both are staying in business! One realizes after a while it's in part because the companies can pass through their worker's compensation costs as a cost of doing business, and in part because the taxpayer helps pay the bill. We thought that changing the tax deductibility would immediately roughly double the cost of worker's compensation to poorly performing firms, and at the same time would provide a bonus and give competitive advantage to the better performing firms in particular industrial segments, all without changing (approximately) the effect on income tax revenues.

There are a number of possible implementation problems with the recommendation: There are data problems, there are differences in worker's compensation benefits from state to state, there are possibilities for firms to be inventive with the data. All of these possible problems are real, but our feeling was that this approach was still the best economic incentive that one could come up with, and also had the least potential administrative cost since the worker's compensation system is already in place.

The second recommendation we made was all carrot – targeted subsidies to help firms in hazardous workplaces (when national economic conditions permitted). The rationale and limitations are given in some detail in our report.

RESEARCH AND EDUCATION NEEDS

In keeping with the theme of this symposium, I'll conclude my presentation with some consideration of workplace safety research and education needs. These needs are applicable to the most effective use of economic incentives, but also to other approaches to improving workplace safety.

They fall in three areas:

- better data and analyses
- better dissemination of research results
- more consideration of using NIOSH and other Federal programs to catalyze larger private sector efforts, for example, through cooperative programs.

In regard to better data and analysis, preceding papers at this symposium, and my own discussion of some anomalous results when using economic incentives, highlight the need for sound data on which to base safety decisions in the workplace, and in government policymaking.

Concerning data, I'm not going to be able to add very much to what yesterday's speakers had to say. I do have a favorite story though, which illustrates how lack of good data led one firm to believe its safety problem was its workers, when in fact it was both equipment, and lack of adequate attempts to determine accident cause (and also lack of access to available information).

As related to me by a colleague from California, there were two garbage and refuse companies, one of whose workers had a high injury rate, and one of whose had a substantially lower rate. Upon detailed investigation it turned out that a particular type of accident was causing most of the injuries. One company had found the problem, and made a modification to garbage trucks. The other comapny hadn't found the cause, and hadn't made the modification. The company that hadn't made the modification thought their problem was the workers, or an act of God. It wasn't either, just the need for a better designed perch on the back of the truck.

The problems: the need for better accident investigation, analysis, dissemination of results and motivation for using them.

Another data problem is the relative lack of safety reseach with deals with behavioral and organizational factors, as well as with physical equipment. Most knowledgable safety experts would agree, at least in private, that workplace accidents and injuries result from multiple causes. Yet little research is done on other than physical factors (the excellent study by Dr. Cohen some years ago being one exception). In part this is because unions are concerned lest behavioral and organizational research turn into a fault finding exercise. I feel more needs to be done here, for example with research protocols established so that there is mutual confidence in the research and hence support for the results.

Going beyond the shop floor, perhaps corporate strategic planning practices can impact workplace injuries. How? Well for some years one popular form of corporate strategy has included the concept of "portfolio management." Various lines within the company are identified, for example, as "shooting stars," "cash cows," and even "dogs." The idea of course is to fund the expansion of the shooting stars using cash from the cows in mature markets, and to dispose of the dogs. The strategic approach has proven very successful on the bottom line for some companies.

On the the other hand, think about that a little. Suppose that it's the cash cow or dog which has got a workplace safety problem or perhaps an air pollution problem. Is management going to allocate extra money to correct the problem, when they know the real objective is to get cash out, or sell? The answer is likely, not often, and a probable result is conscious or subconscoious delay. In the meantime, people may be getting hurt.

Another useful theory of managment which is popular these days concerns the life cycles of companies. A number of professionals are working on this, for example at MIT, at the Harvard Business School, and at UCLA. One talks about life cycles of companies in the same way one might talk about the life cycle of a product. In particular companies get to a certain phase in corporate growth where the management has become what one research calls an "aristocracy." In an aristocracy it's very hard to get anything to change, whether it's a new product or a safer workplace. Could there be some correlation between companies with unsafe workplaces or other regulatory reluctance, and companies that are in the artistocratic phase of their development? I suspect the answer is yes, but I'm not sure anyone has really looked into it in any great detail. I think there's a very a fruitful area here for research in trying to learn about how management strategies influence workplace safety, and areas of business.

Perhaps it will turn out these same strategic and managerial practices also influence, say, productivity, or perhaps they also characterize companies or industries which, once leaders, have now fallen behind and are ripe for "re-industrialization," or lobbying for tax reduction or accelerated depreciation or import controls. This finding, if accurate, could be very useful in that perhaps the same changes could improve the troublesome financial aspects of such a business, as well as workplace safety. The safety improvement wouldn't have to "sell" by itself anymore. And as the title of our task force report, "Making Prevention Pay" suggests, I'm simply not sure that added investment in workplace safety improvements does "sell" as a priority item on most management's agendas right now.

In regard to analysis, I have observed many of the Federal regulatory agencies building up their capabilities to do better regulatory analyses based in part on better research data. I have been surprised not to see a comparable increased capacity for these types of analysis in the private sector. In my experience, the comments made by many private sector groups on proposed on existing regulation, for example, workplace safety regulation, may often be based on the same type of incomplete analysis of which they have often accused the regulatory agencies.

While I guess some have had an image of a large firm with large resources which include a large staff to analyze regulatory impacts better than a Federal regulatory agency, it simply doesn't seem to be so. For example, the workplace safety function in many companies is under the personnel department where it is treated as an overhead function, not directly a part of production. And as in any overhead activity, size is limited and there is trouble getting added budget when times are tougher. Typically then, private sector companies work through trade and consenus groups on environmental, safety and health issues. When that happens, inevitably, it seems, the analysis must be acceptable to the whole group, accommodating various differences of opinion. Often it is difficult to be too quantitative in such a situation.

Then another fruitful area for safety research, in my judgment, is the development of better protocols, techniques and methods for regulatory analysis, useable by and acceptable to both the private sector and tthe government.

Turning to improving dissemination of what is known, to using Federal reseach resources to spark private sector efforts, I believe in cooperative programs involving government, labor and management. In such so-called tripartite programs, each group can own a piece of the agenda, from setting research protocols, to reviewing results, to participation in the active dissemination of useful results.

In this regard, I was particularly interested in yesterday's presentation on knives, and on the safety research program in Sweden.

Some years ago, both meat cutters and supermarket management had a related concern over the need to wear wire mesh aprons, required by OSHA standards, but which they thought were interfering with the meat cutters' ability to perform, and not really protecting them. The retail food industry had previously set up a joint labor-management committee at the industry level. I am told one reason for this joint effort was that this was during the time of wage and price controls, and in this lower profit margin industry there was a great goal congruence between workers and management. That is, both the union and management wanted to improve performance as much as possible so as to have more left for salary increases, and for profits. One high cost area was the whole complex of health care costs, including worker's compensation, health insurance and sick leave. Labor and management worked together, setting up a subcommittee which still exists today, headquarted in Washington. The labor/management group approached OSHA, made some suggestions on the use of wire mesh aprons, set up a joint fact finding effort, did research together, and presented their findings and recommendations. The recommendations were modified by OSHA, implemented, and an advisory was put out which modified the interpretation of the existing OSHA standard. Subsequently this committee undertook another joint project on the health effects of inhaling vapors from plastic film used with heat sealing machines. This excellent model of tripartite sector efforts deserves replication elsewhere, where applicable.

Perhaps some day we here can approach what we have learned is done in Sweden, where the government and industry jointly fund workplace safety research projects on a large scale.

I might also mention our task force recommendation that a cooperative effort be undertaken to better disseminate the results of safety research. A number of speakers yesterday referenced difficulties in getting safety research information. Yet various Federal agencies such as NASA and NIOSH have available computerized information dissemination systems which include workplace safety information. So do various private sector groups (e.g., CHEMTREC). Such individual efforts would seem potentially even more useful through cooperative and tripartite promotion.

Another type of information dissemination is that which can help build a national comsensus for improved workplace safety. Several speakers yesterday commented on the absence of such a national consensus now.

I recently attended the annual meeting of the International Platform Association, a professional organization of platform speakers. One of the programs in the multi-day session presented winners of various high school public speaking contests all over the country. These winners then repeated their winning presentation, on various topics, and judges selected the best of the best for an award. The winner's presentation was strongly against the FDA's proposed banning of nitrites. It turned out, as she developed during the course of her presentation, that her father raised hogs, and she herself was a Future Farmer of America. They were both quite convinced that the banning of nitrites would destroy their business, without protecting the public. None of the speakers had a pro-regulatory story, for example the benefits of improved workplace safety and health. Perhaps we need an effort wherein safety researchers, and others, sponsor and participate in community level efforts to bring forward the facts which we all know. For example, the fact that families living around certain types of workplaces can suffer from adverse effects, as well as workers, and the fact that treatment of injured workers consumes community resources, such as in hospitals. A more supportive national consensus would enhance safety research.

In conclusion, I've discussed the theory behind the use of economic incentives to improve workplace safety, described incentives which have been used successfully, including those developed as part of the administration's regulatory reform program, and others which have produced anomalous results, and then presented some ideas for safety research and educational need. Now I'd be pleased to answer any questions.

KEYNOTE SPEECH

NEED FOR OCCUPATIONAL SAFETY RESEARCH AND EDUCATION

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INTRODUCTION

I am delighted to be with you here in Morgantown. Since my stint as Acting Director of NIOSH, I have never gotten occupational safety and health quite out of my blood. You know, it is exciting to be part of the prevention movement that is now sweeping the nation. Dr. Julius Richmond, Surgeon General of the United States, who issued the report labeled, "Healthy People," often says, "Prevention is an idea whose time has come." There is, indeed, an explosion of concepts and ideas as we enter the 1980's that make it an exciting and heady time.

Perhaps the most profound of these new ideas is the notion that for the first time in man's long history, we are, to a large extent, in charge of our own destiny in health and life. We are no longer cowering victims of plagues, pestilence, and disasters which we do not understand and can neither appease nor oppose. Another profound notion which has grasped us as we enter the decade of the 80's, is the pursuit of "wellness"—an idea that relates to the full flowing of the individual's potential—a notion of wholeness. This powerful idea compels us to realize that just as joy is not merely the absence of pain, health is not merely the absence of disease or disability. That these ideas should seize our consciousness at this time in history, thrilling though it be, should not surprise us. For indeed they are direct fruits of a phenomenon known as "the first epidemiologic revolution"—a specific dramatic victory for the discipline of prevention.

" . . . Free at Last"

Our ability to conceptualize the health promotion and health protection owes its existence to a new-found freedom from ancient plagues. Dr. Milton Terris[1] has labeled this "the first epidemiologic revolution." In short, it represents the conquests of the infectious diseases as major causes of death and disability. The pinnacle of its achievement was reached symbolically in May 1980 when the World Health Organization announced that the world had been freed of smallpox as a result of a global program initiated in 1966 (with the Regional Smallpox Eradication and Measles Control Program in West and Central Africa, under the leadership of the Center for Disease Control).

The eradication of smallpox was, however, merely the global capstone of an era which saw the western world reduce a whole series of infectious and nutritional diseases to levels of insignificance through immunization, improved sanitation, and better diet. This achievement is apparent when one contrasts the leading causes of premature mortality in 1900 with those 75 years later. While infectious diseases constituted 4 of the 5 leading causes of premature mortality in 1900, no infectious disease was among the leading causes of premature mortality in 1975. But the item which should be of interest to you is accidents. For indeed, both in 1900 and in 1975, accidents, which includes occupational accident, were a significant contributing factor to the major causes of premature death in Americans.

To experience some of the redemptive and liberating effect of "the first epidemiologic revolution" let us look at an example that will be familiar to all of you here who are over 35. Before 1960, poliomyelitis was a supreme scourge in this country. Every year, American families were impotent, cowering hostages to its summer epidemics. A perceptible fear gripped communities as the weather warmed. Parents warned children not to swim in rivers, to stay away from swimming pools, to avoid crowds, and suspicious drinking water. But there was nothing really to do but pray that one's children would not be stricken. Iron lungs were familiar to all. There were paralyzed beggars on every street corner, and in every classroom some child wore a brace. Yet, by 1970, polio was reduced to such a low level that the total number of cases could literally be counted on the fingers of two hands. Indeed, as Dr. Foege has said, in the last decade, there have been fewer cases than on single days in the 1950's. What made this miracle possible was an understanding of the epidemiology of polio, the development of a specific intervention to reduce the risks and the widespread application of the intervention, first by the shot and later by the sugar cube!

The control of polio may be the most dramatic, but is is by no means the most significant victory of the "first epidemiologic revolution." Public health and prevention have simply revolutionized man's outlook on health.

The effect on survival and the quality of survival was profound.

A child born in the United States in 1900 could expect to live an average of 49 years. A child born today on the average can expect to live 73 years. The substantial increase (24 years, a 50% increase over life expectancy in 1900) was achieved by reducing the risk of dying in infancy and childhood from enteric disease, vaccine preventable disease and malnutrition. These gains resulted almost wholly from prevention.

A recent article by Fries[2] suggests that the "first epidemiologic revolution" actually eliminated about 80% of the preventable premature deaths occurring at ages lower than the genetically-determined, optimal life span, of about 85 years. Moreover, the achievement of this reduction in unnecessary preventable death has fueled a growing conviction that by preventing and postponing disability, man might aspire to a healthy vigorous life right up to the end. The result is a refreshing and quite reassuring prospect for man of a long healthy life, limited disability, and death with dignity.

In the wake of this achievement, we stand today flushed with success and expectant that we can press onward.

Today's Top Killers

To understand the challenge of the 80's, we must look to the most important health problems of Americans today. Let us begin with an appreciation of today's major causes of death. Table 1 ranks the 10 most common causes of death. It is clear that today's top killers are chronic diseases, accidents, and violence.

Yet simply listing the leading causes of death does not provide especially useful information. In our society, an individual who lives long enough will surely be said to have died of some kind of heart disease. We do better to list the causes of premature death. Table 2 lists the causes of death according to the aggregated years of potential life lost by the victims of these causes. Assuming that nowadays an average life spans 75 years, a 25-year-old person who is murdered has lost 50 years of potential life. In these analyses, such a death is much more significant than the death of a person dying at age 74 from cardiovascular disease. The ranked list differs substantially from the previous one in emphasizing the importance of accidents and violence as causes of premature mortality. Motor vehicle accidents comes from 6th place to 3rd, suicide from 10th to 6th, and homicide comes "from the pack" to 7th.

Risk Factors

Dealing with average death patterns obscures the fact that there are very large variations in the frequency of death by age, poverty, sex, race, and specific cause. Moreover, age has a dramatic effect on the types of conditions that kill us. Accidents and violence kill the young. With advancing years, cancer, especially those related to smoking and hazards of the workplace, emerges. Finally, they are preempted by heart disease.

If we look at the top causes of death for each 10 year age group across a working life span, let us say from age 20 to age 65, the category "All Other Accidents" appears among the top 5 leading causes of death until age 60. This category, "All Other Accidents" includes home accidents, occupational accidents, and recreational accidents. In short, the particular problem of occupational safety is of very real significance in the production of premature mortality for Americans across a wide age spectrum. (Figure 3).

The Canadians introduced a useful approach to the analysis of health problems with the "Health Field Concept" (Table 3).[3] They view all health problems as resulting from four contributing elements: (1) human biology, (2) the environment, (3) health behaviors or lifestyle, and (4) health care organization. Using the Canadian concept, Dever, of the Georgia Department of Human Resources, developed a method for quantitating the relative contributions of each of the four factors to a list of health problems (Table 4).[4] For example, cancer of the lung, while primarily caused by unhealthy behavior (smoking), also received significant contributions from the environment (exposures to asbestos in the workplace) and some contribution from inadequacies in health care (e.g., the late diagnosis of lung cancer when the condition is quite advanced).

Teske of my staff later applied Dever's methods to the ten leading causes of death in the United States in 1977.[5] The estimates in Figure 1 show the results of three different mortality analyses done in this way. This suggests that no matter how "one cuts the salami," over half of the U.S. mortality is due to unhealthy behaviors, (such as smoking, drinking and other dangerous activities) and about 1/4 each to the environment, and to human biology. It is clear that modern plagues have changed from typhoid to self-destructive behaviors, from poliomyelitis to the effects of synthetic and mechanized environment, from infantile diarrhea to occupational accidents. Simply put, personal choice behaviors and the environment (especially the work environment) are the areas where major gains in health can be made in the future through prevention.

These analyses suggest that our priorities for Federal health spending need scrutiny. Figure 2 compares the analyses of premature mortality in 1976 and 1978 expenditures of the Department of Health, Education and Welfare similarly categorized; while inadequacies in the medical care delivery system accounted for only about 10 percent of preventable deaths in 1976, they attracted 80% of the Federal health dollar. Dollars invested in altering unhealthy lifestyles which cause more than half of our current mortality were a scant 0.8% of the total.

The implications of these analyses are tremendous. Unhealthy behaviors are clearly amenable to change by individuals who understand the implications of their behavior and are given some support in attempts to change; environmental factors can be amenable to collective societal intervention especially in the workplace; inadequacies in health care delivery should be correctable within the limits of resources as they are identified; even human biological factors currently beyond effective influence should yield to scientific discovery. There is great reason for hope here. Indeed there are tremendous signs that people have awakened to this vision. Over 50 million Americans have stopped smoking. The incidence of heart disease has fallen in the last 5 years. There is a virtual explosion of interest in personal health behaviors and great hope that we can achieve mastery over today's killers. As yet, the potential for improving risks in the workplace has not seized the public imagination despite almost daily news of deaths due to occupational disasters (as this point Dr. Millar quoted a page 12 article in the Atlanta Constitution describing the killing and maiming of several workers as a consequence of an oil rig explosion in Louisiana).

The Challenge of the Future

I am drawn to contrasting the "first epidemiologic revolution" with the challenge that is now facing us, especially as it regards occupational safety. The "first epidemiologic revolution" happened because (1) the epidemiology of the major killers of that era was soundly and thoroughly developed. (Wade Hampton Frost, perhaps America's greatest epidemiologist, did profoundly significant work in typhoid fever, diptheria and poliomyelitis with careful, meticulous studies of outbreaks occurring in the Ohio River Valley and in such places as Williamson, West Virginia, and Cincinnati, Ohio); (2) surveillance mechanisms were developed which put the case reports in the hands of those who could analyze the information, interpret it correctly, and then respond to it; and (3) a structure for intervention came into being. (Assisted by Federal disease control programs, the State and local health departments structure developed which was capable of intervening as well as providing meaningful interpretation of the expanding knowledge to the public).

It seems to me that the field of occupational safety needs some similar things:

1. There needs to be an epidemiologic correlation, analysis and interpretation of the very considerable amount of data available on occupational injury. In short, a "big picture" of the problem badly needs to be put together by sound epidemiologists.

2. Comprehensive reporting of occupational injuries needs to be developed which can provide an interpretable, ongoing, natural view of the problem of the risk factors responsible for the injuries. In addition to the systems that already exist (which are producing data that cries out for careful epidemiologic synthesis), you might consider making certain occupational injuries reportable in the usual morbidity reporting system managed by health departments.

3. Surveillance should trigger field investigations by people with epidemiologic competence who are oriented to finding out <u>causes</u> rather than particular rules or regulations that have not been transgressed. It seems to me imperative that the NIOSH Safety Research Division get right in the middle of the OSHA fatality investigation system and do enough field investigations to unravel the question of cause. This cannot be done through seat-of-the-pants epidemiology—it must be done by the expenditure of shoe leather on the floors of industrial plants where injuries occur, on oil rigs, at the construction sites, wherever injuries or risks of injuries have been identified.

4. In response to these investigations, there must be action. The existence of the OSHA Act and the existence of a well developed state and local health structure, provide a well advanced system for intervention. It is important that aggressive action take place when the data warrants such action, and that workers and the public know both about the risks and about the actions taken to reduce them.

In my view then, the critical need in this field at this point is to provide leadership in applying the skills of epidemiology to occupational injuries, and to do the field investigations necessary to define cause. This will lead logically to research on appropriate methods for intervention and evaluation of the efficacy of those measures.

However, whether or not (like the infectious disease people of 50 years ago) you reduce occupational illness and disability is very dependent on whether or not the new knowledge you discover through research and investigation is convincing. There is the utmost need that the data emerging from your work be based on unquestionably accurate observations and presented in a clear, logical form.

The "make or break" point in this field is the "believe-ability" of the observations, such that when you say a risk exists, people can rely on it.

Because what you do is so economically significant, you are exquisitely subject to challenge from several sides. No matter what your studies show, somebody is going to be unhappy about it. Furthermore, in this field that "unhappiness" can be expressed through all kinds of very strong and very troublesome pressures from management, from labor, from government and other agencies, from your enemies, and from your friends!

But, here again, you are not the first to walk this path. Similar controversies raged in the early days of infectious disease control—the medical profession itself was the most aggressive opponent of the emergence of public health. But people like Stephen Smith, C. V. Chapin, and others had the guts to pioneer the field of public health, to experience the necessary blood-letting and eventually they won.

But they did so largely because they were right and could prove it . . . when Wade Hampton Frost wrote something about polio, typhoid or diptheria, people knew from the careful, thorough quality of his work that they could rely on what he said. That gave the health officers the kind of foundation they needed for rough action on behalf of the public.

Your job is even rougher today; the early leaders in infectious disease control fought with the medical profession. The medical profession was inept in legal and P.R. maneuvering. That is not the case with those who would seek to discredit your work. By and large, they are bright and aggressive, with lots of financial backing--the capability for effective P.R. and plenty of high powered lawyers.

But you will prevail if what you say is right, and is convincing. That means (1) your methods must be known and their limitations acknowledged; (2) your data must be able to withstand critical scrutiny; (3) your logic must be sound and clearly presented; (4) your conclusions must be cautious. There is no place for carelessness in this field—your vulnerabilities are too great.

But if you are careful and thoughtful, the long-term prospect is bright because in the final analysis, the problems will yield, the big picture will emerge and the risks of the workplace will be reduced. A lot of workers will not have to die young and as that happens, you will deserve your accolades as "freedom fighters" in the "second epidemiologic revolution."

SOURCES OF DATA

1. Terris, Milton, M.D.: The Epidemiologic Revolution, National Health Insurance and the Role of Health Departments, AJPH 66:1155–1164, December 1976.

2. Fries, James F.: Aging, Natural Death, and the Compression of Morbidity. NEJM 303:130–135, July 1980.

3. LaLonde, M.: A New Perspective on the Health of Canadians; Office of the Canadian Minister of National Health and Welfare, Ottawa, 1974.

4. Dever, G. E. A.: An Epidemiological Model for Health Policy Analysis. Social Indicators Research, 2:453–66, 1977.

5. Ten Leading Causes of Death in the United States, 1975. U. S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control.

Table 1

TEN LEADING CAUSES OF DEATH
PERCENTAGE DISTRIBUTION BY CAUSE
TOTAL POPULATION 1+ YEARS OF AGE
U.S.A., 1977

Cause	Rate Per 100,000
1. Heart Disease	336.0
2. Cancer	180.9
3. Cerebrovascular Disease	85.1
4. All Other Accidents	24.7
5. Influenza & Pneumonia	23.2
6. Motor Vehicle Accidents	23.0
7. Diabetes	15.4
8. Cirrhosis of Liver	14.4
9. Arteriosclerosis	13.5
10. Suicide	13.4

Table 2

YEARS OF POTENTIAL LIFE LOST
TOTAL POPULATION AGES 1–74
U.S.A., 1977

Cause	Total Years Lost
Heart Disease	4,295,603
Cancer	3,931,209
Motor Vehicle Accidents	2,005,688
All Other Accidents	1,442,526
Suicide	898,388
Homicide	780,710
Cerebrovascular Disease	775,483
Cirrhosis of Liver	559,097
Influenza & Pneumonia	309,243
Diabetes	252,566

Table 3

HEALTH FIELD CONCEPT

- Human Biology
- Environment
- Lifestyle
- Health Care Organization

Table 4

PROPORTIONAL ALLOCATION OF THE CONTRIBUTING FACTORS OF MORTALITY TO THE FOUR ELEMENTS OF THE HEALTH FIELD

Ten Leading Causes of Death Among the Total Population 1+ Years of Age, U.S.A., 1977

Ten Leading Causes of Death	No. of Deaths	Rate Per 100,000	% of Total	Cumulative % Distribution	Health System	Life Style	Environment	Human Biology
Heart Disease	717,976	336.0	38.8	38.8	12	54	9	28
Cancer	386,529	180.9	20.9	59.7	10	37	24	29
Cerebrovascular Disease	181,741	85.1	9.8	69.5	7	50	22	21
All Other Accidents	52,706	24.7	2.8	72.3	14	51	31	4
Influenza & Pneumonia	49,497	23.2	2.7	75.0	18	23	20	39
Motor Vehicle Accidents	49,234	23.0	2.7	77.7	12	69	18	0.6
Diabetes	32,976	15.4	1.8	79.5	6	26	0	68
Cirrhosis of Liver	30,804	14.4	1.7	81.2	3	70	9	18
Arteriosclerosis	28,745	13.5	1.6	82.8	18	49	8	26
Suicide	28,668	13.4	1.5	84.3	3	60	35	2
					10.8	48.4	15.9	26.3

Figure 1

PROPORTIONAL ALLOCATION OF THE CONTRIBUTING FACTORS OF MORTALITY TO THE FOUR ELEMENTS OF THE HEALTH FIELD

Ten Leading Causes of Death Among the Total Population 1+ Years of Age, U.S.A., 1977

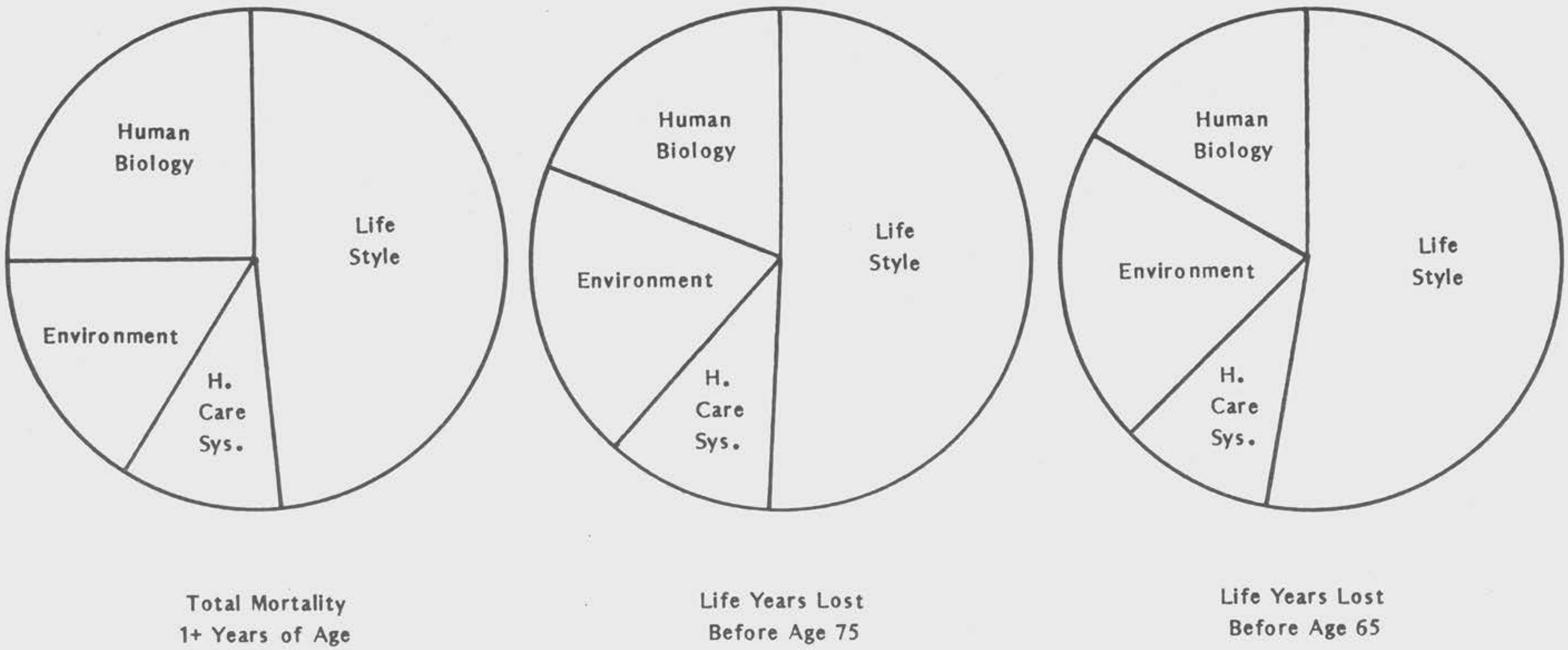
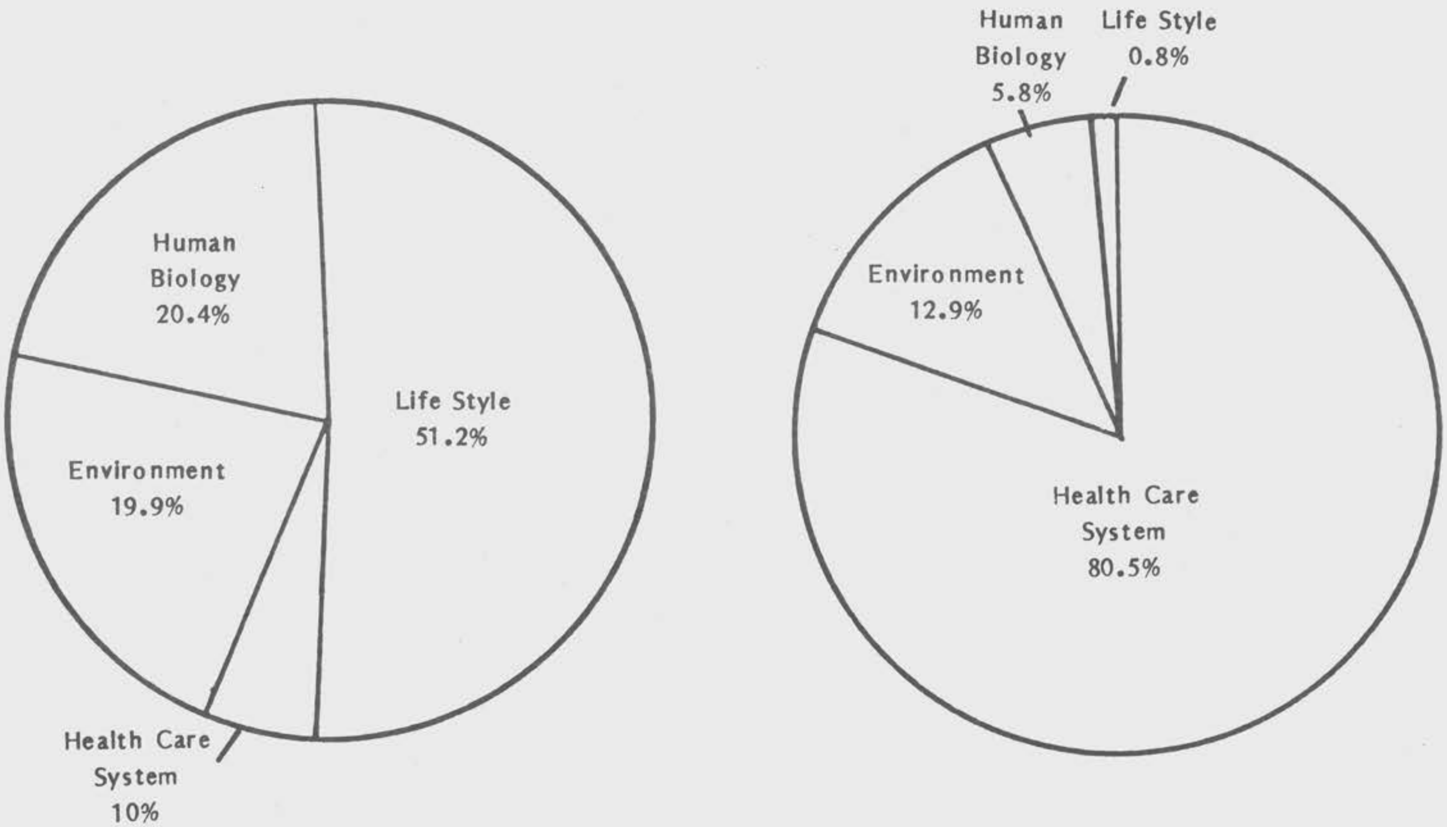


Figure 2

DISTRIBUTION OF FEDERAL HEALTH CARE EXPENDITURES BY HEALTH FIELD CONCEPT, U.S.A., 1978

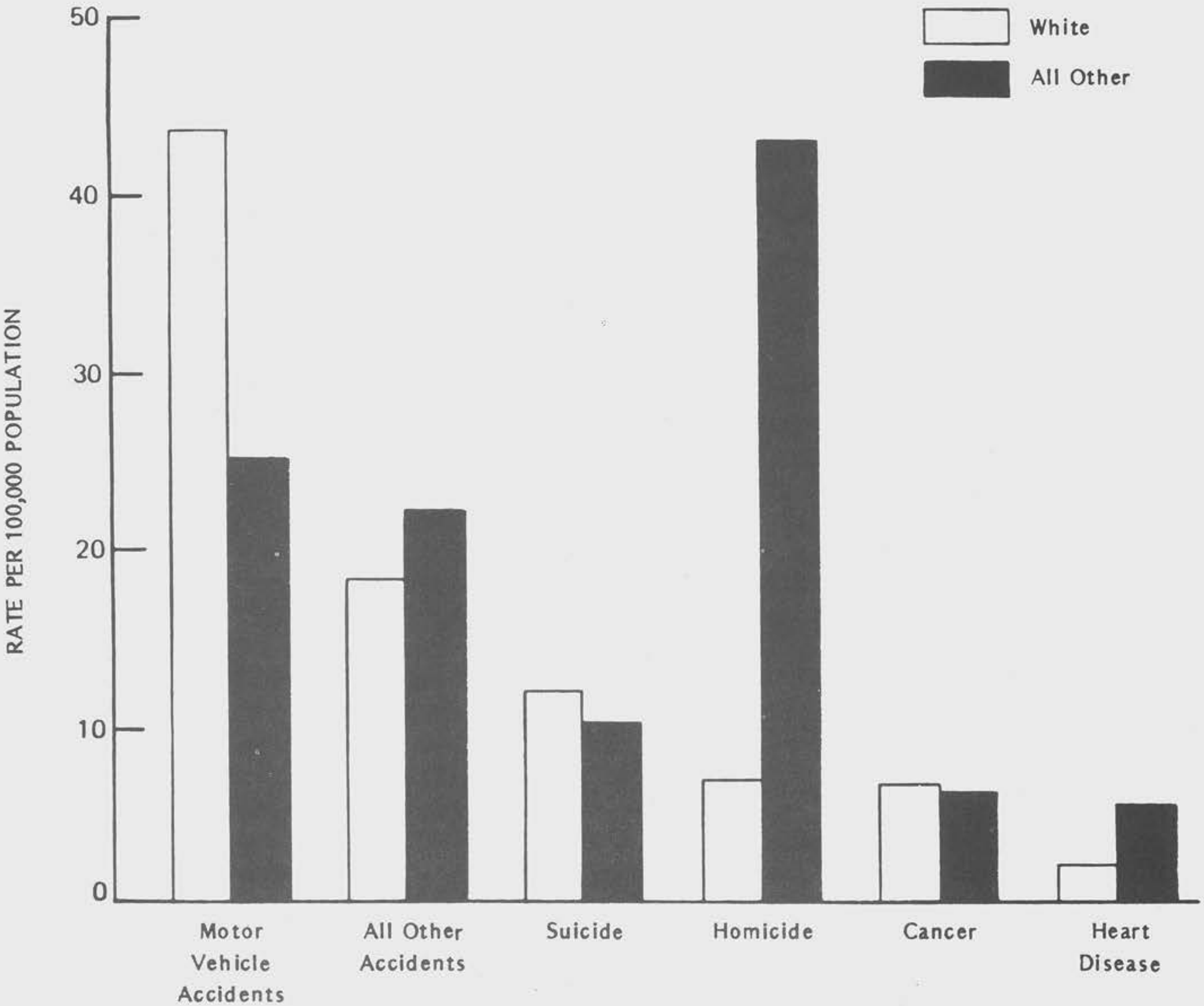


Life Years Lost Before Age 75

Expenditures

Figure 3

MAJOR CAUSES OF DEATH FOR AGES 15-24 YEARS: U.S.A., 1976



SOURCE: Based on data from the National Center for Health Statistics, Division of Vital Statistics. Healthy People, p. 45.

OCCUPATIONAL SAFETY CURRICULA: NEW DIRECTIONS

EDUCATIONAL PROGRAM APPROACHES

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INTRODUCTION

As pointed out by Dr. Millar in his banquet talk to this symposium, occupational accidents are responsible for much more loss of life expectancy than occupational disease, if only because the unknown but postulated occupational disease mortality from previous workplace exposures tends to occur in the retirement years, with little decrease in life expectancy. In education, one might, therefore, expect more programs in occupational injury prevention (safety) than in occupational disease prevention (industrial hygiene).

In fact, as the workmen's compensation laws spread across the country between 1910 and 1920, industry recognized that disabling injuries and deaths represented monetary and human costs which were preventable, and safety programs were established in factories. Alice Hamilton, the mother of occupational medicine, was instrumental in calling the nation's attention to the serious problems of occupational disease during this same period. With these developments, there have been physicians, nurses and safety specialists in factories since the 1920's. Although their injury problems were just as serious, the nature of the way in which their work is organized kept such developments from taking place in construction, logging, and agriculture. University programs in occupational medicine and occupational safety were not immediately forthcoming; the practitioners were self-trained.

With the passage of the Social Security Act in 1933, the Federal Government made funds, including funds for education, available to state health departments. Industrial hygiene, as part of these departments, took advantage of this, and there were graduate industrial hygiene programs in place before World War II. With the development of the atomic bomb and subsequent postwar peaceful uses of atomic energy, there was a demand for health physicists; and with Atomic Energy Commission sponsorship, graduate programs in health physics were established in a number of universities.

With the passage of the Occupational Safety and Health Act of 1970, we thus had a number of university programs in industrial hygiene and health physics, and also had a lack of programs, but many people employed as safety specialists, in industry. The availability of Federal Government support for university programs in occupational safety from NIOSH, starting in 1971, particularly the more recent development of the NIOSH Educational Research Centers, has led to a number of educational programs for the training of staff specialists in safety for industry, and for the training of research scientists in safety.

In industrial hygiene, the graduate programs are quite similar and are almost all in schools of public health. The situation in health physics is similar in that the programs in various universities bear a strong resemblance to one another. In safety, on the other hand, there have been a number of different approaches with programs located in schools of engineering, in schools of public health (or, in our case, medicine), in schools of education, or a school of business. With the increasing emphasis upon worker participation in certain "management" functions, touched upon by several speakers in the safety research segment, there is also an occupational safety education program coming out of the labor education movement.

Speakers in this segment will describe programs with emphasis on business, on public health, on ergonomics, on engineering, and on labor studies. These programs can be compared and contrasted, with some common features, and many very significant differences. These innovative approaches cannot but be encouraging for the future of the safety programs in the United States.

SAFETY EDUCATION IN LABOR STUDIES PROGRAMS

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In order to appreciate Labor Studies as a programmatic approach to Safety Education, an understanding of the area of study should be gained. Unfortunately, there is only very general agreement among educators about a definition of "Labor Studies." Once considered an aspect of Industrial Relations, it can be thought of thematically as the study of work, workers, and their organizations, or more functionally as the subject matter of labor education efforts. It is certainly multi-disciplinary and is focused on the social sciences, but it is possible that its nature can only be gleaned from its history. Labor studies was derived from a professional/technical treatment of work, that is, labor-management relations, as it was taught to trade unionists in continuing education programs specifically designed for workers. Operating since the Second World War, many of these labor education programs expanded to offer instruction in all areas thought to be of interest or use to workers, including the Arts and Sciences. Labor Studies programs, being a relatively recent development in higher education, have only within the past few years included occupational safety and health in their curricula. Currently, of the forty-five Labor Studies institutions listed in the University and College Labor Education Association (UCLEA) Directory, nineteen have a safety and health program. The majority of these are certificate programs; one, Empire State College, Center for Labor Studies (State University of New York) grants degrees in this area.

Without doubt, it was the passage of the 1970 Occupational Safety and Health Act which triggered this development. The Act legislated and encouraged the participation of workers in the process of making work safe. Moreover, in mandating the control of hazards, the Act shifted the focus of prevention from worker behavior and "unsafe acts" to unsafe conditions. The role of the worker changed then, from victim of his or her alleged carelessness, to that of an agent of change who was guaranteed minimal standards for safe and healthy conditions and access to the mechanism of enforcement. The charge to Labor Studies institutions is to assist workers to develop their capability to protect themselves. To be effective "change agents," workers and their organizations need to acquire technical skills in hazard recognition and control, and more importantly, knowledge of the "tools" at their disposal to assure that hazards are eliminated and their right to a safe workplace is in fact realized. The safety and health curricula currently being developed and taught at Labor Studies institutions reflects both of these needs.

The Center for Labor Studies has recently established a concentration in safety and health within its degree program in Labor Studies. The Center, with a current enrollment of 1,700 working adults, is one of the units of Empire State College, part of the State University of New York. Students can obtain an Associate Degree in Labor Studies for Lower Division study. Students in the Upper Division pursue a Baccalaureate degree in a chosen area of concentration. All students are required to satisfy competency requirements in English composition and mathematics. Other required "core" courses analyze work and labor through principles of sociology, economics, history, anthropology, and philosophy and examine basic concepts in union administration and collective bargaining. These required courses, the concentration requirements and electives, plus the student's advanced standing (by transcript and evaluation) make up the student's 128 credit degree program.

Students starting a concentration in Occupational Safety and Health are required to take the following Lower Division courses if competency is not demonstrated:

CLS 161	Survey in OSH
CLS 162	Occupational Health
CLS 163	Life Science
ILR 210X	Statistics

These courses are open as electives for CLS students with other concentrations.

Progressing to the Upper Division Level, a student chooses to specialize in Occupational Safety or Occupational Hygiene.

The Occupational Safety component consists of the following courses totalling 13 credits:

CLS 364	Industrial Safety
CLS 365	Construction Safety and Health
CLS 366	Hazard Control
CLS 367	Hazard Investigation and Laboratory

A student concentrating in Occupational Hygiene will be required to take 14 credits in that specialty:

CLS 360	Advanced Chemistry and Laboratory
CLS 361	Industrial Hygiene Chemistry and Laboratory
CLS 362	Industrial Hygiene
CLS 363	Industrial Hygiene Instrumentation Laboratory

To complete the OSH concentration, students in both specialties will be required to take three general courses:

ILR 356X	Industrial Psychology
CLS 368	OSH Law
CLS 460	Topics in OSH

To meet the needs of trade unionists in the program, two electives are offered:

CLS 317	Collective Bargaining in OSH
CLS 318	Workers' Compensation

All CLS seniors are required to take Senior seminar which is offered annually within the OSH program. Students' research is centered on a topic in Occupational Safety and Health and presented orally and submitted as a paper. Although an occupational health course is required for safety specialists, no corresponding safety course is included in the occupational hazard specialty. Because it is necessary for these students to be aware of safety hazards and basic means of hazard control, a "cross over training" seminar in safety is planned for development. Students are encouraged to register for as many occupational safety and health courses outside of the requirements of their specialty as their degree program will allow. With Faculty approval, students may also earn additional credit in the subject area of safety and health through independent study, field placements and internships. In terms of "outcome," it is projected that completion of the Occupational Safety and Health curriculum will enable graduates to function as "entry level" professional specialists. Such a specialist will be able to conduct a thorough survey of the workplace to evaluate job hazards, and be capable of recommending action to eliminate or control the hazard. Additionally, the specialist should be able to organize and administer a small scale safety and health program, develop worker training programs, use various sources to provide useful technical information on substances used in the workplace, and advise employees and employers concerning their rights and responsibilities with respect to safety and health in the workplace.

The unique aspect of the Labor Studies safety curriculum is its emphasis on the means of achieving safe conditions in the workplace. The "technical" core of several credit hours of safety courses does not differ from traditional offerings. The worker/student is trained in hazard survey techniques, job hazard analysis, human factors engineering, hazards of specific operations and industries, safety program elements, and hazard control. But in addition, through completion of course work in Labor Studies, including Labor Management Relations, Labor History, Economics and Labor Law students gain a perspective on the dynamics of the workplace and an awareness of safety and health as a key Labor issue. They learn that decisions concerning safety cannot be made without regard to production and employment, and that safety improvements can only occur within a labor-management context. For example, in the curriculum the organization and function of joint safety committees is examined in depth. But, when joint activity fails to adequately protect workers, or where labor-management cooperation is not achieved, workers have to be prepared to use all their legislated rights. Accordingly, students also learn the techniques Labor has used to effect a safe workplace and protect worker rights and well being.

The major goal of the Center for Labor Studies Occupational Safety and Health Program is more active, effective Labor participation in the National effort to achieve a safe and healthy workplace. The emergence of a class of workers functioning as safety specialists and attaining "professional" credentials through degree programs may counter the pervasive management bias of safety research, regulation and education as they exist today. As labor is equipped to assume a more sophisticated role, significant changes will extend beyond individual workplaces to encompass the community and society as a whole. Already the demand for toxic substances control and worker "right to know"/"right to refuse" has resulted in state and local legislation. These successes have their roots in the activism of Labor Education alumni in many instances, as have many Coalitions for Occupational Safety and Health (COSH groups). Graduates of Labor Studies programs direct and staff union safety and health programs, serve as full time safety representatives, and have been hired as OSHA compliance officers. That agency, through the "New Directions" program, has targeted safety and health education as a top priority for the coming decade, and is the major source of funding and support for Labor Studies safety and health programs. A safe workplace is precipitated by an aware, educated and activist workforce and a strong Labor presence in programs and policy bodies. There is growing recognition that Labor Studies institutions are a vital resource contributing to this goal.

BUSINESS EMPHASIS IN SAFETY

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The application for the original grant from NIOSH to establish a graduate program in safety management was developed in the College of Business and Public Administration of the University of Arizona with the aid of an outside safety consultant. I had been involved in the teaching of risk management as well as performing consulting services in this area. It was quite obvious to me that safety and loss control was a vital part of the risk management process, which is in an over-simplified manner the protection of a firm's assets and earning capacity against accidental loss at the most economical cost.

Since the subject of safety has been taught, it has been in the colleges of engineering. The problem has been, however, that where it is taught, it is usually a portion of a course rather than a complete course. An article in Business Insurance on January 7, 1980, made reference to comments of Jerome Lederer, former NASA director of safety, on this matter. "Engineering schools say they don't have time to teach safety; industry says it can't dictate academic curricula, and professional certification examiners say they can't test what the schools don't teach."

With engineering curriculum "loaded" with engineering courses, the graduate of such colleges receives very little education in the social sciences, including business. It was with this thought in mind that we decided to change our educational strategy for students of safety, and we embarked on a program in safety management, with emphasis on the management side.

To develop our curriculum, we brought in three safety specialists—two safety consultants and one safety executive in the transportation field. The major comment that was made by them that I shall never forget, and has become our motto in a sense, is that we must "teach safety professionals how to speak management's language."

With this motto in mind, we developed our curriculum around our basic MBA program. Twenty-one units of course work are taken in the first year MBA courses, and twenty-four units of course work are taken in safety and related fields. Within the twenty-four units are six units of electives, the remaining eighteen units being required courses. The eighteen units are the following courses:

Safety Management I and II
Safety Law
Safety Policy
Master's Report (in lieu of a thesis)
Risk Management

It was, and still is, our feeling that since the Safety Director should work very closely with the Risk Manager, the Safety Director should have an understanding of just what a Risk Manager does.

One of the major problems of both risk management and safety management is that of communications with management. Many people in these fields have not made the transition from a technician—either insurance or safety—to a manager. A manager must be able to communicate with senior executives of the organization. In such communications, the language of management must be used, not technical engineering terms. Management understands the so-called "bottom line." In other words, what will be the impact of certain changes on the balance sheet and income statement? Have capital budgeting concepts been employed in developing the proposal?

Not only must senior executives be in communication with the safety and risk personnel, but also the operating managers across the entire organization. To accomplish safety and risk objectives, these must be communicated to managers in manage-language, not frequency and severity rates. Those should be the means to the end, not the end itself.

There is a great deal of similarity in the methodology of risk management and safety management. The basic difference is the final objective. The risk management objective is to fund the losses that do occur; the safety management objective is to prevent or reduce the occurrence of losses.

There have been fifty-two graduates of the safety management program at the University of Arizona. Two are currently Risk Managers, one is teaching safety, and all but one of the remainder, to the best of our knowledge, are in safety and loss control. About five, each of whom lacked prior safety experience, are employed as loss control representatives with insurance companies. The remainder are in corporate work, ranging from the safety director for a major conglomerate to assistant safety director for one of the major copper mines in Arizona.

All in all, I feel we have accomplished our objectives—to put more management into safety management. The specialists and technicians can be hired; it is more difficult to find managers with an understanding and appreciation of the safety function.

PUBLIC HEALTH EMPHASIS IN SAFETY

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OVERVIEW

In the modern occupational environment, workers may be routinely subjected to a wide variety of hazards and stresses while they perform their jobs. Frequently encountered examples include: toxic atmospheres, excessive noise, poorly guarded machines, radiation, excessive strength or energy expenditure requirements, temperature extremes, and poorly designed work stations and tools. Exposure to these conditions can result in toxic effects, hearing loss, or physical injury. The range of effects includes decreased performance, reduction in the quality of life, temporary or permanent disability, or in some cases, even death.

Safety professionals and industrial hygienists are responsible for recognizing, evaluating and controlling the environmental hazards listed above. The industrial hygienist is principally concerned with toxic substances, noise, radiation, and heat stress; whereas the safety professional is concerned with physical hazards or work methods that cause traumatic or cumulative injury. While the two fields can be distinguished conceptually, there is considerable overlap in the practice of most professionals. This duplication of effort seems unnecessarily wasteful of scarce human resources. Further, there is a trend for program directors in industry, labor unions, and governmental agencies to be responsible for both industrial hygiene and safety. Therefore, in keeping with Harvard's mission to train leaders in professional fields, the industrial hygiene and safety programs have been merged to train specialists who can deal with <u>all</u> of the environmental hazards present in the workplace. While some specialization is retained, all students are required to take core training in both industrial hygiene and safety. Therefore, a curriculum has been developed which integrates the traditional disciplines of Industrial Hygiene and Occupational Safety. This curriculum is described in detail below.

PROGRAM OBJECTIVES

Graduates of the Harvard program in Occupational Safety will be able to do the following:

1. Design and conduct work site surveys to evaluate exposure to occupational safety hazards, to evaluate the effectiveness of exposure controls, or to determine compliance with health and safety standards. Specifically, program graduates will be able to:

   a. Analyze a specific work environment to identify hazards, (e.g., chemical, biological, safety, radiation, noise, ergonomics, including those associated with repetitive motion and cumulative trauma).

   b. Determine an evaluation strategy for collecting data representative of exposure to these hazards.

   c. Obtain field data and measurements of environmental conditions and job activities. These measurements should include a description of the work process, work methods, and control systems in use which could influence the validity of the measurements.

   d. Determine if survey findings indicate the presence of hazards.

2. Develop hazard control strategies, evaluate the effectiveness of proposed alternatives, and select an optimal control strategy that may include: engineering controls, work methods improvement, personal hygiene measures, personal protective equipment, and administrative controls.

3. Review designs and plans for facilities, equipment, tools, and work stations to assure compliance with safety, industrial hygiene, and ergonomic principles and standards.

4. Establish a collaborative relationship with other members of the occupational health team (physicians, epidemiologists, and nurses) and utilize multidisciplinary approaches in the development of comprehensive occupational safety and health programs.

   a. Design and conduct exposure measurements as a part of epidemiological safety and health studies.

   b. Criticize and analyze safety or industrial hygiene data supporting occupational health and safety standards.

   c. Design training and orientation programs to teach workers safe work practices and use of personal protective equipment, and to give them information on health and safety hazards.

d. Design and implement an industrial hygiene and safety program for an industrial establishment, labor union, governmental agency, or insurance company.

CURRICULUM

The curriculum for the program is illustrated in Exhibit A. Courses have been organized into three core areas: Public Health; Occupational Health; and Evaluation and Control.

The Public Health Core consists of courses in biostatistics, epidemiology, and human physiology. Basic training in these areas is required for all professionals who are engaged in the prevention of accidents, injuries, and diseases. Innovative epidemiological methods may be used to discover the underlying causes of work accidents in order that controls can be developed and implemented.

The Occupational Health Core introduces students to commonly encountered health and safety problems in the modern work environment. An overview of basic manufacturing processes, economic and policy considerations, and human factors is also presented. Students from the related fields of Occupational Medicine, Industrial Hygiene and Occupational Health Nursing are also required to enroll in these courses. This encourages the formation of interdisciplinary teams for evaluating the developing solutions to health and safety problems.

The Evaluation and Control Core provides students with the analytical skills to recognize and quantify health and safety hazards in the workplace. In addition, students develop the skills which are needed to design systems for controlling exposures to these hazards. Tutorials and research projects are used to stimulate the problem solving process and provide important field experience. The student's area of major interest is used in the selection of field experiences for tutorials and problem areas for research.

SUMMARY

The field of Public Health has traditionally been concerned with disease prevention and involves understanding the biological, chemical, physical, psychological and social factors which affect the health of society. In recent years, Public Health practitioners have scored big successes in several areas. Once feared diseases such as smallpox and polio have been virtually eliminated through the development of vaccines and the innoculation of large numbers of people. In the United States, work-related accidents are a serious Public Health problem. Each year, approximately 14,000 workers are killed and several hundred thousand sustain disabling injuries and illnesses while performing their jobs. To solve this problem, it is necessary to study the complicated interaction of factors in the work environment which cause accidents and injuries. As accident processes are understood, preventive measures can be developed and implemented to provide a safer workplace.

Exhibit A

REQUIRED COURSES

Public Health Core Courses	Credits
Principles of Biostatistics or	5.0
Statistical Methods in Research	(5.0)
Introduction to Epidemiology or	2.5
Environmental Epidemiology	(2.5)
Human Physiology	5.0
	12.5

Occupational Health Core Courses	
Human Factors in Occupational Performance and Safety	2.5
Policy Issues in Occupational Health	5.0
Basic Problems in Occupational Health and Industrial Environments	5.0
Manufacturing Processes and Related Health Hazards	2.5
	15.0

Evaluation and Control Core	
Occupational Safety Science	2.5
Occupational Biomech. and Work Physiology	2.5
Aerosol Technology	5.0
Id. and Measurement of Air Contaminants	5.0
Introduction to Radiation Protection	5.0
Industrial Ventilation	2.5
Noise and Vibration Control	2.5
Tutorial in Safety	1.25
Research in Safety	10.00
Department Seminar	
	36.25
Total Required Credits	63.75

RECOMMENDED ELECTIVES

Computing Principles and Methods	2.5
Introduction to Computing	5.0
Regression and ANOVA	5.0
Current Topics in Occupational Health and Safety	1.0
Critical Review of the Scientific Basis for Occupational Standards	5.0
Technology, Law, and the Working Environment	5.0
	23.5

EDUCATIONAL PROGRAM APPROACHES – ENGINEERING

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Certified Safety Professional (BCSP)

Since this purports to address an aspect of engineering education, perhaps it would be wise to hurriedly review engineering as a profession. In the 1963 Annual Report of the Engineer's Council for Professional Development (ECPD) the following definition of engineering appears:

> Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice, is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.

In the National Council of Engineering Examiners' Model Law, the following statement is found:

> Engineer shall mean a person who, by reason of his special knowledge and use of mathematical, physical, and engineering sciences and the principles and methods of engineering analysis and design, acquired by education and experience, is qualified to practice engineering.

Many have compared the engineer and the scientist. Both are thoroughly educated in the mathematical and physical sciences, but the scientist primarily uses this knowledge to acquire new knowledge, whereas the engineer applies the knowledge to design and develop usable devices, processes, procedures, products, and structures. It might be concluded that the engineer is dependent on the scientist for the development of new knowledge for the benefit of mankind. Such is not always true. The functions of the scientist and the engineer frequently overlap to the extent that an engineer could be involved in some activity in which he or she might play the role of engineer/scientist and other types of projects in which the role of scientist/engineer may be assigned to him.

The end result of an engineering effort—generally referred to as a design—is a device, process, procedure, product or structure which satisfies a need. The engineer—often as a part of an engineering team—would follow a logical procedure to arrive at a suggested or recommended design. A suggested order is:

1. Identification of the need,

2. Definition of the problem,

3. Search and acquisition of information,

4. Establishment of criteria and constraints,

5. Consideration of alternatives,

6. Analysis and test of alternatives,

7. Decision (trade-off time),

8. Specification (remember the criteria and constraints), and

9. Communication (sketches, designs, data, written reports, oral reports).

These activity steps may never flow progressively from item 1 to item 9 but will often overlap and may require backtracking in accomplishing the final recommended design. Such a concept is depicted graphically in Figure 1.

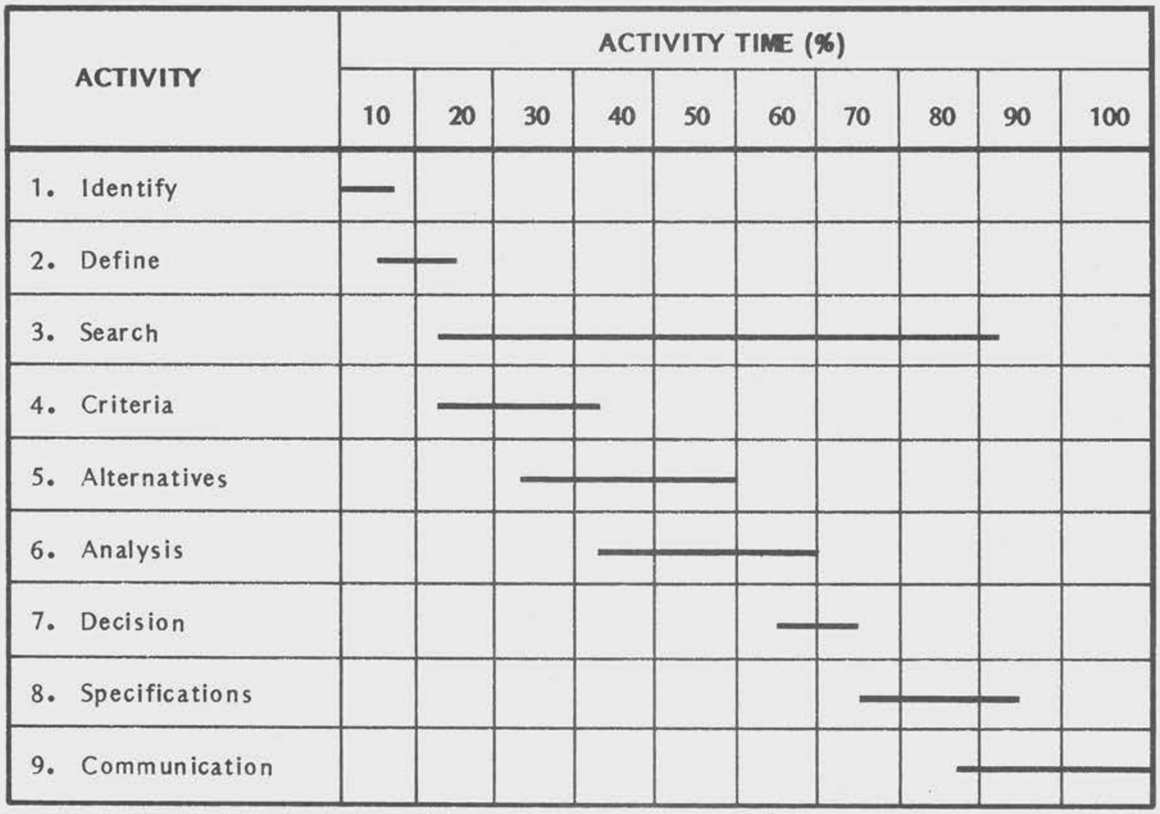
Throughout the activities suggested in Figure 1 and in all other professional activities, the engineer is guided by the Code of Ethics for Engineers. Section 2 of that code is:

> The Engineer will have proper regard for the safety, health, and welfare of the public in the performance of his professional duties. If his engineering judgement is overruled by nontechnical authority, he will clearly point out the consequences. He will notify the proper authority of any observed conditions which endanger public safety and health.

For many practitioners in occupational safety and occupational health, the foregoing is a simplified review of some of the basics of engineering education. It is also true that the basic, and perhaps simplified, concepts of <u>Recognition</u> of an exposure, <u>Evaluation</u> of the exposure, and development of <u>Controls</u> prevalent in occupational safety and occupational health mirror the nine suggested "activities" of engineers provided in Figure 1.

Figure 1

CONCEPT OF DESIGN PROCESS



Previous reference was made to the ECPD definition of engineering. The ECPD is also the accreditation body for academic programs in engineering. To the best of our knowledge, no baccalaureate safety engineering degrees are currently accredited by the ECPD. The academic subject matter requirements include those listed in Table 1.

Table 1

ECPD SUBJECT OR COURSE REQUIREMENTS FOR BACCALAUREATE PROGRAMS

Subjects or Courses	Percent of Hours In Curriculum	Semester Equivalent
Mathematics	12.5	1
Basic Sciences	12.5	1
Engineering Sciences	25.0	2
Engineering Design and Analysis	12.5	1
Humanities and Social Sciences	12.5	1
Other	25.0	2

Consideration is being given to the possibility of safety engineering curricula at several institutions. As in many fledgling disciplines, some time is required for the synthesis and assimilation of required information for such an effort.

Is there an acceptable definition of Safety Engineering? Yes.

> Safety Engineering is that discipline concerned with the design, operation and maintenance of optimally safe systems of man, materials, equipment and environments to achieve optimum effectiveness in protection of both man and property.

Does a curriculum exist that meets both ECPD criteria as well as produce graduates who function in Safety Engineering as defined? Yes. A program does exist at Texas A&M University and is producing graduates at both the baccalaureate and graduate levels. The baccalaureate program is to be considered for ECPD accreditation in the fall of 1980. Graduate programs also exist in engineering colleges at other universities including the University of Michigan and the University of Miami.

The Texas A&M University Safety Engineering baccalaureate curriculum is provided in Figure 2. The distribution of subjects and courses by ECPD criteria are illustrated in Figure 3. The curriculum is divided by subjects into:

Figure 2

TEXAS A&M UNIVERSITY
SAFETY ENGINEERING BACCALAUREATE CURRICULUM

The freshman year is identical for the curricula of: Aerospace Engineering, Bioengineering, Chemical Engineering, Civil Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering, Mining Engineering, Nuclear Engineering, Ocean Engineering, Petroleum Engineering, Radiation Protection Engineering, and Safety Engineering.

FRESHMAN YEAR

First Semester	(Th–Pr)	Cr	Second Semester	(Th–Pr)	Cr
Chem. 101 Fund. of Chem. I	(3–0)	3	Chem. 102 Fund. of Chem. II	(3–0)	3
Chem. 111 Fund. of Chem. Lab. I	(0–3)	1	Chem. 112 Fund. of Chem. Lab. II	(0–3)	1
Math. 151 Engr. Math I	(3–2)	4	Math. 152 Engr. Math. II	(3–2)	4
Engl. 103 Comp. & Rhetoric	(3–0)	3	Hist. 105 Hist. of the U.S.	(3–0)	3
Engr. 101 Engr. Analysis	(2–0)	2	Phys. 207 Gen. Phys. for Engr.	(3–0)	3
E.D.G. 105 Engr. Graphics	(0–6)	2	E.D.G. 106 Engr. Design Graphics	(0–6)	2
*Military, Air or Naval Science or Elective		1	*Military, Air or Naval Science or Elective		1
P.E. 101	(0–2)	1	P.E. 102	(0–2)	1
		17			18

SOPHOMORE YEAR

First Semester	(Th–Pr)	Cr	Second Semester	(Th–Pr)	Cr
Econ. 203 Prin. of Econ.	(3–0)	3	C.E. 205 Engr. Mech. of Math.	(3–0)	3
Math. 253 Engr. Math III	(3–2)	4	Biol. 220 Human Physiology	(3–3)	4
M.E. 211 Statics & Dynamics	(4–0)	4	S. Eng. 220 Prin. of Safety Engr.	(3–0)	3
Hist. 106 History of the U.S.	(3–0)	3	Math. 308 Diff. Equations	(3–0)	3
*Military, Air or Naval Science		1	Pol. S. 206 Amer. Nat. Govt.	(3–0)	3
P.E. 201	(2–0)	1	Military, Air or Naval Science or Elective		1
		16	P.E. 202	(0–2)	1
					18

JUNIOR YEAR

First Semester	(Th–Pr)	Cr	Second Semester	(Th–Pr)	Cr
C.S. 203 Intro. to Computing	(3–0)	3	E.E. 305 Elect. Cir. & Mach.	(3–3)	4
S. Eng. 310 ~~Ind. Hyg.~~ Engr.	(3–0)	3	S. Eng. 321 Ind. Safety Engr.	(3–0)	3
S. Eng. 312 System Safety Analysis	(3–0)	3	S. Eng. 322 Fire Prot. Engr.	(3–0)	3
I. En. 314 Stat. Cont. of Qual.	(2–3)	3	S. Eng. 324 Analysis & Design I	(0–6)	2
Phys. 219 Electricity	(3–3)	4	M.E. 323 Thermodynamics	(4–0)	4
Engr. Sci. Elective		3			16
		19			

SENIOR YEAR

First Semester	(Th–Pr)	Cr	Second Semester	(Th–Pr)	Cr
I. En. 320 Found. in Eng. & Systems Analysis	(3–0)	3	I. En. 412 Labor & Industry	(3–0)	3
S. Eng. 410 Eval. & Cont. of the Occup. Environ.	(3–0)	3	S. Eng. 422 Fire Prot. Engr. – Facilities Design	(3–0)	3
S. Eng. 413 Prod. Safety Engr.	(3–0)	3	S. Eng. 424 Analysis & Design III	(0–6)	2
S. Eng. 414 Analysis & Design II	(0–6)	2	I. En. 430 Intro. to Human Factors Engineering	(3–0)	3
M.E. 346 Fluid Mech. & Heat Trans.	(3–0)	3	N.E. 408 Prin. of Rad. Protect	(2–3)	3
Humanities Elect.		3	Humanities Elect.		3
		17			17

Engineering Science Elective (M.E. 340, M.E. 222 and 322, E.E. 331, E.E. 420, N.E. 401, C.E. 306, Ch. E. 204)
Humanities Elective (any elective on list at end of College of Engineering section, including English Electives)
*Students not electing to take Military, Air or Naval Science must take Pol. S. 207. See "Requirements for a Baccalaureate Degree beginning on page 24 of this catalog.

Figure 3

TEXAS A&M UNIVERSITY SAFETY ENGINEERING CURRICULUM
DISTRIBUTION OF SUBJECTS AND COURSES BY ECPD CRITERIA

Institution: Texas A&M University   Date: 1980–1981

Program: B.S. Safety Engineering

BASIC LEVEL PROGRAM

Semester or Quarter	Course (Dept. & No.)		Category (Credit Hours) Math	Basic Sci	Engr Sci	Engr Design	Hum & Soc Sci	Other
1	Chem 101	Chem 111 Fund. I		4				
	Math 151	Engr. Math I	4					
	Engl 103	Comp. & Rhetoric						3
	Engr 101 K	Engr. Anal.						2
	EDG 105	Engr. Graphics				1		1
	PE 101	Phys. Ed.						1
	Military							(1)
2	Chem 102	Chem 112 Fund. II		4				
	Math 152	Engr. Math II	4					
	EDG 106	Engr. Graphics				1		1
	Hist 105	Hist. of U.S.					3	
	Phys 207	Gen. Phys. for Engr.		3				
	PE 102	Phys. Ed.						1
	Military							(1)

( ) Military or Pol Sc 207 State and Local Gov't + 1 hour elective

Figure 3 (Continued)

TEXAS A&M UNIVERSITY SAFETY ENGINEERING CURRICULUM
DISTRIBUTION OF SUBJECTS AND COURSES BY ECPD CRITERIA

BASIC LEVEL PROGRAM

Semester or Quarter	Course (Dept. & No.)		Math	Category (Credit Hours) Basic Sci	Engr Sci	Engr Design	Hum & Soc Sci	Other
3	Econ 203	Principles of Econ.					3	
	Math 253	Engr. Math III	4					
	ME 211	Statics & Dynamics			4			
	Hist 106	Hist. of U.S.					3	
	PE 201	Phys. Ed.						1
	Military							(1)
4	CE 205	Mech. of Mat'ls			3			
	Biol 220	Human Physio.		4				
	SEng 220	Principles of S. Eng.			3			
	Math 308	Diff. Equations	3					
	PolSc206	Amer. Nat. Gov't					3	
	PE 202	Phys. Ed.						1
	Military							(1)
5	CS 203	Intro. to Comp. Sci.			3			
	SEng 310	Ind. Hygiene Engr.			3			
	SEng 312	System Saf. Anal.			2	1		
	IEn 314	Stat. Contl. of Qual.				3		
	Phys 219	Electricity		4				
	Technical	Elective			2	1		

Figure 3 (Continued)

TEXAS A&M UNIVERSITY SAFETY ENGINEERING CURRICULUM
DISTRIBUTION OF SUBJECTS AND COURSES BY ECPD CRITERIA

BASIC LEVEL PROGRAM

Semester or Quarter	Course (Dept. & No.)		Math	Basic Sci	Engr Sci	Engr Design	Hum & Soc Sci	Other
			Category (Credit Hours)					
6	EE 305	Elect. Cir. & Mach.			4			
	SEng 321	Ind. Safe. Engr.						3
	SEng 322	Fire Prot. Engr.			2	1		
	SEng 324	Anal. & Design I				2		
	ME 323	Thermodynamics			4			
7	IEn 320	Eng. & Syst. Anal.	3					
	SEng 410	Eval. & Cont. of Env.			1	2		
	SEng 413	Product Safety Engr.			1	2		
	SEng 414	Anal. & Design II				2		
	ME 346	Fl. Mech. & Heat Tran.			3			
	Humanities					3		
8	IEn 412	Labor & Industry						3
	SEng 422	Fire Prot. Engr.–Fac.			2	1		
	SEng 424	Anal. & Design III				2		
	IEn 430	Intro. to H. F. Engr.			3			
	NE 408	Prin. of Rad. Prot.			3			
	Humanities							

Mathematics	18 credit hours
Basic Sciences	19 credit hours
Engineering Sciences	43 credit hours
Engineering Design and Analysis	18 credit hours
Humanities and Social Sciences	18 credit hours
Other	21 credit hours
Total	138 credit hours

As stated in the ECPD accreditation materials prepared by Texas A&M University, the principle objective of the Safety Engineering Program is to provide the students with the intellectual background which will enable them to participate effectively as engineers with special attributes related to the design, operation and maintenance of optimally safe systems. This is accomplished through a broad selection of basic engineering science, safety engineering, industrial hygiene and fire protection courses with supportive courses in the physical and life sciences. Through engineering analysis and design courses, problem identification and solution development are enhanced. Graduates of this program are securing positions in petroleum refining, petrochemical, and aerospace industries, as well as government. In addition, the curriculum prepares the student for advanced study in safety engineering, fire protection engineering, industrial hygiene or other related disciplines.

The history of occupationally-related safety courses at Texas A&M University extends back to 1948. Courses at that time were taught in the Industrial Education Department which was a part of the College of Engineering. In 1966, there was a desire to create both baccalaureate and graduate curricula in Industrial Safety and a graduate curriculum in Industrial Hygiene in the Industrial Education Department. That desire was accomplished and the three degree programs were later transferred to the Engineering Technology Department of the College of Engineering. In 1972, the Dean of Engineering transferred the three programs to the Department of Industrial Engineering where the two Industrial Safety curricula were revised and approved in 1977 as the present baccalaureate degree in Safety Engineering and the Master's degree in Safety Engineering.

Is Safety Engineering concerned only with occupational safety and health? No, but Safety Engineering does have something to offer to both occupational safety and occupational health. Public Law 91-596 passed by the 91st Congress and enacted into law in December 1970, provided in Section 2(b)8 ". . . for training programs to increase the numbers and competence of personnel engaged in the field of occupational safety and health." An engineering program is one approach to preparing young men and women with known competence to enter this vitally important field. After all, the thrust of compliance with the law of the land is engineering controls, administrative controls, and personal protective equipment.

Then, it seems natural for academic programs sponsored by NIOSH or other Federal agencies to desire engineering-based academic programs. When Safety Engineers are employed as engineers and permitted to function as members of design teams, then we will have a much better chance for the development and application of improved control technology and should reduce the need for constant retro-fitting which is not always successful and is often very expensive. Initially designed control technology should be more rewarding to the purchaser (management), the user (the employee or private owner), the public (you and me), legislative interest (government) and, ultimately, the Safety Engineer himself.

In conclusion, the Safety Engineer is not simply another practitioner of occupational safety and health. He should have special talents, knowledge and ability to contribute to that aspect of safety. He does not replace nor is he replaced by graduates of other types of programs. After all, there is a need for other types of educational programs to prepare individuals to meet the needs of today and tomorrow; and there is a need for cooperative efforts between those specialities. With such efforts by the engineer, the manager, the technician and others, the probability of success should increase.

REFERENCES

Beakley, George C. and Leach, H. W., Engineering, The Macmillan Company, 1967.

Eide, Arvid R., et al, Engineering Fundamentals and Problem Solving, McGraw-Hill, 1979.

Engineers' Council for Professional Development, Questionnaire for Review of Engineering Programs, E.C.P.C., 1979.

ERGONOMICS AS A BASIS FOR GRADUATE EDUCATION IN OCCUPATIONAL SAFETY:

A Multidisciplinary Approach Involving Engineering, Psychology, and Public Health

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INTRODUCTION

For the past twelve years I have had the privilege of directing a graduate-level traineeship program in safety, initially with support from the former Division of Accident Prevention (U.S. Public Health Service), later under a variety of successor organizations, and finally, of course, under NIOSH as it came into being following passage of The Occupational Safety and Health Act of 1970. During all of these years the program has been administered under the umbrella of a Graduate Program in Ergonomics that has been jointly supported by the departments of Industrial Engineering and Psychology. The joint nature of the program includes: some cross-listed course; graduate students from either major area of concentration; and support from both departments in terms of teaching assignments, space, and equipment resources. My own dual appointment has provided a means to program coordination between the two departments. Since few, true joint programs exist in our field, I have wondered at times whether a dual role such as mine is a "key" to their existence. But before you ponder such an alternative approach to program direction, I should remind you that attendance at more departmental faculty meetings goes with the role. In any case, I have learned much about safety and program direction over the last dozen years, and today have the opportunity to share my experience with you.

SOME PERSPECTIVES ON ERGONOMICS AND SAFETY

Ergonomics (or human factors engineering as it is called in some quarters) is a hybrid field of study concerned with the design of systems involving people, machines, products, and environments. Our data base involves the behavioral and biological sciences in that our design efforts, broadly defined, involve consideration of human anatomical, physiological, and psychological characteristics. Thus, in an engineering design setting, the ergonomist often stands out as a protagonist of human performance, in contrast to the typical engineer schooled in the physical sciences.

Prior to 1970, most educational programs in our field were centered in psychology departments. But over the last decade such programs have come to be more commonly situated in industrial engineering. Indeed, there has been a decline in the number of major programs in our field that can be associated with psychology departments. While I can speculate on a variety of reasons for this shift, one thing that is clear to me is the impact of the OSH Act on I.E. departments. Certainly much of the training and research in support of occupational safety is centered in I.E., while few psychology faculty appear to be interested, or active, in research in this specialty.

ERGONOMICS AS A JOINT PROGRAM

The goal of our program is to prepare a student at the M.S. or Ph.D. level in the broadest sense of ergonomics so that he or she may ultimately possess the potential to apply his or her talents across a broad spectrum of problems and employment opportunities. This implies exposure to such "sub-specialties" within ergonomics as systems design, human performance theory, environmental factors, enthropometry, biomechanics, work physiology, and work design. Beyond this the student specializes according to his or her interests and career goal (e.g., research scientist, technical support, management, administration, systems specialist, etc.). Of course, superimposed upon this base are requirements a) for developing research and professional skills, b) for minor area coursework, and c) for some amount of concentration in the major (I.E. or Psychology) apart from Ergonomics *per se*.

Our prime graduate-level Ergonomics courses include the following:

PSY-IE 540	HUMAN FACTORS IN SYSTEM DESIGN
IE 541	SYSTEMS SAFETY ENGINEERING
IE 542	PHYSIOLOGICAL CRITERIA IN WORK MEASUREMENT
IE 544	OCCUPATIONAL BIOMECHANICS
PSY 545	FUNDAMENTALS OF SKILL
PSY-IE 593	AREA SEMINAR IN ERGONOMICS
PSY-IE 640	SKILLED OPERATOR PERFORMANCE
IE 641	ENVIRONMENTAL FACTORS AND HUMAN PERFORMANCE
IE 693	SEMINAR IN APPLIED ERGONOMICS
IE 694	ADVANCED PROBLEMS IN ERGONOMICS

Not all of these courses, of course, are necessarily taken by NIOSH trainees. With regard to occupational safety specialization, the plan of study commonly involves those courses emphasizing systems design, biomechanics, work physiology, safety, and environmental factors. All of our graduates are expected to have had, at the minimum, six semester credit hours of graduate-level statistics. A minor in "Environmental Health" is also required of our NIOSH trainees. I will discuss this shortly.

Digressing briefly, I should like to comment upon the character of a joint program in terms of the background of students involved. Here there is a contrast to be noted between those entering our program with undergraduate degrees in engineering versus those from psychology. Generalizing, the engineers are skilled in solving problems (especially with equations), more analytical, and pragmatic; in contrast the psychologists are better at defining problems, more prone to philosophical debate, and ready to offer critique in terms of experimental design and control. The psychologist knows his way around the library and how to do a literature search; the engineer often doesn't have these skills. But this mix has its blessing. One "side" is exposed to the other — and this makes for interesting classroom discussion. In short, it approximates a situation found in the world of work—communicating with (and learning from) those in other professions. Insofar as safety problems require solutions via multidisciplinary approaches and collaboration, I feel this characteristic of our program is a most desirable one to have.

ALLIED SUPPORT, RESEARCH, AND FIELD EXPERIENCE

Now, returning to the requirement of a minor in "Environmental Health" for our trainees, I should like to note the advantage of a distributed minor (i.e., across departments) which our graduate school policy allows. Thus, our trainees can choose from courses in noise and vibration effects and control (taught in Mechanical-Aerospace Engineering), toxicology, survey research methodology, and, from the School of Public Health at Chapel Hill, industrial hygiene, occupational medicine, epidemiology, and injury control. While those options at Chapel Hill have been pursued for many years, the recent formation of the NIOSH-funded Occupational Safety and Health Educational Resource Center there (which incorporates our own program) provides a most desirable mechanism for fostering inter-campus faculty and student interaction through which all benefit.

Active research programs are also a desirable adjunct for graduate education, as are opportunities for trainee field experience. Lately, my colleagues and I, a) either through research grants in such areas as pre-employment strength testing, safety management information systems, and emergency egress from fires, or b) through consulting opportunities with industry, have been able to involve our trainees in safety-related project or thesis research, field studies, or both.

With such educational backgrounds as I have described, our graduates have taken a variety of positions—in safety research or management, as educators or consultants in occupational safety, or as administrators or safety engineers within industry or with state and federal agencies.

THE FUTURE

In closing, I should like to mention briefly at least one topic of study which we have added to our curriculum — occupational stress. There appears to be rapidly growing research interest in this area, and it is a broad one at that, ranging in consideration from the production-line worker (industrial boredom), to the office "word-processor" (eye strain from VDU's), and to the manager or executive (stress management). Certainly such topical problem areas as I have just mentioned should be considered relevant issues of concern within any broad definition of occupational safety and health.

OVERVIEW OF EDUCATIONAL APPROACHES - SUMMARY

Howard Ayer

Dr. Roos presented the history of the business administration approach to education of safety managers. His program emphasizes the management aspects of the safety professional's job. Although the traditional safety and health topics are given in courses, these are apparently presented in much less detail than in most other programs. The suggestion is that engineering is done by the engineering department in any event, and the day-to-day safety activities of inspections, accident investigation, supervisor training, and etc. are secondary to management involvement and commitment, which is better achieved by one trained himself as a manager.

Dr. Keyserling made the case for occupational injury as a public health problem, best approached by more or less traditional public health training. Supported by other speakers from the podium and the floor during the day, he also gave his view that traumatic injury and other types of health damage caused by work cannot readily be separated, so that the safety specialist should also be trained in industrial hygiene and vice versa. The objectives of the program at Harvard and the curriculum used to implement these objectives were given to illustrate his point.

Dr. Pearson gave the way in which psychology and industrial engineering are integrated into an ergonomics training program at North Carolina State. Unlike the other presenters, he emphasized the preparation of doctoral candidates, who would be more prepared for the conduct of research in prevention of accidents and injuries. Although his program is in the departments of psychology and industrial engineering, it is neither of these, but one which emphasizes the interface between human factors and work tasks/machines, i.e., ergonomics. This program gives the student knowledge applicable to the prevention of ill health, whether from interaction with his tools and machines or his chemical and physical environment at work.

Dr. Vernon emphasized the importance of engineering in developing a safer workplace. His program at Texas A&M prepares undergraduate engineers in the industrial engineering program to specialize in safety and gives graduate students skills which include engineering. The emphasis in his presentation was upon the integration of safety and fire prevention into an undergraduate I.E. program. He gave a summary of where the graduates had accepted employment, showing that most had remained in occupational safety and industrial hygiene.

Ms. Roznowski gave the status of a program in occupational safety and health in a labor education context at Empire State College. Because the students in this program are already employed, the classes are presented during evenings and weekends, so that workers can participate. In this manner, it is hoped that a more thorough and complete knowledge of occupational safety and health can be obtained by those who must represent the workers' interest with employers. The degree granting program will also better prepare them for leadership positions than the traditional short-term labor studies extension presentations.

Missing from this part of the program were the associate degree programs in occupational safety designed to give preparation in basic skills to those who are employed in safety programs in individual installations. These programs, largely in community colleges, were represented by several symposium participants. They tend, more than those presented in this session, to be oriented towards the needs of local employers. Such programs, perhaps located in the college of education, can also be baccalaureate programs, still with a strong emphasis on the perceived needs of area employers of safety specialists.

Each of the speakers gave cogent reasons for the approach adopted by the particular institution. The overall impression is that the diversity of approaches will continue, and that this diversity is desirable in that each of the approaches (including those omitted from this program) has unique strengths which will contribute to the reduction of occupational injuries and illnesses in the University States.

INDUSTRIAL INPUT FOR SAFETY AND HEALTH CURRICULUM

R. W. Allen, C.S.P.
Ferris State College

It is imperative that loss control professionals participate in the construction, implementation, and administration of academic curricula designed to prepare students for employment in the occupational safety and health profession. This may be done by maintaining lines of communication with the academic world through advisory committees and the employment sector of the representative industry.

We are now observing the inception of an increasing number of programs in occupational safety and health, although there are shortcomings in the areas of curriculum models, lack of correlation of curriculum content, and in the need of structured, professional input from a recognized "Advisory Council Committee."

In the past, such input has been lacking in several aspects. Few program advisory committees have been formed, and there is no formal review process of these committees. The selection of committee members should include representative types of potential employers from the immediate geographical area, such as members of the manufacturing and insurance industries, compliance organizations, and labor and/or municipal groups. Individuals of a similar philosophy should not be considered for committee selection. Arrangements should be made for overlapping the tenure of committee members. Members must be acquainted with the functional bureaucracy of the academic institution, including information on administrative structure and function; faculty organization and operation; and student body composition.

The functions of an advisory committee are several. Committee member participation may be maximized by assigning definite tasks for groups within the committee and for individual members. The members should be contacted whenever advisory assistance is needed in the areas of curriculum content, including initial course selection and content as well as revisions necessary to maintain the current state of the art as it exists in the occupational world; procedural matters; and equipment selection and procurement.

The committee is also responsible for following up individual committee member suggestions. Members must be kept informed of the status of input items. Serious considerations should be given to each member's input item. Instructors should not allow the "sacred cow" aspects of their own method or philosophy of operation to detract from the value of another member's input. Members must be advised of the final disposition of each suggestion.

Another area involving committee functions deals with the utilization of program directors from the safety and/or health program with prior industrial experience. Many industrial, municipal and state operating units have individual occupational safety and health programs. Some have an operating group comprised of both professions. For this presentation they will be recognized as separate units. Much of this depends on the extent and type of industrial background.

In the past, input has originated from adjunct instructors who may have been simultaneously employed by industry or recently retired from industry. The publications of professionals in the field have also been a source of input. Other input has stemmed from professional groups, and from the limited number of professional publications available. In this respect, now that more colleges and universities are requiring advisory committees, there is increased input in professional publications that is the result of increased author experience and increased safety and health professional education and experience in a greater number of areas.

Informative articles in other professional technical publications also serve to keep the program director advised of the current state of the art of safety and health programs in industry and, hopefully, of future needs of these programs. They indicate topics that should be addressed by academicians so as to better prepare students for a position in the field of work they will enter upon graduation.

Greater participation is evidenced by professional societies that promote the advancement of a safety and health methodology and philosophy of operation. These groups include:

1. Societies with memberships in the various segments of occupational safety and health;

2. Organizations that have an "education committee" or similar group dedicated to the advancement of safety and health training and education activities; and

3. Guest speakers and/or adjunct instructors from industry who can illuminate a particular segment of safety and health.

Future input situations suggest a continuation of present input sources from the occupational sectors to the academic areas. Some of these include: advisory committees, professional societies, and professional and technical publications. Graduates of safety and health programs will also contribute, as well as individuals at large from the industrial world. Students from an on-going curriculum who have prior industrial and significant internship experience will also be asked to provide input.

Safety and health program directors and instructors will also be encouraged to participate in the various segments of industry that employ graduates of their respective programs or to participate in industrial areas in which the instructor anticipates placing graduates. Some of these areas include summer employment of the instructor; consulting employment; sabbatical leave employment; and planned professional development.

Soliciting input also includes promoting professional certification among educators. Program directors will be encouraged to participate in professional bodies that are concerned with the promotion and improvement of safety and health programs. These activities will foster a better interchange of information between occupational and academic professionals.

Input regarding graduation qualifications, course content, and structure within the curriculum will be solicited from former students or graduates of the safety and health program who are presently employed in various occupational fields of safety and health.

It is imperative that safety and health professionals in the academic and occupational world communicate with each other. This will better inform both communities of their respective needs in the areas of technical requirements, philosophical requirements, goals, and personnel. Each of these areas is highlighted below.

Technical Requirements. Industry should advise the program director of the technical abilities required to enable industry to maintain and improve methods of equipment, design, selection, and use. Both safety and health professional groups should keep each other informed of present and proposed innovations in the areas of systems analysis and similar programs to be utilized in industry to anticipate and control accidents.

Philosophical Requirements. Techniques, including behavioral modification, designed to maximize participation in accident prevention and loss control programs will be utilized by groups of workers, management personnel, students, and administration and faculty.

Goals. In order to promote and insure future growth in the many areas of occupational safety and health, it is necessary that professionals in both the occupational and academic areas keep each other informed of their future goals. Future goals may include personnel requirements, program changes in the scope and utilization of safety programs, program research and development; and academic areas, including program development, student recruitment, and anticipated equipment usage requirements.

Personnel. Both industrial and academic loss-prevention professional bodies should be aware of each other's needs and the problems associated with these requirements in personnel areas. Areas facing difficulties include occupational personnel needs, specifically professional managerial and technical qualifications of graduates entering the work world. Industry should recognize the ability and limitations of colleges and universities to produce graduates. The time span of education training periods covers 2, 3, or 5 years, versus the often cyclic employment patterns of industry.

Academic personnel needs encompass instructors, students, and occupational personnel needs. Instructors and program directors must exhibit technical and managerial qualifications, the ability to work with students, and occupational experience in loss control areas. The ability of institutions to hire and maintain a professional safety staff is another important factor. They will have to compete with industry for qualified personnel, which may entail the hiring of retired professionals or adjunct safety professionals.

In meeting student needs, information should be shared with elementary and secondary school personnel and students of the various occupational safety curricula regarding job functions, employment opportunities, career areas, and academic requirements in the areas of math, science, and communication skills. Student placement and participation is another critical area.

Occupational personnel needs include offering extension (home-study) courses leading to a possible degree in occupational safety. These courses may be held in conjunction with labor unions and management training groups.

In summary, when the occupational and academic communities better understand each other's needs and problems, the result will be a better supply of qualified individuals seeking employment in safety and health professions. The end product of this desirable situation will be that less training and retraining by the employer will be necessary to fit the individual to the job. But without effective communication and its resulting understanding, programs may continue to be isolated from the "real world" and fail to fulfill the expectations and needs of both students and employers. To help circumvent this, the advisory committee is an essential mechanism in communication structuring and program monitoring, as well as an ongoing source of guidance for the faculty and administration.

LABOR NEEDS IN SAFETY EDUCATION

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It has long been recognized that sole reliance on industry cooperation and voluntary activity in the area of job safety and health has not achieved "acceptable" injury rates or adequate protection of this country's work force. As a result, Labor lobbied long and hard for the passage of Federal legislation to create minimum standards for safe and healthy working conditions. When the Occupational Safety and Health Act was passed in 1970, it contained not just a mandate for employers but an acknowledgement of the rights of workers to a job free of serious hazards. Key provisions regarding worker participation and protection from discrimination have encouraged increased Labor activity in workplace safety. Such provisions initiated a reexamination and a redefinition of the roles of labor, management, and government in the securing of a safe workplace.

Workers are no longer the passive recipients of the success (or failure) of management safety programs. The accident victim, so often blamed as guilty of carelessness or "unsafe acts" now has the legal right to challenge that assumption by demanding the abatement of hazardous conditions which may be a causative factor, and the right to appeal to the federal government if the complaint is ignored. While responsibility for safe working conditions remains with management, the continuing failure of many employers to provide what is now legally regarded as a fundamental right has forced workers to become active or become victims. As J. C. Turner, President of the Operating Engineers has put it, "While management has the legal responsibility to conform with Federal and State laws and regulations, the Trade Unionist Movement has the responsibility of seeing to it that management meets their obligations."

The OSHA Act boosted Union efforts in safety and health, where progress had been slow under existing labor laws (it was not until the fifties that the National Labor Relations Board ruled that unions had any right to negotiate on safety and health). Unions were given new tools and a basis for increased involvement, and accordingly, they increased the resources devoted to this effort. In 1970, there were only two safety and health specialists on union staffs, and there were no community based worker advocacy groups, such as the Brown Lung Association and local "Coalitions on Occupational Safety and Health" (COSH groups). There are now more than sixty union professionals and support staffers number a few hundred, and some unions have left positions unfilled because of a lack of qualified individuals. As is the case with the professionals working in Industry, these individuals come from a variety of backgrounds and academic programs, but their function in labor organizations is not currently addressed by educational institutions to the extent that the development of Industry professionals has been. There are many programs that, in addition to teaching hazard recognition and safety engineering, offer many courses determined essential for the developing industry professional (safety management, employee relations, management techniques). For those interested in a Labor perspective, such a specialized program is not available. To date, not even a "skills task analysis" has been conducted to identify the requisite skills for Labor safety specialists and determine the curricular components that will produce qualified individuals.

In developing a Safety and Health program at the Center for Labor Studies, Empire State College, an attempt was made, through conversations with labor leaders and union safety staff professionals, to identify those activity areas in which staffers need competency (See Figure 1). Some may argue that a Labor-related safety specialty such as is being developed at the Center is unnecessary, given that academic preparation for safety as a technical specialty should not be altered to suit a particular application. In fact, the technical areas of safety education do not require alteration; they are needed by Labor. What is also needed is the Labor "flavor" missing in overall program design. Virtually every safety program in this country has extensive orientation towards safety "management." The proliferation of such programs is testimony to the importance of specialization in approach, and the needs of labor deserve consideration. Comparably, the professional working for a Labor organization must understand how unions and workers "manage" safety problems in the workplace. A knowledge of labor management relations and Labor Law whether gained firsthand or through course work is essential. Related educational innovations addressing this critical aspect of safety training include "para-professional" Safety and Health education for workers at the certificate, associate or bachelor degree level and the inclusion of safety as a specialty in labor studies curricula. Another approach might be modelled on the Health Service Corps in the medical profession, in which graduates who received government scholarships and support would be required to work in an "under served area" such as Labor and community groups. This would assure a supply of technical expertise for these organizations while providing these professionals with valuable work experience.

Figure 1

FUNCTIONS OF A UNION SAFETY/HEALTH SPECIALIST

Task Areas:

Training

Development of instructional and course materials, newsletters, worker education in safety and health.

Services

Hazard information requests, Safety and Health hazard evaluations, special studies, and hazard alerts.

Participation in Federal and State Programs

Standards review and hearings, industry and federal study review, advisory panels for policy and standards, liaison with federal and state enforcement efforts, workers' compensation.

Skills/Knowledge Areas:

Hazard Survey

Walk-around techniques and instrumentation, recordkeeping, epidemiology and data analysis.

Hazard Abatement

Control technology, contract language and collective bargaining, grievances and arbitration, labor law, OSHA standards, government programs.

The shortage of safety and health professionals in worker advocate positions is a visible problem, one which must be addressed by government programs. What scant resources are currently provided for Labor are often not utilized because of a perceived anti-labor, pro-management bias and patronizing attitude on the part of "public" institutions. Particularly, NIOSH needs to develop supportive safety expertise on its national staff and field offices. In order to provide the Labor movement with qualified and effective specialists, new education programs must be developed and supported. Specifically, the NIOSH-funded Educational Resource Centers must develop safety education programs, curricula, and materials, particularly at the associate and baccalaureate level, which are accessible to workers. When safety and health programs are developed that include worker advocate emphasis, a significant step will have been taken towards the goal of a safe workplace. It is only by actively encouraging Labor and by affirmatively expanding the opportunities for its participation at all levels that government agencies and publicly funded institutions will begin to function fairly and effectively towards that goal.

THE NEED FOR UNIVERSITY AND UNION COOPERATION IN RESEARCH AND EDUCATION FOR CONSTRUCTION

Jim E. Lapping
Director of Safety and Occupational Health
Building and Construction Trades Department
AFL-CIO

I think this section on Labor input is a forerunner of what you'll see in the future. I say that because of those of you working for NIOSH, OSHA and the Universities and working on government funds that were created and continued through the Union movement by our lobbying the Congress are going to enjoy the input of the Unions and their involvement in your program. Many of you have solicited the Labor movement in your area to become involved in your programs.

What is happening now as we become more sophisticated in Washington and with our International Representatives and Local Unions as they grow in the field of safety and health, is that they are questioning what's happenning in the NIOSH funded Centers. They're questioning the research that OSHA is funding. We want results and involvement. I'll tell you why we are so interested in this. In the Building Trades, the Construction Unions, of which we represent 15 with 4.5 million members, each year there are about three thousand deaths. With construction workers averaging about 1,500 hours a year, that's two deaths every hour in construction.

So we need the Universities, we need the research and we need the help. We have 500,000 injuries per year. This is a very serious issue with us in the Union movement and one that we need the Universities to address. Especially in construction where the injury rate is 70% higher than the average of all industries. I think John Molovich of the Steelworkers did an outstanding job of pointing out what labor's interests are and what the problems are.

You'll see as the Unions start concentrating more on this area and start coordinating our efforts that we are going to be more involved. Nancy Samuelson out at Stanford has an Advisory Committee with union representatives. We've worked with a lot of people at the University levels. I know one day that you'll be pleasantly surprised when a gentleman shows up and says that he's from the Union and wants to become involved in your program. I think we are going to have to face the fact that as long as the programs are funded and supported by the labor movement that labor will be involved in them. But we have to develop our expertise together.

Hopefully, the people in OSHA—Dr. Pursewell, who came from a university, is an excellent example—take a little while to develop a relationship with the Unions. These relationships are very positive and to your advantage. Often, you will not see them to your advantage but they will be in the long run. We must work together to try to protect our members. That's what you're there for—even though I know you are in the universities and the medical schools. All these programs are to protect our people. And that's what we are here for - to improve safety and health for workers.

I think a very important concept that I want you to be aware of as you become involved with union people, is to let the union people be the union representatives. You be a facilitator, a helper and a person who gives advice, but let the union person be the union representative. What often happens as we become friends with the university people and other academicians, as well as government people, is that pretty soon they think they know more about the unions and the needs of our people than the elected representatives. The end result is frequently a conflict.

We have elective procedures that are probably the most democratic, the strongest democratic organization in the world, the union movement, and we have to answer to our own people. These people have a job to do, they know how to do it—we need your help, not interference with established procedures.

So there are two very separate important roles. One is representing the person down on the job and one is representing the universities in the academic community. That is why I really appreciate this opportunity in a short time to give you our view of the future for academic, scientific and union cooperation. This conference is an example of how union people and representatives can become involved in your programs. Jim Oppold has been very good to include labor in this conference. I hope that in your meetings at the universities you will involve labor and allow them to be a help to you, just as you can be to them.

ISSUES IN DEVELOPING UNIVERSITY LABOR-MANAGEMENT ACTIVITY ON OCCUPATIONAL SAFETY AND HEALTH

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It is important to have some understanding of our philsophical orientation. The program at the University of Maryland is called the Industrial Relations and Labor Studies Center. Industrial relations is one of the oldest multi- and interdisciplinary fields, but it is not a discipline. Industrial relations is a study dealing with the wide set of issues encompassed in the employer-employee relationship. Professor John Dunlop in Industrial Relations Systems suggested that this complex relationship is "a web of rules". The issue is whether the rules are to be established, applied, interpreted and altered in unilateral, bilateral, or multilateral fashion.

Let us put this general framework into the study of health in the workplace. Employers might say that the rules dealing with health are unilateral, bilateral or multilateral. One of the speakers on a prior panel said that health was exclusively the province of the employer. The field of industrial relations generally would reject that position. Issues of health and safety are intimately related to the subject of management prerogatives and work rules. These questions of management prerogative are knotty. What is the exclusive province of management: investment, planning, research, etc.? Each can ultimately impact on working conditions and therefore be within the scope of interest or of bargaining. Couldn't the above potentially affect worker health?

Work rules have always been the "no man's land" of industrial relations. The size of crews, speed of work, definitions of legitimate assignments, etc., all impact on productivity affecting the security of the job as well as the health and well being of the incumbents. Any union that failed to pursue those subject areas would be remiss in its duties and would probably have only a brief tenure. These complex issues are part of the intricate tapestry of industrial relations. Our approach suggests that there is a legitimacy in unions and worker's association, where formal trade unionism does not exist; the concern is with questions of health, utilization of manpower and, in some cases, the industrial engineering of the work site.

The issue of legitimacy is at the heart of the matter. There is a legitimacy in industrial relations for universities. That is, an authentic university has at its core research and teaching. If an activity is not intimately associated with research and teaching, it does not have legitimacy within the university. Occupational safety and health, or the subject of productivity and quality of worklife may test the limits of legitimacy for a university. The head of Maryland's Center for Productivity and the Quality of Worklife has as a goal the removal of productivity from collective bargaining. One can also hear that health and safety are technical issues and should therefore be removed from collective bargaining. But I also hear that "You can't do that because the parties won't let you," and that, I believe, is correct. One cannot fragment, or attempt to sanitize an issue like health and remove it from the entire relationship between the employer and the employee. The question has both positive and normative attributes and therefore is most researchable; research being a prior activity to giving advice, teaching or producing polemics.

In order for a subject to have legitimacy within a university, it is necessary to have research as an ongoing function. One needs to engage members of the academic community to conduct legitimate scholarly and non-biased research. What are the incentives that members of the academic community really respond to? At a base level they respond to financial resources to direct the utilization of their time. They also must respond to increasing scholarly productivity, the fundamental academic currency. A faculty member must produce, and the production must be accepted by peers and colleagues. If faculty don't produce, they will be assigned second class and possibly third class citizenship status. Put more forcefully, a long run strategy to develop university involvement with labor and management on health issues must engage the legitimate and traditional parts of the university while pursuing these traditional goals and exploiting the single system that is generally recognized. A program must be linked to the academic incentive system. Researchers need to carry out research, test hypotheses, and satisfy reasonable donors. These donors can provide fresh ideas and problems, data, and financial resources. In action-oriented subject areas like industrial relations, it is useful for the academic community to selectively intervene in the policy world and to have that client-donor group as a natural vehicle for the dissemination of research findings.

The strategy for developing university participation must have an external component as well as an internal one. The external strategy for establishing an authentic university program of industrial relations or occupational health is neutrality. The university should be neither the servant of labor nor of management. Intellectually and psychologically, one should receive more pleasure out of biting the hand that feeds one than licking it. Any respectable program should look upon itself as neutral even if the patron, say the government, may attempt to cloak itself in a "neutral" selfless garb. A second best strategy is to be an advocate. That descends into a third class status when, under the mantle of objective research the university becomes an advocate, or worse, an agent for someone.

When labor and management approach issues like occupational safety as adversaries, a vital function for the university is to aid the parties to become more enlightened and informed adversaries. Many discussions of workplace health and safety are virtually valueless because the parties are talking off the tops of their heads about the remediation of problems where the indices of the problems, no less than the definition of the problems, are vague. Frequently the health and safety issues are too complicated to be sensibly resloved at a bargaining table, where the complex health problems are encased in a set of other complex problems and the resolution faces an awesome deadline.

There are alternatives. A labor–management committee assigned in a bargain can develop solutions which can be returned and ratified through the collective bargaining process. That is, the labor–management committee's work is not designed to bypass collective bargaining, but is an integral part of collective bargaining. Within this non–crisis approach, the university can provide expertise to clarify issues as well as pose or evaluate options.

Operationally, how can this be achieved in the health and safety area? One must realize that for a long time there has been a natural bond between the management community and universities through colleges of business and management. That is, the management community is the natural clientele of university's management. Those who run universities have tended to look upon trade unions as, at best, the "great unwashed", against which it might generally choose immunization. Certainly trade unions are an unknown group about which one should at minimum be apprehensive. After all, unions might come in and start organizing your own faculty or staff and then where would the university be?

The question of appropriate university involvement is complex. If universities were willing to open themselves up to trade unions, there is a long historical tradition of distrust and antipathy to be overcome between the university, i.e., the intellectual community, and the trade union movement in the United States. In the Continental tradition as well as in England, university intellectuals played a strategic leadership role in developing an ideoloical thrust for trade unions. Pragmatic unions in the United States have historically rejected such meddling. When academic writers analyze unions, the interpretation is frequently in an adversary framework. The growing concerns of racism and sexism as well as interest in union bureaucracy as a force adversely affecting individual rights and usurping political power add to the problem. Economists have tended to treat unions as a force lowering the forces of competition and so generally to be criticized. Pro–union writers frequently are dismissed as flacks and panderers even when they are not. The new labor history frequently consigns traditional unions to benign neglect but certainly moves them from center stage.

Unions for their part have problems which make a frank and open relationship difficult. Fundamentally, they are political institutions with power relations running among the levels of organization as well as within organizations. Criticism is not particularly welcomed and there has been a tendency to treat outsiders as either friend or foe. Unions like most institutions have loyalty as a dominant trait. While personal combative loyalty is not personal combative loyalty is not unknown in universities, it is a scarce resource. In trade unions one is dealing with a group of elected leaders who are continuously aware of the electoral process. An outsider cannot become a partisan either of labor or management absolutely, and one certainly cannot become a partisan of one elected group of trade union officials because the next election may bring a change in leadership. The alterations could leave one tarnished by the tie to the old regime.

If a union leader offhandedly decided that he would rather not participate with a scholar or university acting as an advocate, he would be perfectly wise. There is a need to form a neutral relation that has to be supportive of the parties developed in a framework of mutuality and legitimacy. There is a tendency to be condescending toward unions, particularly on the part of universities. Let me again return to a particular experience. The head of a unit wanted to develop a labor-management committee. He chose the person to represent labor; I argued that this was unacceptable. Simply put, trade unions are institutions which are very hierarchical, that have their own procedures and processes for determining who represents labor. No outside group, to assure what it wants, can choose labor's representatives. The unions want to discover whether you are using them or whether you are really going to be open to their needs and interests. To be open, though, does not mean that one must concede to all that they want, for certainly, they will be demanding. The outsider has to accept the legitimacy of their proper positions and work with them.

In many ways management is even harder to deal with than trade unions. Joint efforts within an industry always have the shroud of anti-trust above them. Action to lower costs via worker's compensation that affects one firm can give a competitive advantage, and a state university in particular should be neutral. The variants in expertise, interest and authority even within an industry make working with firms very difficult. The problem is exacerbated across industries, such as regional industrial bodies. The mainstay of chambers of commerce tends to be those sectors which have the lowest industrial relations experience (banking, real estate, retailing, wholesaling, and services). The issue is less clear in transportation and public utilities. Both the level of sophistication and the anti- to neutral trade union spirit make any joint action among employers difficult. On top of this is a fear of litigation on the part of employers. Their attorneys and their insurance carriers tend to make the occupational health and safety waters particularly turgid. One needs to develop rapport with management as well as with labor.

The Industrial Relations and Labor Studies Center at Maryland works on two levels: on one level we are training unionists to be adversaries—adversaries with respect to management, to the government, and to the University. In doing that, we have representatives not only of the AFL-CIO and all of its regional councils, but of every major sector in the economy, both public and private. We have non-affiliated unions, and we have groups which are not quite sure whether or not they are unions. We also have management, and that too is an adversary group. We are training management people in how to deal with unions. A lot of employers do not know what to do with unions or with their own employees, and this causes problems in direct collective bargaining and in operational grievance procedures, as well as in the area of health.

On top of the Center's pyramid, there is an Executive Advisory Committee made up, for instance, of the Maryland State & Washington, D.C., AFL-CIO presidents as well as representatives of the United Auto Workers. Because of our location, near Washington, national figures such as J.C. Turner, President of the Operating Engineers; Dr. Rudy Oswald, Director of the Research Department of the AFL-CIO; Jerry Wurf, President of the American Federation of State, County and Municipal Employees; and the President of the Rubber Manufacturers' Association are on the Committee. The individuals in that group have to step back from their own adversary positions and consider the long run professional interests of what is the essential consensual relationship between labor and management in this country. In fact, the consensual relationship suggests that each of the two sides should accept the legitimacy of the other. The unions are not out to overturn the system and management is not out to break the backs of unions. If you eliminate that consensual foundation, university activities in this policy field are in perilous waters. As suggested above, labor and management issues cannot be segmented from the whole employer–employee realtionship. It can be put aside for particular attention, but it takes a great deal of work and openness. For the university it means linkages to the outside world and the ability to tie together inside resources in an effort that does not force anyone to weigh anchor from their own political, economic or intellectual moorings.

A POSITION PAPER:
CORE PROGRAM REQUIREMENTS

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It is generally accepted that educational preparation is only one of many factors that influence professional performance. Additionally, curriculum design is only one of many factors that determine the adequacy of educational preparation. Nonetheless, there are those who hold that improper curricula design can so detract from educational preparation and handicap professional performance that only the most fortuitous combinations of other factors can compensate for it. The justification for accreditation in certain professional disciplines is based upon this very precept.

Arguing that the safety profession should be without guidelines for curriculums designed to prepare occupational safety professionals is to argue that, "almost any preparation will do." Both the performance requirements imposed by employers on safety professionals today and the persistent efforts of professional and governmental groups to establish and upgrade competencies of safety professionals strongly suggest that not just "any" preparation will do. The issue therefore seems to be not if guidelines are needed but what guidelines are needed and the degree of flexibility that is most desirable.

Any discussion of programs to educate professionals has to start with a consideration of the functions performed by those professionals and the competence with which these functions must be performed. The Scope and Functions of the Professional Safety Position developed and adopted by the American Society of Safety Engineers in 1966[1] is still the most authoritative statement to have been developed in this regard. A brief excerpt follows in order to put the remaining discussion in some perspective.

The functions of the position are described as they may be applied in principle to the safety professional in any activity. The major functions of the safety professional are contained within four basic areas. However, application of all or some of the functions listed below will depend upon the nature and scope of the existing accident problems and the type of activity with which he is concerned. The major areas are:

A. Identification and appraisal of accident and loss producing conditions and practices and evaluation of the severity of the accident problem.

B. Development of accident prevention and loss control methods, procedures and programs.

C. Communication of accident and loss control information to those directly involved.

D. Measurement and evaluation of the effectiveness of the accident and loss control system and the modifications needed to achieve optimum results.

My personal assessment based upon internship studies involving approximately 170 organizations and feedback from over 100 graduates is that present occupational safety professional positions still closely correspond with the above functional description. The absence of any explicit design function is significant in that while it still may be quite desirable to have the safety professional educationally prepared in an accredited engineering program, it removes the absolute requisite to do so.

Our natural temptations to redefine these functions in terms of what we believe they ought to include should be tempered with an appreciation for the gradual processes of organizational change. Likewise, a pragmatic analysis for curricular design is based upon the realization that professionals hired in the foreseeable future are likely to be selected based upon the current needs of existing positions.

Caution should also be used before exempting from this discussion the functions performed by safety professionals in the insurance industry. As long as loss control specialists in insurance can move laterally to safety positions in other industries, it will be necessary to include them in this scenario (although it may be wise to consider any additional preparational needs of these professionals).

Sufficient technical functions and management functions are implicit in the Scope and Function statement above to preclude the possibility that the necessary educational preparation could be either solely engineering or solely managerial. We will therefore operate from the premise that traditional arguments that safety professionals be prepared only in management specialties or only in engineering fundamentals are both substantially lacking in merit.

As a starting point please consider the baccalaureate program. Graduates from these programs in technology - intense disciplines are often classified as "professionals-in-training." Such a designation implies the presence of the educational foundation needed to carry out the professional functions but not the maturity, the competence in application, nor the skill in solving unique problems. Full professional status can come from graduate study or experience of a specific scope and quality, however a proper educational foundation is always a prerequisite and this is achieved in the baccalaureate program.

In the absence of research correlating academic preparation and professional (on-the-job) performance we are forced to rely on empirical evidence for general guidance in curricula design. Though less than ideal, it is nonetheless a useful beginning in what has to be recognized as a trial and error process. This paper will take the position that a sound academic foundation in occupational safety requires a curriculum with certain general but readily identifiable course groupings. These are given in Table I.

Table I

ACADEMIC PREPARATION IN OCCUPATIONAL SAFETY

	Course Grouping	**Suggested Range of Intensity**
I	Hazard recognition, evaluation and control	24–30 Semester Hours (or the equivalent)
II	Natural Science	20–28 Semester Hours
III	Mathematics	11–14 Semester Hours
IV	Communications*	9–12 Semester Hours
V	Social Sciences	15–18 Semester Hours
VI	Organizational Management	12–15 Semester Hours
VII	Industrial Processes and Technology**	6–9 Semester Hours
VIII	Field Studies	6–12 Semester Hours

* Includes oral and written (literature, composition, etc.)
** Includes computer studies

With the Group I courses we are suggesting not only that hazard recognition, evaluation, and control are nucleus functions around which all professional safety positions are created but that this is the unique body of knowledge that the safety profession can claim as its own to distinguish itself from other professions such as management, engineering, natural sciences, etc. If the safety professional lacks expertise in hazard recognition, evaluation and control, it becomes extremely questionable whether or not he/she can effectively perform any of the aforementioned functions. The specific hazards to be covered should include the full occupational gamut. Safety, health and fire/explosion hazards are suggested logical subgroupings.[2] Ergonomics and system safety analysis provide important and unique methodologies for hazard recognition, evaluation and control therefore they should be well represented within this grouping.

The nature of the Group I courses is certainly technical and will undoubtedly involve the introduction and application of many engineering principles. This makes Group II, III, and VII courses necessary as prerequisites for a fuller understanding of the theory underlying the principles covered in Group I. Since the ultimate objective in hazard control is to effect change within the process and/or the organization it is essential that the safety professional receive preparation in communication, social sciences, and organizational management. These are listed as Groups IV, V, and VI.

In an evolving discipline such as safety it is vital that the student have an opportunity to apply (not just to observe) the principles and techniques learned in the classroom to existing situations in the actual workplace. Group VIII represents internship or other similar coursework which is considered mandatory in most health related disciplines and which has been found to be extremely valuable in the preparation of safety professionals at the baccalaureate level.[3]

These suggested guidelines attempt to include coursework which is regarded as essential; they also leave enough flexibility to orient the program in directions which will meet the needs of certain industrial sectors while utilizing available faculty resources. The specific courses designed within each grouping will establish the emphasis or "flavor" of the program.

At the Associate Degree level the usual objective is to provide a preparation for a person who will be performing technician-type functions. Such a preparation is frequently rich in the technical areas with as much supporting coursework as can be included in a four semester program. The same general course groupings shown in Table I apply with reduced intensity in many instances.

Here we suggest identical intensity (24-30 semester hours) for Group I courses; about one-half the intensity for Group II, III, VII, and VIII courses and about one-third the intensity for Group IV, V, and VI courses. This preparation would emphasize the technical area, deemphasize the areas important to the professional who has to effect process/organizational change, and still attempt to provide essential prerequisites but with reduced coverage.

Graduate programs are of course designed to impart a deeper more intensive preparation in a very specific academic area so as to develop advanced intellectual abilities and skills needed for research/teaching. Graduate work normally builds upon the strong foundation created at the baccalaureate level; admission requirements are therefore essential to insure that the academic foundation is in fact sound and compatible with the anticipated graduate coursework.

Faculty often tailor the graduate program to fit the preparational needs of each individual student, giving each the orientation necessary to meet his/her educational objectives. Specialties such as industrial hygiene, industrial engineering, fire protection, management, and ergonomics are some that would be compatible with an undergraduate preparation in occupational safety. Guidelines already exist in many of these specialties and the need for program flexibility is at a maximum at this level; the need for additional guidelines therefore seems minimal. It does appear advisable, however, for students seeking professional status via the advanced degree to have at least one course in Risk Determination. It is a matter of growing importance that individuals at a policy-making level have some familiarity with the qualitative and quantitative methodologies which can be used to estimate the levels of risk accompanying the presence of a particular hazard.

In summary, it has been the purpose of this paper (for purposes only of discussion) to suggest some educational program requirements which should exist to help promote acceptable competencies among graduates at all program levels. How these requirements would be set or upheld is an entirely separate issue but one certainly worthy of contemplation and discussion.

REFERENCES

(1) "Scope and Functions of the Professional Safety Position," ASSE Journal, December 1966, pp. 4–7.

(2) McClay, R.E., "Professionalizing the Safety Function," Personnel Journal, February 1977, pp. 72–77.

(3) Lauda, Robert J., "Safety Management Internships," Proceedings of the College and Safety Educator's Association, 3rd Annual Conference, West Virginia University, Morgantown, West Virginia, August 10–12, 1977.

Other Important Sources

(1) Suggested Curricula for Industrial Hygienists and Safety Professionals, Technical Report XI, Texas A & M University, NIOSH, May 1977.

(2) A Suggested Curriculum for the Occupational Health and Safety Technician, Technical Report VII, Texas A & M University, NIOSH, May 1977.

(3) Curriculum Guide for Occupational Safety and Health Technicians, California Community Colleges, Sacramento, California, 1977.

(4) Curriculum Guide for a Bachelor of Science Degree in Occupational Safety, ASSE, Park Ridge, Illinois, (undated).

(5) Guidelines for Accreditation of Degree Programs in Safety, ASSE, Park Ridge, Illinois, January 1980.

SUMMARY OF DISCUSSION FOLLOWING THE PRESENTATION

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While there were numerous questions and considerable discussion following this presentation, it was difficult to determine if there were any serious reservations about the principle of core requirements for academic programs in Occupational Safety. No one questioned the need for such requirements but two questions were raised about the balance suggested between technical and managerial course work.

1. One question asked if the need for some management courses at the undergraduate level is based upon the perception of the entry-level Occupational Safety Specialist as a decision maker (with corresponding authority and responsibility for "managership")? The answer given was, "No". The Occupational Safety Specialist has a consultive relationship with the management but nonetheless performs many management and management-related functions (planning, coordinating, communicating, organizing, controlling, etc.). Indeed the establishment and administration of a loss control program at the plant level involves primarily management functions. Conversely in the role of technical advisor to line management on the hazards (their recognition, evaluation and control) the Occupational Safety Specialist must possess strong technical competencies, thus there is a need for a balance in preparatory course work. Another commentator added the point that the advancement and mobility of the Occupational Safety Specialist will undoubtedly be enhanced by a strong foundation in the management sciences. Also it could be added that an understanding of management can help one work directly with managers and an understanding of technical matters helps one work directly with engineers; it has long been recognized that occupational safety professionals have to work extensively with both groups.

2. In reviewing designs and technical approaches, doesn't the Occupational Safety Specialist need to have significant design skills? Other discussion participants thought not. It is obvious though that his/her knowledge of hazard control principles must extend far beyond a simple understanding of standards if he/she is to be effective. The Occupational Safety Specialist will need a full array of hazard recognition, evaluation and control skills (including system safety analysis and ergonomics) to prevent incipient hazards from being included in new system designs. There is nothing, however, inherent in the nature of the design review process which casts the Occupational Safety Specialist in an exclusive role of either manager or engineer. Indeed, being a little bit of both can be quite helpful.

Two separate questions were asked on the subject of students who progress either from associate degree programs to undergraduate programs or from baccalaureate programs into graduate programs.

1. Do schools which offer undergraduate degrees in occupational safety accept credits earned in safety, health and fire protection at two (2) year schools? Individual policy differences between four (4) year schools seem to be significant with regard to credit transfer but IUP has done so in the past and probably will continue to do so in the future. Associate Degree Program Administrators need to do more missionary work with the four (4) year schools whose institutions' policies allow the acceptance of such credits. Perhaps the NIOSH Directory of occupational safety programs could in the future include entry requirements and policies on the transfer of credits.

   Another commentator stated that time requirements in the two (2) year program permits the teaching only of the math and natural sciences needed for understanding the technical course work (Group I). He implied that a full understanding of foundational concepts in natural science and mathematics is usually not achieved. This seems to be a valuable point for faculty in the undergraduate program to consider when working with 2 year program transfers.

2. Graduates from baccalaureate programs in occupational safety meeting the recommended core guidelines may wish to enter Graduate School. What would be their prospects? Based upon our experience at IUP, I would say that a good technical foundation (understanding of hazard recognition, evaluation and control principles) should adequately prepare such individuals for graduate study in Industrial Hygiene, Ergonomics, Safety or Industrial Engineering, Fire Protection or Business Administration. It should be pointed out that traditionally the Schools of Public Health have preferred to accept Biology and Chemistry majors and also Chemical Engineers (none of these with any foundational course work in hazard recognition, evaluation and control) into Industrial Hygiene graduate programs. A reevaluation of these traditional practices in light of present-day realities seems very much in order.

Perhaps the most important issue was raised by the moderator (Dr. Stevens) at the conclusion of the presentation. If occupational safety educators are among the leading authorities in this field, why shouldn't they advise industrial management on the proper educational preparation of safety practitioners and the functions which they are hired to perform? The answer is that they should and have (Refs 2, 6, 7 and 8 are listed as typical examples) but this type of consultation has not borne much fruit in the past and it may be unwise to presume that it will in the future. It might be worthwhile to suggest some reasons for this here:

1. Safety educators have not spoken with one voice on the subject of educational preparation for occupational safety professions. Hence industry has failed to get a clear indication that changes are needed in the traditional preparation and functions of this specialist. If NIOSH can bring a consensus among educators on points where substantial agreement now exists, perhaps we can begin to give clear and consistent advice to industry.

2. The voices of individual educators have been drowned out by the practices and policies of the professional safety organizations and societies. It is notable that <u>not one</u> professional organization for safety practitioners now has membership requirements which specify a particular educational preparation for entry-level professionals. Worse yet, no undergraduate course work in safety is presently required for certification as a Safety Professional; only Physics, Chemistry and Math through Calculus are required undergraduate courses for CSP applicants. Until the BCSP, the ASSE, and other prominent safety organizations give some official recognition to hazard identification, evaluation and control as the body of knowledge over which the Safety Professional must have mastery, the efforts of individual educators and researchers will continue to lack effect. Industrial managers correctly reason that if the largest and most prominent professional safety organizations don't know what educational preparation Safety Professional should have, then who does? And if a particular educational preparation is superior to others, then surely these professional societies and organizations (like those in other fields) would require all new professional members to have this or something equivalent to it.

ADDITIONAL REFERENCES

(6) "Preparing for the Occupational Safety and Health Profession", R.E. McClay, <u>National Safety Congress Transactions</u> Vol II, National Safety Council, Chicago, 1977.

(7) "University Education for the Safety Professional", W.E. Tarrants, presented at a meeting of the System Safety Society, Washington, D.C., April 15, 1971.

(8) "Safety Management Curricula for the Future", Ted S. Ferry, <u>Journal of Safety Research</u>, Vol 9, No. 2, June 1977.

SAFETY FACULTY REQUIREMENTS

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INTRODUCTION

A discussion of the faculty attributes required to implement safety curricula can be as open-ended as current programs, curricula, and institutions are diverse. The location, composition, and "flavor" of existing safety programs are all strong determinants in defining the boundaries into which an individual faculty member's strengths and weaknesses are interposed. As the boundaries of the safety discipline itself become more precisely defined, the education and experience requirements for the faculty body involved in developing and directing that discipline will gain some much needed clarity. In the meantime, the present discussion will briefly address some of the existing program differences which complicate the formulation of an idealized list of safety faculty requirements. It will then examine such an ideal list from the perspective of the safety program, the institution in which it is housed, and the individual faculty member.

GOALS AND DIFFERENCES OF SAFETY PROGRAMS

The raison d'etre for academic programs devoted to safety is two-fold. The education and output of a professional body of safety practitioners is of prime importance and has the most direct and immediate impact on the safety and health status of American working men and women. A second mission is the advancement of the knowledge base from which field professionals operate. Such knowledge advances have historically been dependent upon a high degree of involvement and commitment on the part of the academic community.

Teaching and research have not been consistent bed fellows in safety programs around the country. Past emphasis seems to have been placed on infusing programs and curricula with an experience-based body of knowledge. Such an emphasis has demonstrated success in graduating practitioners well versed in applying proven technologies to current problems, but may leave the safety discipline as a whole vulnerable to stagnation in the face of exploding technology.

The requirements imposed on a faculty involved solely in teaching future professionals the existing body knowledge in safety are quite separate from those associated with trying to conduct the research needed to expand the boundaries of that body knowledge. The institutional parameters which define the settings for the different endeavors also contribute to substantial differences in faculty requirements.

IDEAL ATTRIBUTES OF A SAFETY FACULTY

The range of knowledge incorporated within the scope of the safety profession is broad indeed. The effectiveness with which that body knowledge is passed along to safety students in academia, or drawn together to synthesize new directions through research, is a function of the accumulated talents, interests, and experience embodied in any safety faculty. Don Chaffin of the University of Michigan is involved in on-site evaluation of a number of the NIOSH Educational Resource Centers. In that capacity, Chaffin has formulated the following shopping list defining his ideal faculty body to conduct a safety program devoted to both teaching and research. The list draws a distinction between a teaching and research emphasis, and refers to a faculty body instead of to a singular, superhuman academician.

1. A common requirement for faculty members involved in teaching and/or research is a base of real experience in occupational safety and health problem solving in the field.

2. Faculty members primarily involved in research should possess:

   A. An inquisitive and disciplined mind to go beyond simple solutions.

   B. Statistical or epidemiological competencies.

   C. Access to systems modeling to turn sloppy data into descriptive models and to formulate prescriptive models to be tried out in the real world.

   D. A concern for methodologies that have been applied in the social, biomedical, and engineering sciences.

3. Further requirements that apply to both teaching and research faculty include:

   A. Knowledge of costing and analysis methods applicable to health and safety.

B. Understanding of fundamental industrial hygiene methodologies.

C. Appreciation of the importance of communication methods and skills.

4. Additional sets of knowledge that need to be incorporated in the safety faculty body include:

   A. Injury and illness data.

   B. Standards and guidelines (and sources thereof).

   C. Manufacturing process technology

   D. Administrative law.

   E. Personal and industrial psychology.

   F. Toxicological information.

   G. Work physiology.

   H. Biomechanics and anthropometrics.

   I. Traditional human factors information.

   J. Fire and explosion principles.

   K. Organization structure and function.

   L. Occupational medicine practices and procedures.

INSTITUTIONAL REQUIREMENTS

The faculty requirements that are generated by the safety program must interface with requirements specified by the institution housing the particular safety program. Such institutional requirements often tend to be rather traditional in nature and have been reviewed by Charles Billings of Johns Hopkins University.

The traditional function of the university has been to increase and disseminate the collective knowledge of mankind. Contemporary terms such as "grantsmanship" and "publish or perish" attest to the fact that major universities everywhere are keenly aware of the sequence contained in the above functional description. Research dollars are a common barometer of university prestige and funding, and have a large impact on the definition of the environment in which safety programs and faculty exist.

Traditional job descriptions for university faculty include teaching, research, and service. An ideal distribution of effort on the part of a faculty body is generally considered to have 40% of the resource devoted to teaching, 40% to research, and 20% to service to the institutional, professional, and national communities.

An actual job description for a safety faculty member at Johns Hopkins includes the following requirements:

1. Must have a doctorate in engineering since the faculty opening is in an engineering department.

2. Teaching load will be shared with department faculty, so course load may require traditional engineering as well as safety courses.

3. Must take primary responsibility for the core safety program within the department.

4. Must do research since salary ultimately comes from research.

5. Experience desirable but not required.

PERSONAL REQUIREMENTS

From our current perspective regarding safety curricula and resultant faculty requirements, quite a bit seems to be lost between statements of idealized requirements and the reality that exists in many safety programs. The broad range of knowledge encompassed by the safety discipline is often embodied by one of two, or at most a few, faculty members directly involved in any program of safety education. Programs and faculty members must often fit into a departmental structure where safety education is not the primary objective towards which departmental resources are allocated. That structure dictates a number of requirements and defines the rules by which programs and faculty are evaluated and advanced.

Several factors combine to form national constraints on safety faculty. Imprecise definition of the safety discipline and all that it entails has not enhanced the national safety faculty body. A second constraint has been a glaring lack of graduate programs aimed at establishing and replenishing a well-recognized faculty body around which the safety discipline could evolve. Given the lack of doctoral programs in safety, faculty members educated in more traditional areas have approached safety from a niche somewhere along the broad spectrum that defines the safety discipline. Advances are consequently measured more in terms of individual thrusts than as an orchestrated movement along the broad front.

The question of degree versus experience has raised an additional constraining factor in many faculty selection processes. An experience base fostered in real safety and health problem solving is deemed an essential faculty requirement in many circles. The ability to credibly teach current techniques of hazard recognition and control is certainly limited by a lack of actual application of those same techniques. On the other hand, actual experience beyond the academic setting is gained either in conjunction with a practicing safety professional or through a more independent trial and error approach. Both methods of experience acquisition can provide valuable insight but are ultimately constrained by the occupational setting and personnel from which they are derived. Faculty experience level requirements are primarily defined by the amount of problem solving methodology versus problem solution that their graduates are expected to acquire.

SUMMARY

The national safety faculty body must educate safety practitioners to deliver safety and health programs to the occupational population of America. It must also conduct a major portion of the research needed to expand the knowledge base from which those practitioners operate.

The continuing evolution of the safety discipline will more precisely define the broad array of characteristics that need to be incorporated in safety faculty committed to education and research. The national safety faculty body is currently constrained by imprecise definition of the safety discipline, a lack of graduate programs dedicated to producing safety faculty members, institutional requirements that are often targeted at other than safety programs, and a current inability to couple strong work experience with research credentials and capabilities in prospective additions to the national safety faculty body.

FACULTY REQUIREMENTS: UNIVERSITY EXPECTATIONS

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INTRODUCTION

Dr. Crutchfield has indicated to you that this working group has divided the subject of Safety faculty requirements into three separate topics: required characteristics of the Safety faculty members; institutional expectations from the Safety faculty; and Safety Program requirements from its faculty members. Dr. Chaffin has just provided us with a menu of about two dozen desirable characteristics that safety faculty members should have in order to make meaningful contributions to control of industrial accidental injuries. Professor Freeman will present safety program requirements from the faculty point of view.

The purpose of this presentation is to outline the institution's expectations with respect to its Safety faculty members. Initially, we may define the function of the university as directed to the increase and dissemination of knowledge. The order is significant, as Professor Chaffin has indicated, depending upon the objectives of individual institutions, whether primarily teaching or primarily research. Johns Hopkins University is primarily a research institution with a distinguished faculty whose principal criteria for acceptability for appointments is research productivity as measured by publication in scholarly journals, books, etc.

UNIVERSITY EXPECTATIONS OF THE FACULTY

An overall job description for the functions of faculty will include teaching, research and service, divided approximately into 40%, 40%, and 20%, respectively (at research institutions). Specific requirements for appointment to safety faculty include:

- An earned doctorate, Ph.D., Sc.D., Dr.P.H., Dr. Eng., as evidence of ability and interest in research;
- An engineering degree, typically in mechanical, chemical, civil, industrial, or environmental engineering; and
- "experience" in the safety field (more on this below).

In addition to these general requirements, the separate institutional components (university, school, department, division, center, or program) will have their own specific requirements to support educational objectives of each component. For example, faculty members will normally be expected to share the teaching load for several courses in general departmental or divisional offerings.

The safety program will require a set of safety courses designed for a variety of objectives such as (1) education, training and experience for general industrial practice of the safety profession, (2) specifically oriented education, as, for example, fire protection, ergonomics, or other institutional competency areas, and (3) program elements appropriate for national safety program accreditation. Since accreditation of academic safety programs is still some little way in the future, we at the Johns Hopkins ERC are using a curriculum model provided to us by Dr. Clapp and Dr. Walters (Appendix One). (Additional information on our program offerings is also presented below.)

RESEARCH

The principal function of faculty in a research-oriented institution is the development of new knowledge or increase of its use in technical applications. One finds pure science departments primarily concerned with fundamental knowledge and applied science and technology-oriented departments primarily concerned with application of knowledge to practical uses. Safety research is of the second type. New fields of technology are developed, frequently interdisciplinary in scope, by application of fundamental knowledge from two or more fields to a third (as for example, human factors engineering from psychology, behavioral science, physiology, biomechanics, engineering, etc.). The purpose of research is at least two-fold: (1) development of knowledge and (2) generation of faculty and student support and resources. The location of the safety faculty affects its ability to acquire institutional resources and external support. Biomedical sciences and public health have had a fairly dynamic parallel growth in the past 30 years based primarily on applications of fundamental health and engineering sciences to public health problems, diseases, and conditions. In many cases, the fundamental sciences may not be in the same department or school, and this is particularly true in public health schools, which have few or no fundamental science departments. Research in safety will be problem, industry, and field-oriented as well as having related laboratory disciplines in-house. Safety research and teaching are viewed as engineering-oriented and appear in engineering schools (e.g., Michigan, Texas A&M) with certain notable exceptions in Public Health (e.g., Ross McFarland at HSPH).

SERVICE

The service functions of faculty responsibility can be divided into two major parts: (1) service on committees, panels, boards, or as a special consultant or officer of government, or as lecturer on special topics, and (2) the private practice of consulting. Government service activities are seen by the institution as providing for agency interactions (e.g., NIOSH, OSHA, NIEHS, EPA, NAS, state, city, etc.). Consulting activities are used as opportunities to develop awareness of new field problems and to define areas for needed research by students and faculty. As was mentioned above, one of the desirable characteristics of a safety faculty member is experience. This is usually obtained by consulting engineering activities, and the curricula vitae of developed faculty are reviewed for productivity in this area. Young faculty are encouraged and assisted to develop consulting opportunities. Perhaps needless to say, both consulting and government service activities also involve students in research and provide opportunities for publications.

PRESENT SAFETY PROGRAM AT JHU ERC

Program Objective

The present safety program at JHU ERC is a major component of a combined curriculum for the professional practice degree of Master of Health Science in Occupational Safety and Health. Courses offered in safety outlined below are taken by all industrial hygiene and safety students, as well as selected students from related programs in occupational medicine, occupational health nursing, occupational health education, and other departments or programs in the school (e.g., Occupational Epidemiology program; Health Education, Health Services Administration Department; etc.). Practitioners in industrial hygiene will have an adequate introductory background in occupational safety principles, applications, management and law to function effectively with a developed safety group. Present plans are to continue to expand didactic offerings in safety and opportunities for graduate student research in safety. Plans for a complete Safety Specialist MHS degree program are critically dependent on faculty recruitment efforts, which are now in progress.

Educational Program

Specific safety courses include:

- Principles of Occupational Safety – M. Corn, R. Reilly (Corporate Safety Director, ALCAN), A. Blackman, Consultant

- Management of Safety and Health Programs – R. Reilly, M. Corn

- Safety and Health in Biomedical Institutions – B. Tepper, H. O'Toole

- Issues in Injury Control – S. Baker

- Epidemiology of Injuries – S. Baker

- Occupational Hearing Loss and Noise Control – H. Shimizu, P. Michael, G. Bienvenue

- Occupational Safety and Health Law – Gary Nothstein, Labor Lawyer, Venable, Baetjer and Howard, Inc., Baltimore, MD, and M. Corn.

Research Program

A safety research program is being initiated. It will involve student and faculty from several disciplines in the field of respiratory protective devices. Technical aspects of respirator construction and use will be investigated by students and faculty of the Division of EH Engineering; aspects of respirator use on individuals with respiratory impairment, and objective criteria for medical recommendation of respirator use will be developed by faculty and students of the Division of Environmental Physiology (user qualification for respirator assessment, and physiological assessment of use); new and improved testing methods for institution in vivo tests on respirator performance in use on chemical gases, vapors and particulates will be developed in conjection with faculty and students in the Environmental Chemistry Division; behavioral aspects of respirator acceptance will be investigated by faculty and students of the Department of Behavioral Sciences. Space facilities have been arranged and mechanisms for support are under discussion.

Internship Program

Selected students, particularly those without industrial experience, will be placed in three month internships with local industries. This aspect of the program started with the summer of 1978 (six internships) and will be expanded in 1981. The student and preceptor response to the program has been very favorable.

SUGGESTED ELEMENTS FOR OCCUPATIONAL SAFETY CURRICULA

I. Principles of Industrial Safety

Introduction to Occupational Safety and Health
Accident Causation Models (Historical, Energy Transfer, Psychological, Stress, etc.)
Injury Sources and Causes
Hazard Recognition (Inspections, Investigations, Monitoring, Sampling)
Trauma Related Exposures
Safeguarding Mechanical Hazards (Types, Limitation, Designs, etc.)
Electrical Hazards
Plant Housekeeping
Hand Tools/Power Tools
Walking/Working Surfaces
Plant Layout and Arrangement
Appraising Safety Performance

II. Safety Management and Organization

Safety Organization and Structure
Loss Control Principles
Workman's Compensation Laws
Theories of Management
Staffing, Budgeting, Decision Making, Bargaining
Worker Selection and Training
Safety Program Evaluation (Records, Reports, Objectives)
Training Principles (Methods, Strategies, Incentives)
Personnel Administration (Human/Industrial Relations)
Techniques of Gaining Acceptance of Safety Programs
Business Information Systems

III. Principles of Fire Protection and Control

Theory of Combustion
Characteristics of Flammables/Explosives
Facility Design for Control of Fire and Explosion
Methods of Control (Extinguisher, Sprinklers, etc.)
Insurance Programs and Costs

IV. System Safety Analysis

Principles of Systems
Fundamental Probability, Quality Control/Reliability Theory
Preliminary Hazard Analysis/Job Safety Analysis
Failure Modes and Effects
Fault Tree
MORT
Statistical Analysis and Accident Data
Economic Analysis Techniques

V. Manufacturing Methods, Processes, and Properties of Materials

Characteristics of Forces (Tension, Torsion, Compression, etc.)
Manufacturing Processes (Welding, Spraying, Dipping, Plating, Painting, Drilling, Machining, etc.)
Facilities Maintenance and Operations (Pressure Vessels, Disposal, Equipment Maintenance, Emergency Procedures, etc.)
Industries and Manufacturing Methods (Petroleum, Chemical, Assembly, Forging, etc.)

VI. Legal Aspects of Safety and Health

History and Development of Safety Legislation
Employee Safety Laws (OSHA, State Laws)
Vehicle Safety Laws (Motor Carrier, Railroad Commission)
Product Safety Regulations (Consumer Product Safety Act, Treasury Laws, etc.)
Standards (ANSI, NFPA, ACGIH, ASTM)

VII. Ergonomics/Human Factors/Workplace Design

Man-Machine Interface
Job Design
Workplace Design
Human Behavior Characteristics
Stress
Materials Handling (Manual, Mechanical, Warehousing, etc.)

VIII. Fundamentals of Industrial Hygiene

Categories of Hazard Exposures (Air, Water, Chemical, Biological)
Toxic Substances (Effects, Routes of Entry, Properties)
Gases, Vapors, Dusts, Particulates
Sampling, Measuring, Evaluating Airborne Contaminants (Types of Instruments, Calibration, etc.), Industrial Hygiene Surveys
Noise and Vibration

VIII. Fundamentals of Industrial Hygiene (Continued)

Radiation (Principles, Measurements, Controls)
Health and Safety Standards
Anatomy and Physiology
Toxic Substances/Chemical Hazards
Industrial Diseases
Setting Up Industrial Hygiene Programs

IX. Health and Safety Control Strategies

Ventilation Analysis and Design
Basic Life Support (First Aid, Disaster Planning)
Personal Protective Equipment and Devices (Respirator, Clothing, Eye Protection, etc.)

X. Other Appropriate Topical Areas

Epidemiology
Biostatistics
Toxicology
Physiology
Cost Accounting
Management
Industrial Psychology
Technical Writing/Oral Communication
Radiological Health
Bioengineering
Environmental Medicine
Field Internship

CONSTRAINTS TO DEVELOPING CURRICULA AND ADMINISTERING PROGRAMS IN OCCUPATIONAL SAFETY

Robert J. Firenze
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> As the correct solution of any problem depends primarily on a true understanding of what the problem really is, and wherein lies its difficulty, we may profitably pause upon the threshold of our subject to consider first, in a more general way, its real nature; the causes which impede sound practice; the conditions on which success or failure depends; the directions in which error is most to be feared. Thus we shall more fully attain that great prerequisite for success in any work—a clear mental perspective, saving us from confusing the obvious with the important, and the obscure and remote with the unimportant.[1]

Wellington's perspective on problem solving lends itself to the assessment of any program and sets a realistic tone for the task to be accomplished during this symposium—determining the causes which interfere with the development of occupational safety curricula and the administration of programs, the conditions which promote success and those which induce failure.

This paper is not intended to be an exhaustive dissertation on all problems related to developing occupational safety curricula and operating programs, nor does it suppose that all problem areas can be identified. Instead its purpose is to discuss the role of **constraints** to developing and expanding occupational safety curricula and degree programs. In this way those confronted with the task of designing programs can do so with their eyes wide open, knowing the problems with which they must contend.

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[1] Arthur Mellen Wellington in The Economic Theory of the Location of Railways (New York: John Wiley & Sons, 1877).

Your role as participants in this symposium is to examine the constraints discussed, add new ones, determine their impact on occupational safety degree programs, present your own perspectives, and, where possible, offer strategies to eliminate or effectively reduce the constraints which hinder the establishment of needed occupational safety curricula in colleges and universities throughout the United States. I am also asking you to take the one extra step which Wellington suggests—to trace the visible effects back to their not so easily perceived origins. In the backs of our minds, we must balance three questions: not only "What are the constraints?"—the present—but also "Why did these constraints arise?"—the past—and "How can they be removed and prevented from recurring?"—the future. This paper is a preliminary one. In its final form—as part of the symposium proceedings—it will include your comment and contributions.

INTRODUCTION

The OSHA Act gave NIOSH a mandate: to foster educational programs which would supply qualified personnel in the field of occupational safety and health. Motivated by the funds available and the demands for qualified occupational safety professionals, colleges and universities throughout the nation began expanding existing occupational safety degree programs and establishing new programs to satisfy the need. Perhaps the strongest impetus to the development of these programs has been individual curriculum development grants from NIOSH and, over the past four years, the establishment of the NIOSH-funded Educational Resource Centers (ERC) at twelve universities throughout the United States. Under a single grant for servicing a particular geographical area, Educational Resource Centers provide a mechanism for combining and expanding existing activities and for coordinating multidisciplinary and multilevel training and continuing education in occupational safety and health.

A cursory review of the occupational safety curricula developed in colleges and universities reveals that in many instances they have not attained the level of success considered possible. Success can be seen from two vantage points, internal and external. Those operating a program can judge it successful if it meets its program objectives. If it does what it sets out to do and therefore possesses internal consistency, it is successful. But this definition of success may not satisfy an outside observer, who believes the program objectives to be unrealistic or irrelevant. This external observer wants a program that produces professionals who are qualified to meet his occupational safety needs. He judges a program successful if its graduates can capably perform the tasks that need doing. Programs are being appraised at two levels, then: how well they meet internal objectives, and how well they satisfy the needs of labor, industry, and government.

Using these two ways of judging success as the basis for our definition, for the purpose of this symposium we will define a **constraint** as **a barrier to achieving program objectives (internal)** or **a barrier to preparing qualified individuals to meet the needs of industry and government (external).** Realistic appraisal of these constraints is a necessary prerequisite to establishing strategies to eliminate or work around them.

Overriding Issues of Concern in Curriculum Design

There are three perplexing issues facing a program designer: (1) determining appropriate curricular components; (2) establishing their relative importance; and (3) placing the program within the institutional structure.

Without common agreement on the disciplines necessary and the academic courses required to prepare a professional, programs are built on the basis of individual preference. An academic institution tends to concern itself with that aspect of occupational safety which corresponds to what the institution does best. Thus a new program is plugged in to existing expertise and to the philosophies on which present programs are based. If an institution's strength is its School of Education, its occupational safety program may stress instructional methodologies and curriculum development at the expense of health and technical areas. Placing a program in a School of Public Health or Medicine may mean sacrificing engineering and technical requirements and stressing clinical methods, epidemiological elements, and diagnostic principles.

It may be unrealistic to expect one occupational safety program to do everything. Nevertheless safety professionals are expected to share a certain broad base of knowledge. The American Society of Safety Engineers has offered its recommendations as to what courses should be included in a program leading to a B.S. degree in occupational safety. The Board of Certified Safety Professionals also has suggested a curriculum for a safety professional. Labor, industry, and government have certain needs which they expect occupational safety technicians and professionals to meet. However, a definitive study does not exist which specifies what those needs are or what preparation and skills are expected. Determining the relative importance of a curricular components requires an in-depth study of industry's safety and health needs and the academic community's ability to meet them. In the absence of such a study, it still is safe to say that industry requires a wide range of knowledge on the part of the graduate. The curriculum must be broad enough—effectively combining related disciplines—to enable the generalist to perform well under a variety of situations. At the same time the curriculum must be specific enough to provide the specialist with the highly technical expertise necessary to competently perform limited but critically important tasks.

The proper placement of the curriculum within the university structure is crucial. Whenever the options exist, this placement should be decided on the basis of program objectives. For instance, a curriculum with a technical/engineering orientation might best be situated in a School of Engineering or a discipline which has a demonstrated record of close interaction with a School of Engineering. A program designed to prepare the safety professional with the disciplines of management, organization, and behavioral science should be placed in a School of Business or as part of a multidisciplinary program which depends heavily on the Schools of Business or Psychology. In summary, the curriculum objectives determine the content and placement of the program. Content which does not relate to objectives is unacceptable. Forethought must be given to placing the curriculum within the milieu it needs for its survival. To isolate a program so that it cannot interact with related disciplines is to create problems and detract from program effectiveness.

The Cart Before the Horse

In designing a program where excellence is sought, before objectives are put in finished form and the criteria for evaluation established, program designers must take a hard look at the feasibility of the program operating successfully. Barriers must be identified and their impact on program success assessed. With knowledge of the obstacles to be overcome, program designers must employ carefully engineered strategies to hurdle the stumbling blocks. The more successful the strategies, the better the chance of the constraint being nullified and the program succeeding.

Identifying constraints is not an easy job. Unfortunately an experiential base of knowledge did not exist at the time many occupational safety programs were established. Many educators did the best they could to develop programs from their own perspectives with the materials and expertise available.

In retrospect, those who developed occupational safety curricula see two weaknesses:

1. They took little time to ferret out the existing and potential constraints to their program's mission. Hence, many problem areas which might have been successfully overcome at the onset now have become major impediments to meeting their program's short- and long-term objectives. An example would be placing a program in a department or school of a university which does not share its philosophy or is incapable of meeting program objectives.

2. Those constraints which were identified in the past but could not be countered are creating the problems anticipated. In many cases, the problems are worse than had been predicted. An example would be a program where there is no in-house expert familiar with industrial processes and operations and no money to hire such a person. The program may be producing theoreticians with views that those in the field find unrealistic.

This paper does not suggest that all constraints to occupational safety curricula can be identified during this symposium. But those who design occupational safety curricula and administer degree programs can derive considerable assistance from the combined experience and observation of those of you here today—the insights of those who give students their academic training and those within industry and government who utilize the skills of safety professionals. In the last century philosopher John Stuart Mill observed, "Knowledge insufficient for prediction may yet be valuable for guidance." We may not be fully aware of every constraint to the establishment and operation of occupational safety programs now and in the future. However, we have learned from the past. **Our task is to document the problems we have been able to identify, study the effect of such problems on the expected outcomes of occupational safety degree programming, and develop and recommend solutions to increase the effectiveness of these programs so that they will have a favorable impact on their target population, the nation's work force.**

Types of Constraints

I am going to list some stumbling blocks to the development of effective occupational safety curricula and the administration of undergraduate and graduate programs. This list is meant to stimulate your thinking. I will group constraints into three categories: institutional, program administration, and program operation. The examples in each category are for illustration only. They may be discussed individually, combined with others, discarded, or replaced by new ones.

A. Institutional

1. Inability to acquire the support of departments of schools within a college or university for the occupational safety program. Lack of interest of related disciplines—engineering, psychology, business, law, etc.—acts as a constraint to establishing interactive, multidisciplinary programs.

2. Geographical separation of schools within a given educational institution. Interactive educational experiences are limited because of problems in coordination and timing.

3. Mandated degree requirements which allow students little leeway to take elective courses in areas closely aligned with their professional career objectives.

4. Institutional funds not set aside for the continued development of the occupational safety program. Program directors and faculty hired on soft money from grants or contracts. In some instances, if grants were to stop, programs would either end or be drastically reduced in scope. Cutting back funds could mean a corresponding reduction in experienced faculty, perhaps resulting in the loss of the entire program.

5. Funding agencies establishing criteria. In some instances an institution ignores its own strong capabilities in order to concentrate its efforts on satisfying the requirements of the funding agency.

6. Inequity of salaries among faculty within a given academic institution. For example, in a School of Public Health, where occupational safety programs are often based, physicians and occupational medical personnel demand and receive higher salaries than the faculty in the occupational safety program regardless of achievement, degrees, and experience.

7. Entry level requirements of professors. The policy of educational institutions to hire only faculty with doctoral degrees is a major constraint. These people are as rare as hens' teeth. Those who do exist are often attracted to higher paying jobs in industry and government.

8. Hiring faculty who do not possess adequate understanding of industrial processes and an overall knowledge of the functions of the safety professional.

9. Promotion and tenure policies which review only accomplishments in research and publishing. Often faculty members who have undertaken a heavy administrative load during the establishment of the occupational safety degree program, precluding other scholarly activities, are either passed over for promotion or forced to resign because tenure was not approved.

B. Program Administration

1. Inability of the program director to identify and use faculty in related disciplines and to bring in qualified persons as adjunct faculty.

2. Placing an occupational safety program within a school which does not share or value the objectives of the program.

3. Making up a curriculum in occupational safety which lacks its own point of view but plugs in to courses already being offered in the educational institution without regard to their relevance or validity.

4. Allowing the occupational needs of local industry to shape the curricula and direction of the program.

5. Lack of criteria for evaluating the curriculum. Without criteria to ascertain the value of the academic program and its impact, efforts to determine program effectiveness become fruitless exercises.

6. Disproportionate ratio between students and instructors caused by limited number of instructors assigned to the occupational safety program. This situation is worsened if the institution is set on acquiring students without quota. It causes problems with student academic advising, general supervision, supervision of internship programs, and so forth. Students are not provided with the opportunity to work closely with the faculty and thus become familiar with the field of occupational safety.

7. Inability of the school in which the occupational safety program is based to conduct research. This situation could be a primary impediment to an effective program and the enhancement of the state of the art in occupational safety.

8. Failure of the institution to encourage continuous training of the faculty. Thus, instructors may be unable to provide current information on principles, theories, and methods developing in the field of occupational safety.

C. Program Operation

1. Insufficient instructional materials. Specifically missing: better texts on basic theory, case histories, and problem solving.

2. Occupational safety curricula which do not encourage student participation in courses offered by other schools or departments.

3. Graduate programs which produce technicans who have not been exposed to the theoretical and conceptual framework of disciplines associated with occupational safety. This situation may limit a graduate's professional growth or entry into a doctoral program.

4. Inability to motivate students to advance to doctoral programs. Masters level students in occupational safety see the challenges presented by industry but not those of higher education.

5. Inadequate field supervision of students during their internship period. Whether caused by limitations of faculty or funds, the results are the same: the quality of the field learning experience is jeopardized, and students cannot share their problems and questions with their instructors.

6. Difficulty in acquiring host organizations for meaningful internship course experiences. Unavailability because of the geographical location of the school or industry's lack of cooperation. "Wearing out" those organizations which are willing to participate.

The Best Offense is a Good Defense

Greater effectiveness may be achieved in the design, development, and operation of occupational safety and health curricula throughout the United States if precise information (1) defines the problem areas which adversely affect the development and operation of occupational safety curricula; and (2) suggests the action to eliminate or reduce the unfavorable impact of these constraints. The educational community, industry, and our nation's working men and women will reap the rewards of these results.

DIALOGUE: ACADEMIA AND RESEARCH

CONTINUING EDUCATION FOR PROFESSIONAL DEVELOPMENT

Herbert H. Jones
Central Missouri State University

During the last two days of this symposium, there has been much discussion of research in safety, getting this information out to the front line where it can be applied. There has been much discussion of keeping our university faculties informed of new developments so that we can keep our classes up to date, keep our curriculum up to date, even though we seem a long ways from any consensus as to what constitutes a curriculum in the safety area. There has been much discussion, I have heard it mentioned many times, that we need to be applying what we currently know about safety. That is, to those individuals who are out currently, I'll say on the "front line," in the safety profession. And then, of course, we have the other problem, we have those individuals, who, due, I'll say, to a decision in the "front office," learn that today they are the safety director, and that this has been added to many other activities which they have to carry out. Quite frequently, these individuals have little or no training in the area of safety. These all point toward needs for what I feel is continuing education. We are also working in a rapidly changing field. Again, much discussion on Wednesday, the feeling that our safety research is moving ahead rather slowly. Granted, we need much additional research, and I know, that the individual who is doing research full time feels that we are making advances very slowly. But for those outside of the research area trying to keep up with the changes, it is extremely difficult. We have materials published in a number of technical reports, a number of different journals. It has been pointed out that I don't follow human factors and ergonomic journals routinely. But we do have much material coming out that does need to be applied. Also, we find many new demands being placed on the safety professional. This is brought about by new standards being implemented, maybe more so in the health area than in the safety area. But quite frequently, it is up to our safety staff to implement these new standards. That is, maybe it is a health standard requiring environmental monitoring, and quite often this falls back to the safety personnel to carry out the requirements specified in the particular standard. I have, for a number of years, been teaching basic industrial hygiene to safety students. This has been due to the various demands placed on the safety professional and should be included in a safety curriculum. Quite frequently this is restricted to a three-semester hour course. I attempt in those three-semester hours or, say, forty-five lectures to alert the individuals going out in the safety area as to the potential hazards or provide them some technique for recognizing that they may have these potential hazards. I probably will attempt to prepare them for simple environmental evaluations and simple control techniques, hoping that they can at least take care of this portion. But also at the same time, I try to instill into them an ability to recognize their limitations. We have run into this problem, and I do find potential employers looking at this very frequently. The question I am asked frequently about a particular student is, does this student recognize his limitations, and will he go to ask for help? Employers feel that safety is a broad field and that no individual can have expertise in all areas. The current feeling with many employers seems to be that they would like to have some individual who is sharp, can recognize hazards and recognize his limitations, and will ask for help from someone else.

Also, we have another thing developing that brings pressure on us for continuing education, and that is requirements for maintaining certification or requirements in continuing education for maintaining licenses. This is already operational in the industrial hygiene field, where we have to accumulate the necessary points. Periodically you are evaluated by the board. You are all aware, of course, that the CSP has done much work in this area, gone through a two-year evaluation period, and, I might say, is kind of in a hold position. But I feel certain that it is going to move ahead and this will be a requirement soon. We have our requirements for continuing education becoming mandatory in a number of states for licensing. This is particularly true in the health professions and I would not be surprised if it moved over into the other areas. And I guess I have to say that I feel that there is a need for it. I know coming down here to Morgantown, thinking back to some 32 years ago, I took the first portion of the professional engineering examination. My area of specialty was civil engineering, supposedly some knowledge in the design of buildings, roads, structures, dams, this type of facility. I am still a professional engineer. I have paid my necessary dues, but I guess I have reservations; or there are certainly limitations as to what I can do as a professional engineer, according to the state. I have the authority to do many things in the area of civil engineering, but there have been no requirements for me to keep current in that field. I stayed in the strictly civil engineering field for about six months and then chose to go into industrial hygiene, where I have spent 31-1/2 years now. But I still carry a license as a civil engineer. So I feel that there is a need for these types of continual evaluations as to whether our certification or license really means what we would like for them to mean.

So we can see many different reasons for continuing education. The Educational Resource Centers, funded by NIOSH, are required to develop a continuing education program. In looking at continuing education, I have chosen to divide it into two general types of training, that is, short term training and what I classify as long term training. In our short term category, we have our short courses, symposiums, workshops, whatever title you want to give them. These vary considerably in content and in intensity. I can recall back two or three years ago, a series of four 8-hour sessions purporting to provide you with all the information you need to know about OSHA. Or I see them still, one day symposiums, all you need to know about safety. We can go from that extreme up to very specific courses, where we may spend several days on one limited area. For example, respirator training is a three to five day training course getting into much depth. So we have quite an assortment of training courses. It has been quite a change. I think I was involved in the first basic industrial hygiene training course put on by the NIOSH predecessor—two weeks' basic industrial hygiene offered one time per year, in the early 1950's—one of the first efforts in that area. We put on the training course in addition to our regularly assigned duties. The course was well attended, much in demand, has moved to the point now where I believe NIOSH and their training program will have basically a training course every week. Some of the other earlier specialized courses include the University of Michigan's industrial ventilation, which started some 26 to 28 years ago. That course has been repeated annually and comes up the middle week of February every year; attendance is restricted or limited to 250 students. That's also been picked up by a number of other universities. With the activities from the ERC, we seem to have ample short term training courses, as reflected in the fliers I received on short term courses just last week. Actually one week's mailing would cover many, many different courses. So we seem to have ample short term training courses. One problem is the current going rate, typically $100 per day plus travel expenses. So we can easily invest $1000 in one week's training. So it's an expensive way to provide continuing education. I notice some of the ERC's are changing methods of operation which may cut down some of the travel costs. I happen to be out in Missouri, there is no ERC in the NIOSH region. Supposedly our region is served by the group in Minnesota, and this year they are expanding their continuing education activities and are offering short courses in the Kansas City area. So for those in our immediate area, this will cut down appreciably on costs if we can take a short term training course and stay in our home town and not have to pay lodging and transportation.

Looking at the area of long term training, I think there are a number of possibilities. We have our academic programs and have a number of students who are taking these courses for credit on a part time basis. There are a number of students at CMSU that are doing this. I held an adjunct position at the University of Cincinnati for a number of years. That was standard practice. In fact, I had taken a number of courses on that basis. I think it provides very good training, and most employers will subsidize this or permit time off. I am a little amazed, sometimes, at how much effort an individual will place in rearranging schedules or whatever type of work, or what they will go through in order to attend regularly scheduled courses. I am thinking particularly of one student we had who worked the 11–7 shift in a wiremill at a steel company, would drive 60 miles after he got off at 7 o'clock in the morning, attend two or three classes and then get back home, and do his studying. And he did this for almost one year, in order to further his education.

Then we have our regular courses, which we can offer in the evenings or off campus. CMSU has carried this out in offering many courses in the St. Louis and Kansas City areas. There they saw fit to have the faculty member travel 50 miles, say into Kansas City, to do the instructing with 20–25 students, rather than have the

20–25 students commute all the way to campus. So this has been utilized, I feel, in the area of continuing education. Another feature that has been tried there, and I'm not sure how common it is, is offering the regular university courses at what has been defined as weekend college. Classes go from 6 to 10 o'clock Friday evening, and 8 to 3 or 4 on Saturday. This continues for three or four weeks to give the necessary 43 to 45 hours of lecture time. Such an approach has been rather successful.

Now we have presented four different ways of providing continuing education. Looking at quality, how do we rate them? I've been involved in short term training, regular class schedules, off campus or evening school, and weekend college, and my feeling is that nothing is better than the regularly scheduled course—that would have to rate number one. I tend to find the evening schools number two. Weekend college is number three, and I guess I would have to put short term training down at the bottom of the list. This is based on teaching the same course in all four settings and trying to evaluate how much material the students had retained at the end of the training period. The regularly scheduled courses, one hour at a time with time for reflection and studying in between, appear to be better than the short term courses where you are in school six or seven hours a day, then attempt to study at night, before coming back the next day for another seven hours. So as far as quality, I would have to rank them in that order. Then how do we go about monitoring or how do we go about establishing quality of training? There seem to be many questions in that area. If I'm looking for training in this area, I would look at the institution or professional organization that might be putting on the training courses. Hopefully they have established some type of a track record and can give me some indication—do they have a reputation for putting on a good training course? For myself, I would check with colleagues. I've been in the field for some time and I have a number of other friends in the field. I can check with them. That works well for me, but for the novice in the field, this is difficult. I know that the alumni from CMSU check with their colleagues and classmates, all of them relatively new in the field, and they may have attended a training course that they were impressed with. But this was a totally new area to them and they have very little way of evaluating it. The other thing I think we have to look at is the staff. And again, I see this happening: we have a group, institution, an organization, who in general has a reputation for putting on good, quality training courses. But at the same time some staff provides better instruction than other staff, so that comes into it too. Again, you have to look at the institution, look at the staff, and come up with some evaluation as to what is the potential for this being a quality course.

Possibly we now have another way deloping for monitoring quality: the CEU unit, or credits for certification, where we do have some professional organizations reviewing the course and approving or disapproving it for credit. So maybe that is going to add considerably to improving the quality of our continuing education.

Now there's another area that I would like to toss out: that is the question of correspondence courses. Does anyone know of any correspondence courses being offered in the area of safety? I see one hand, so there are some. I know that in some of the other professions this has worked rather well, and I raise the question, is this something worthwhile? The reason I bring this up is that I find a lot of people have difficulty coming up with funds, say $1000, to attend a short term training course in order to meet requirements for certification, maintenance of certification for licensing. Often they are a long distance from any educational institution where they could take advantage of current academic programs. So I see a real need for development of this type of training. I have some real reservations about handling this through a university; while I was at CMSU we received requests for information on correspondence courses. The problem I see with this is that you may have a faculty member who is very much interested in the particular field and who goes through all of the efforts to get the necessary clearance from the university for offering a correspondence course. As long as that faculty member is supervising, it moves along very well. But faculty members move, and I can see that if a faculty member moves, and somebody else picks up this ongoing program, it will really suffer in quality. I could see a professional organization getting involved in this, in which I feel there might be some continuity. You have a committee responsible for the courses and you have someone always working on it who is definitely interested in it. I can see this as a possibility, and I'll toss it out as a possible addition and as something I think is greatly needed. This is particularly true for employees with governmental agencies, particularly state and local, who have problems coming up with the necessary funds for taking short term training. There are other professional groups that have gotten quite involved in continuing education. One of those is the American Nursing Association; they have developed a very extensive continuing education program within their professional organization. Ms. Susan Mann will present the material on how the American Nursing Association has approached this problem.

MODEL FOR A NATIONAL SYSTEM FOR CONTINUING EDUCATION

Susan Mann, M.A., R.N.
American Nurses' Association

I have been invited to present to you information about the development of a national system for continuing education in nursing. The major purpose of this presentation is to provide you with a description of one model that should give you a starting point for discussion and planning for continuing education within your discipline. Based on what I have heard from others during this symposium, the occupation of nursing and the field of occupational safety have some similar problems, particularly in regard to education and research – the two major communities represented here. During the course of my remarks, I will try to point out the reasons for certain policies and procedures affecting the system for continuing education as well as to identify some of the problems that have been encountered in developing it.

First, some background information. The American Nurses' Association (ANA), the professional membership society for registered nurses, recognizes that, because of the constant increase in new nursing knowledge and skills, maintenance of competence is a major problem. It is also the opinion of the association that participation in continuing education activities is one way to maintain that competence. In 1974, the House of Delegates of the association passed two resolutions that are of significance to this topic. One called for the development of a national system of accreditation to assure the public and the consumer (the registered nurse) that continuing education offerings meet established educational standards. The second resolution also speaks about the responsibility of the association to assure the quality of continuing education as well as the need to develop a system of continuing education that would facilitate the interstate transferability of registered nurses. I would point out here that registered nurses are licensed by regulatory bodies of each state government. A criterion for initial licensure is an acceptable score on an examination. This examination is developed nationally and then administered by each state regulatory agency. Let me assure you that nursing worked long and hard to accomplish this so that nurses will have geographic mobility.

In the next year, 1975, three major events occurred to begin the process of implementing the 1974 House of Delegates resolutions.

1. Publication by the American Nurses' Association of the standards for continuing education in nursing. For purposes of my presentation, a standard is an authoritative statement enunciated by nursing by which the quality of practice, service, or education may be judged.

2. Development of a model for accreditation of continuing education in nursing by an ad hoc committee appointed by the ANA Commission on Nursing Education and the ANA Council on Continuing Education.

3. The first meeting of the National Accreditation Board—the body designated by the accreditation model as the policymaking group.

1976 was the first year of operation for the national model for accreditation or national system for continuing education in nursing. In that year, two major activities occurred to accomplish this.

1. The criteria for accreditation as well as application procedures were published. For purposes of my presentation, criteria are indicators by which standards are measured and evaluated.

2. The actual accrediting committees began meeting to review applications.

The model for accreditation is <u>decentralized</u>. Let me give you some information about how it works. Agencies and organizations — such as colleges and universities, nursing organizations, and federal nursing services—may apply for accredited provider status. If this is granted, they provide contact hours for all their continuing education offerings that are recognized by all who are participants in the national system plus many organizations and agencies who are preparing to enter the system. At this point, approximately 80 organizations have been granted this status, and based on my correspondence, 30–40 more will be attempting to enter the system by applying in the next year.

Certain organizations may apply for approval status as well. This means that they are accredited to approve the offerings of other sponsors of continuing education within their jurisdiction. At the present time, seven of the specialty nursing organizations (including the American Association of Occupational Health Nurses), four federal nursing services, and thirty-one state nurses associations (ANA constituents) have been granted this status. Many sponsors of continuing education provide approved contact hours for their offerings by applying to the above groups.

Because the National Accreditation Board wanted to avoid any charges of conflict of interest, commercial products companies—those companies providing continuing education for nurses who also sell a product other than continuing education—must apply at the national level for approval of offerings or a series of offerings—what is known as program approval. At the present time, 10 companies have program approval and 43 offerings of commercial products companies have been approved.

The mechanism calls for a national body to set policy and procedures—the National Accreditation Board referred to earlier. The mechanism is a part of the American Nurses' Association in terms of financial support. The mechanism has operated "in the red" since its implementation, but in the past year the number of applications has increased so greatly that we are close to having income meet expenses. The standards for continuing education are developed by the ANA Commission on Nursing Education through the ANA Council on Continuing Education. Using these standards, the National Accreditation Board develops criteria, policies, and procedures to implement and evaluate the national accreditation mechanism. Regional accrediting committees are used to do the actual review of applications only to expedite the process and keep expenditures down. These accrediting committees meet three times per year. Members of all the committees represent nursing education, including continuing education nursing practice, nursing service administration, continuing education in other fields, and society.

This year a new publication was released describing the accreditation mechanism, giving instructions to applicants, and listing the criteria that must be met for accreditation and approval. In addition, we initiated a staff consultation service to assist potential applicants in preparing for accreditation or approval.

To close this general description of our national model, I would like to list the general categories of criteria that must be met to be granted accreditation. Of course there are specific criteria under each of these headings.

I. Philosophy of the Organization

II. Organizational Structure

III. Resources

   A. Personnel
   B. Financial
   C. Physical Facilities

IV. Records and Reports

   A. Offerings
   B. Individual Participants

V. Offering Design

A. Assessment
B. Faculty
C. Objectives
D. Content
E. Teaching Methodologies
F. Physical Facilities
G. Evaluation

VI. Provider Unit Evaluation

VII. Co-sponsorship

Although the majority of approved continuing education being provided to nurses takes the form of the more traditional workshop or seminar approach, several companies, universities, and organizations have developed self-study or independent study offerings that are made available to nurses through subscription or actual purchase of a module. While these offerings satisfy a critical need and their development should be encouraged, it is my opinion that until nurses become more independent learners, their use will be limited.

Let me discuss a couple of items that relate to things I have heard during this symposium. First, information about the area of evaluation. I can relate to you that the people closely associated with the mechanism, that is the appointed committee members, believe that it is strong, viable, and worthwhile. This is an internal evaluation, of course - one we would assume would be positive. In the beginning, the external evaluation of the system was for many organizations, "Let's wait and see." That this attitude has changed in the last year can be seen by looking at the increasing number of colleges and universities that have become a part of the system.

The second item relates to preparation of nurses to function in today's world. It is my opinion that we have been fairly successful in using our national system to satisfy this need in one area of nursing—that is, what we call the nurse practitioner. This nurse is prepared with physical assessment skills and relates to the client as he enters the health care system and/or continues on a maintenance or prevention regimen. Preparation for this kind of nursing should probably occur at the master's degree level, but because of some educational realities within the occupation, this was not immediately feasible. As a result, continuing education certificate programs preparing nurse practitioners were developed to satisfy the immediate need for individuals with these skills. These programs are eligible to be a part of our national system, and 28 programs are currently accredited. In the future, this number should begin to decrease as these programs are absorbed into the degree-granting sectors of colleges and universities.

The nursing continuing education system has the potential for providing the knowledge and skills to current registered nurses who must become competent in new areas, particularly as we move to implement higher educational requirements for registered nurses who will be beginning practice in the future. This is not in place as yet, although there are some positive signs that it could occur because of the work being done by ANA to define the competencies of the new graduate beginning practice as a registered nurse.

The system is currently being used extensively to prepare nurses who are entering specialty areas of practice or assuming new functional roles such as teaching or administration. As you may or may not be aware, over half of the one million nurses practicing today have less than bachelor's degrees. Less than 10% have master's degrees or higher. Thus they are not formally prepared to assume these roles or enter specialty practice. In academia, formal preparation in nursing at the master's and doctoral levels is becoming a necessity in order to legitimize our place in higher education. In the other areas, while master's preparation is desirable, it will not become a reality for years to come particularly when the demand for registered nurses with any preparation remains so great.

Thus it can be seen that the national system for continuing education in nursing is being used to assist nurses in maintaining their competence as well as in becoming competent in new skills and roles. The potential for growth in the system is unlimited.

DISCUSSION

(Audience) I think there are a number of other issues that you have alluded to, but what is the total population of nurses in the United States, hundreds of thousands?

(Ms. Mann) Yes, over a million.

(Audience) Therefore you have a very large constituency, consequently you have a very large potential market, so you can try a lot of experiments. What is the position of your association on accreditation of nursing schools? It would seem to me that you would start in that area first.

(Ms. Mann) Nursing schools are accredited, they have that capability. It is not done by the American Nursing Association, however. This is an activity of another organization called the National League for Nursing. They do have an accreditation mechanism in place for formal degree programs at the Associate Degree, Diploma Hospital School, and Baccalaureate Degree and higher.

(Audience) You have a million members and five hundred thousand of them don't have bachelor's degrees. It seems to me that there is a problem with your accreditation process, that is the place to begin improving the situation so as to raise the levels of your schools through the accreditation process.

(Ms. Mann) That process is in place. I'm not sure I want to get into that discussion. In 1965, the American Nursing Association published a position statement saying that in the future the professional nurse beginning practice should have a bachelor's degree. Obviously that is not in place yet. But we are moving in that direction. Within the last three or four years, things have been occurring at a more rapid rate, although the controversary within the occupation is unbelievable.

(Audience) You have a similiar situation both in public health and engineering, as you probably know. Public health as a school is essentially reviewed and accredited, but that's only because there are a very small number of schools who do it. On the other hand, the engineering disciplines are independently evaluated and accredited. I think that many of us, from an education point of view, would like to see something like that applied to the disciplines of safety and industrial hygiene, for example, and to other health related disciplines within the school. That's why nursing seems to be an important point somewhere between accreditation in medicine or engineering professional accreditation. There are three steps necessary for that accreditation and at the moment we are on the threshold of thinking what we ought to do about accreditation.

(Ms. Mann) Don't do what we've done in terms of formal academic programs. One of the problems with the accreditation system is that now you are talking about upgrading the schools. The association that does the accreditating gets its money from the people who move into the system to be accreditated. They are not going to give up receiving the money from the hospital diploma schools for example, and say they will only accredit the community colleges and the baccalaureate and higher degrees because that is where the education takes place. If they do that, they are going to fold, because they get their money from the people who are accredited.

(Audience) I would like to say that it is a mistake to assume that the diploma schools are inferior to the degree schools, because all students take the same state examinations and some diploma schools students graduate with scores considerably higher than the four year degree students. So it should not be assumed that the two or three year program is inferior to the four year program.

(Ms. Mann) I am not, I really do not want to get into a discussion about that, that is not my role. I would say that, first of all, the licensing exam is a test to indicate that the person has...is a minimum safe practitioner, and that's all it indicates. Second, and I would agree with you that we are not necessarily saying that the diploma schools are inferior, what we are saying is that nursing education should be in the mainstream of higher education. That is what we have been trying to do over a long time and should have done a long time ago, but we are moving slowly.

(Audience) Can you give me some numbers on occupational nurses, that is, those in that particular discipline in the field of nursing?

(Ms. Mann) I don't have any idea.

(Audience) Approximately 20,000, that is the best information we have.

(Ms. Mann) The real problem is that nurses say that they are occupational health nurses, which is where they may be functioning. They may be functioning in that role, but they really aren't. It depends on who asks the question and how the question was asked. If the question is, are you prepared at the master's level in occupational health nursing, you are going to get one answer. If the question is, are you an occupational health nurse, you are going to get another answer. So that really confuses the issue.

(Audience) When I say 20,000, that means nurses that are practicing, that doesn't necessarily mean that they have any preparation at all in occupational health care. In other words, these are the ones holding the positions and who call themselves occupational health nurses, even though they may not be qualified by the standards of the occupational nurse association and the guidelines they use and the other criteria. The occupational health nurses are not as well organized—there are a lot of occupational health nurses that do not belong to the American Association of Occupational Health Nurses, which would make it more difficult to determine how many there are.

(Audience) Do you feel that the main problem has arisen because of the financial problems of the accreditation process? Certain schools may be accredited because they force the function of accreditation.

(Ms. Mann) What I was trying to indicate was that in the beginning, when the system started, particularly the colleges and universities took a wait-and-let's-see attitude. From my perspective, when the colleges and universities begin to move into the system, buy into it and make application for accreditation, that says to me that the system probably has some creditability and is going to be meaningful in terms of a national system. And it is only within the last year that that has really begun to occur.

(Audience) I was referring to the shorter class of...nurse practitioner, certificate programs preparing the nurse practitioner.

(Ms. Mann) Those programs, from the perspective of ANA, were stop gap programs to satisfy an immediate need to prepare nurse practitioners. In the future, and it has already begun to occur, those programs are going to be absorbed in the master's program.

(Audience) Who will be taking the role of the nurse when you have a professional who will take on the more immediate tasks of patient care occuring in the hospital setting?

(Ms. Mann) You are back to the educational preparation of nurses. According to the ANA position, in the future, nurses should be prepared in two educational settings for beginning practices nurses: the baccalaureate program and the associate degree program.

(Audience) What criteria do you have for approving continuing education?

(Ms. Mann) Would you like to read our manual? There are criteria about how contact hours should be defined. The organization who receives the accreditation as a provider or else the approval of the offering must demonstrate how they are going to monitor that. We have lots of people who call us because they are interested, they are offering some kind of a program, and they have in the past received approval through AMA, but they always have a few nurses who come, too. They call us and say we'd like to offer contact hours for the nurses to come next year. We will send in our outline and you can approve us. It doesn't work that way. Some of them do follow the procedure and get approval, but we hear lots of complaints about how strict our system is in relation to the AMA system.

(Audience) I would like to mention what we are doing and have available: a micro-campus. It's a TV tape of our classroom setting, and works like taking a class to a group, which, unfortunately, at this point is still a one-way communication. But it is a TV film or tape of that classroom with student participation, and is available for university credit.

(Audience) I have a couple of comments to make. I really appreciate Ms. Mann's coming, because I think this type of exchange between professional organizations is beneficial. I do work with the occupational nurses association and, believe me, they take roll. If a nurse is not there for a session, she does not get credit. They are work horses, believe me. My question is are standards set at the ANA level general broad standards versus specific standards? For example, the Nurses Association of Occupational Services, I know, is accredited under your program. Are the standards very specific, or are they broad standards that have to be followed? Or are they defined as needed?

(Ms. Mann) The standards are broad enough that all those organizations that I was talking about can apply and meet them.

(Audience) Really, it's a different approach for a different field like, say, a clinical nurse, or where you are dealing with industry, or where the input on one side is the medical system and the other, the doctors. You are actually putting the people in a position to take a different approach.

(Ms. Mann) The standards that are the basis or the criteria for accreditation are general enough that all the different specialty organizations and so forth can move into the system.

(Audience) Has the ERC, as established, made any significant differences so far, in your judgement, in the training of nurses or in assisting in the training of nurses?

(Ms. Mann) No, I have not noticed any change, but I am not the authority in that area. One of the problems we've seen is the fact that so few of the nurses are graduate nurses, baccalaureate nurses, percentage-wise, and that there are few nursing programs on their level.

(Dr. Allan Stevens) I have to make one point with respect to the short term training: there's a lot of educational research in that group. Yes, they have made a difference, not tremendous, in the area of nursing, because the nursing program requires highly trained or Ph.D. levels. However, they do provide the availability of courses for specific areas. But generally, covering all areas, not just nurses, trainees have gone in the last three years from about 2,000 to over 10,000. Between 10 and 12 thousand trainees in all four of the areas. The main comment I'd like to make about the educational short term programs is that there is a misunderstanding, generally, that the costs provided in the grant, educational research management, completely subsidize short term training, and that therefore they should be providing continuing education or short course workshops free of charge. This is not the case; the funds that are provided within the grant specifically for continuing education are generally rather minimal. Our intention was to provide developmental funds for continuing education activities, so that they would, in fact, become self sustaining and, in most cases, provide for special lecturers, special equipment. Most of these expenditures should be recovered by charges. I'd like you to pass the word around because they're getting a lot of bad raps from people who say we are giving all this money to these educational resources, and that they ought to be providing all these courses for free. It is very costly and they do not have nearly enough money to do so.

PREREQUISITES FOR INCOMING STUDENTS: UNDERGRADUATE AND GRADUATE PROGRAMS

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INTRODUCTION

With the passage of the occupational safety and health act, there has been an increased need not only for the development of research programs, but also for the development of various levels of training programs. These levels lead to associate degrees, baccalaureate degrees, and graduate degrees.

With the rapid growth of this field and the need for occupational safety and health specialists, there has been some effort to provide the education community with information about industries' needs in order that curricula could be developed to produce an end product valuable for industry and government. As a result of this, there have been various types of programs with different philosophies and different emphases, as perceived by the individuals in charge of the educational programs and their perceptions of industries' needs. However, evaluating most of these programs that have been developed reveals that there has been an agreement on the background required to enter an undergraduate program, and to graduate in occupational safety and health.

UNDERGRADUATE PROGRAMS

Undergraduate programs in occupational safety and health are housed in many different schools, including engineering, biology, chemistry and others that are health related. Therefore, the prerequisite for incoming students in these programs may vary slightly. Generally, they are an acceptable high school diploma with an interest in this area. It would be extremely helpful for the high school student who is interested in a career in occupational safety and health to have taken as many of the science courses offered as possible, such as chemistry, biology, and physics. However, it should be noted that, those who enter occupational safety and health in colleges of engineering generally receive courses such as statistics and engineering economy, both of which are extremely useful, especially the latter. For on many occasions an occupational safety and health specialist may be asked to evaluate alternative designs or alternative processes. Although the evaluation emphasis is being placed on safety, the cost is of prime importance. Therefore, a knowledge of engineering economy and how to evaluate alternatives can be extremely useful.

Undergraduate students in occupational safety and health programs do receive adequate courses, which involve industrial hygiene, safety, safety management, epidemology, etc., all of which are considered the core for the program. However, in addition to these, even on the undergraduate level a course or two in human factors engineering would be extremely helpful. The student at that level should understand the man-machine interface and the problems generated as a result of faulty designs, as well as what modifications must be made to eliminate hazards resulting from the incompatibility of the hardware with the human operator.

It should be noted that, recently, it has been difficult to attract undergraduate engineering students to study in an engineering program leading to a baccalaureate in safety engineering. This is particularly true because of the high salaries offered to engineering graduates the last three years. These salaries have ranged from $20,000 to $24,000 per year, and, therefore, the student has been reluctant to deviate from the established engineering programs and branch out into a relatively new program. However, emphasis now should be and has been placed on providing safety engineering courses as electives in all engineering curricula, in order that an engineer can become aware of safety and health. This will provide him the ability to communicate with safety and health professionals on the job. Several schools have started such elective programs, until such a time when programs leading to a safety engineering degree have the same recognition as the current, established, programs.

GRADUATE PROGRAMS

At the graduate level, there have also been difficulties in recruiting engineering baccalaureate holders to programs in occupational safety and health. Therefore, in many of these programs students have been accepted with varied backgrounds, such as chemistry, biology, and, occasionally, some psychology. Such backgrounds, especially because of their diversity, make the education process a little bit more difficult. This is due to the leveling necessary to bring students with these varied backgrounds to an acceptable level for entrance into graduate programs in occupational safety and health. These students represent a valuable resource that should not be ignored. Experience in occupational safety and health training indicates that students with a background in chemistry and biology have done extremely well when given adequate leveling and the opportunity to progress in the program. Furthermore, recent graduates with backgrounds in chemistry and/or biology have had no difficulty in securing good jobs in the field.

Graduate students in occupational safety and health who have had baccalaureate degrees in programs such as biology, chemistry, psychology, or engineering should, upon graduation with a master's or a Ph.D. in the field, be knowledgeable in engineering economy. Unfortunately, this is one course in which most occupational safety and health specialists are deficient upon graduation. As a result they cannot adequately evaluate cost alternatives.

It goes without saying, that graduate students in occupational safety and health at any level should be knowledgeable about ergonomics, especially occupational ergonomics and its application, so they can be knowledgeable about workplace design and qualified to make it less hazardous without jeopardizing high productivity.

When students with backgrounds in chemistry and biology are trained at the master's level in occupational safety and health, they often become more interested in the field. As a result, some of those students apply to medical schools. Students who have gone through a master's program in this area are matured and are knowledgeable, and, hence, are acceptable to medical schools. If such individuals maintains an interest in the field and pursue careers in occupational medicine, then the training is really not lost. But time will tell.

ADDENDUM
PREREQUISITES FOR INCOMING STUDENTS: UNDERGRADUATE AND GRADUATE PROGRAMS

Richard G. Pearson
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Dr. Ralph Vernon and I (Dr. Richard G. Pearson) joined Dr. M. M. Ayoub on the platform and contributed our views to this session. The following is a summary of my principle points:

1. Our NIOSH-funded training program in Occupational Safety at North Carolina State University involves M.S.I.E. students and Ph.D. candidates from both Psychology and Industrial Engineering. The program is adjunct to a graduate program in ergonomics jointly supported by both departments. There is great difficulty nationwide in attracting B.S.I.E. graduates to graduate schools because of high starting salaries offered to them by industry, e.g. $20,000 to $22,000 and sometimes higher. There is no shortage of applicants from the psychology discipline; however, such students generally are less well prepared for graduate study in Ergonomics and Safety than are those arriving with the B.S.I.E.

2. While psychology is, overall, probably the most popular undergraduate field of study in the country, its graduates are often ill-prepared to deal with practical, real-world problems, especially with regard to the industrial setting. There is poor guidance for this undergraduate major involving a lack of understanding of career options. Undergraduate "Introductory" textbooks rarely mention the field of ergonomics let alone the possibility of a career field in occupational safety. Most faculty, lacking industrial experience, are poorly prepared to offer effective career guidance. The typical undergraduate program emphasizes the liberal arts, humanities, and social sciences. As a result the student is usually deficient in the physical sciences, mathematics, statistics, computer science, or in any technology, business, or design-oriented area.

3. Of those psychology majors who apply to graduate study in ergonomics, many have "discovered" the field late in their undergraduate program or after graduation. This then raises the question of how and when deficiencies are rectified. In some cases the B.A. Psychology graduate expresses an interest in the NIOSH traineeships which are available only at the M.S. level in industrial engineering, and so he/she applies for admission to that department. Beyond grade point average and GRE minimum score prerequisites, we require preparation in mathematics through calculus, probability and statistics, computer science, and linear and matrix algebra. The new student is also required to make up I.E. background deficiencies by taking one-credit hour "mini-courses" in work measurement, production control, management information systems, engineering economy, and manufacturing methods. These hours are not counted for credit towards the M.S.I.E. degree. It should be noted that many psychology majors do switch to I.E. We speculate that this is due (a) to the higher visibility of the I.E. in the industrial marketplace, and (b) to the much higher salary possibilities.

4. Among other desirable prerequisites, we include some exposure to anatomy and/or physiology, mechanics, and experimental psychology (sensory processes; information processing; perceptual-motor skills). But it is rare to find such preparation among U.S. undergraduates. Only two U.S. universities offer undergraduate degrees in the field of ergonomics (human factors) in terms of a blend of engineering and psychology coursework (such programs are not uncommon in Europe, it should be noted).

5. In an attempt to broaden the outlook and knowledge of psychology undergraduates on our campus, a newly-revised B.A. curriculum now includes a requirement for five courses (15 credit hours) of interdisciplinary breadth. Group choices here include (a) business and technology, (b) biomedical applications/occupational safety and health, (c) energy, ecology, and environment, and (d) environmental design/urban planning. We hope that exposure to group "b" (above), plus more effective faculty advising, will draw more (and better prepared) students to our graduate program.

6. There is a current lack of qualified faculty in occupational safety within U.S. universities. We also need more total faculty members in the area. Thus, one current goal requiring the focus of NIOSH resources is to support the career development of future educators in the field. Apart from a need for more qualified educators, there is also a need for higher quality administrators and research scientists at the doctoral level in our field. As an example, there has been a conspicuous lack of quality research grant proposals in areas of occupational safety as reviewed by the NIOSH SOH (Safety and Occupational Health) Study Section. This is especially true in the accident-injury study area. The problem appears not to be grantsmanship naivete, but rather a lack of good research ideas that meet the criterion of scientific merit.

7. Finally, I note a European trend involving the collaboration of ergonomists with "work scientists" (who are interested in "Quality of Working Life" issues) to solve problems of occupational safety and health. Considering the goal of the OSH Act (safety, health, and well-being at the workplace), this approach might be viewed as a model upon which U.S. educational programs related to occupational safety might base portions of their educational curricula.

THE EVALUATION OF EDUCATIONAL PROGRAMS IN OCCUPATIONAL SAFETY

Ronald D. Baker, Ph.D.
Human Resources Institute

Occupational safety education has developed to a point in national scope where questions are being asked about the character and quality of programs and their graduates. Most programs are federally funded in part or totally. Within the context of federally funded safety education there exists reasonable concern for program accountability. Labor, management and the federal funding agencies are increasingly interested in the products and effects of these programs. The topic of occupational safety education evaluation appearing in a national symposium indicates an awareness and need for a systematic appraisal of programs.

Ultimately, evaluation of any kind depends upon criteria set for judging some factor or feature of an object, process or system. Criteria, the testing of the quality of something, rest upon and are derived from the values held about the matter in question. Therefore, before criteria can be set clearly and understandably, the value system and perspective that generate them must be explicit.

One intent of the symposium presentation and this paper was to bring attention to the diversity of interests and audiences in occupational safety education as a whole. Those present and active in the symposium were administrators and staff of the National Institute for Occupational Safety and Health; directors and faculty of Educational Resource Centers and other occupational safety educational programs;

and representatives of organized labor, professional societies and management. The importance of such diversity is that no single approach to program evaluation will satisfy all of these audiences. Although all are concerned about the betterment of occupational safety education and its impact upon the workplace, the priorities held by each differ.

Evaluation consists of two basic steps: measurement and judgment — that is, assessing some thing and then deciding the quality of that thing based on values given to it. The evaluative process is and must be value-laden no matter what the subject of the evaluation. This does not mean, however, that your guess is as good as mine or that our guess is as good as anyone's. The matter of values often raises an image of a subject area that is unstable, capricious — governed by personal preference. There are rules and methods that regulate proper evaluation; values and priorities are placed in a framework that permits them to be viewed objectively.

This topic generally is not a new one. Educational program evaluation is a well developed area of study and practice. The approach offered today, however, is new — at least in occupational safety education. There are many occupational safety programs and projects now being conducted in numerous universities and colleges. These are being evaluated in some manner. NIOSH's site evaluations of the Educational Resource Centers is a ready example. That the evaluations are producing information that will be useful for making decisions about program successes, adequacies or deficiencies by educators; safety and health professionals; industrial, labor and governmental leadership; etc., is an area to examine carefully.

WHAT IS THE PURPOSE FOR THE EVALUATION?

Program evaluation may be conducted for two broad purposes: (1) to demonstrate accomplishment of proposed objectives or (2) to guide internal program decision-making. In the first, a summative evaluation, the intent is to express degrees of program accomplishments in relation to objectives posed before the program began. This is an accounting for program management, operations, funding, resource allocation and products.

In the second, a formative evaluation, the intent is to gather information to assist the management of the program as it develops. Evaluation in this mode provides information for internal program adjustments and development.

It should be apparent that the two forms of evaluation differ markedly. The first is invariably called for by a source external to a program; a funding agency may be one example. The second is performed by the program managers to enable the best use of resources, etc., in order to accomplish the proposed objectives. The perspectives of the two forms of evaluation are different; the first is historical ("How well did I do?"), the second current ("How am I doing?").

Impact evaluation is a third general type which seeks to determine the effects of the program on the setting toward which its projects and products are aimed. Increasingly occupational safety educational programs will have to examine impact. Impact data in relation to summative evaluative data will demonstrate the utility of the programs locally and nationally.

WHAT IS THE AUDIENCE FOR WHOM THE EVALUATION IS CONDUCTED? WHO WILL USE OR ACT UPON THE RESULTS OF THE EVALUATION?

The individuals for whom an evaluation is performed will be indicated largely by the purpose of the evaluation. The importance of the audience as a factor in evaluation is that the criteria established for the evaluation must have meaning and relevance to the priorities and interests of the individuals composing the audience. A common difficulty in program evaluation is that it is conducted in a way that produces information that cannot be used by those for whom the evaluation is performed. Faculty interests and informational needs may differ from NIOSH Project Managers', and both may differ from those of organized labor. Numbers of enrollees in a series of laboratory courses may be meaningful to a college departmental evaluation to demonstrate resource allocation, but such a statistic is meaningless to an employer of graduates from that program whose interest is in performance.

The methodologies and techniques are available at this time to assess occupational safety educational programs. The criteria for evaluating such programs are questionably well defined. Applying assessment techniques, finding things to measure — such as the number of students enrolled in a program or the number of courses offered — are pointless exercises if the meaning of the measures is ambiguous or undeclared.

A meaningful evaluation is one that is conducted from an identified perspective, for specific purposes, using criteria that are relevant to the audience for whom the evaluation is performed. In order to perform a meaningful evaluation of an occupational safety educational program a number of key issues or questions must be addressed. Failure to do so weakens the utility of the evaluation for program decision-making. The questions are:

1. What is the purpose for the evaluation?

2. What is the audience for whom the evaluation is conducted? Who will use or act upon the results of the evaluation?

3. Who will conduct the evaluation?

4. What is the context of the program being evaluated?

5. What program phase is being evaluated?

6. What is the time frame for the evaluation?

These questions must be answered or attempted before evaluative methods, criteria and measures are considered. Although the matter of how to evaluate is important, it is dependent upon the answers to the questions above. Unfortunately, too many evaluations begin with a selection techniques hastily conceived criteria and ready measures. The result is that the problem is shaped by the method of evaluation instead of the method of evaluation being shaped by the problem.

WHO WILL CONDUCT THE EVALUATION?

Conduct and control of evaluation are serious matters. I have emphasized the importance of values in the evaluative process. Control of evaluation means control of the assessment process and the selection of the criteria to be applied.

There are four likely centers of control in the evaluation of occupational safety education programs:

a. The federal agencies that sponsor programs.

b. The institutions that contain or operate programs.

c. A group or organization that has interest in safety education and its products.

d. A group formed from representatives of all of the above.

The values and perspectives of each of these potential controllers of evaluation do not need to be described at this point. Any of the first three have interests that would and do greatly affect the design and conduct of evaluation.

Because the scope of occupational safety education is so extensive and its impact so important in advancing the goals of the OSH Act, a combination of values and views seems at this time to be the most appropriate option among the four.

WHAT IS THE CONTEXT OF THE PROGRAM BEING EVALUATED?

There are two general contexts in which to view occupational safety education programs. One is national; the other is local or institutional.

Evaluation in a national context—from a federal perspective—requires attention to the entire movement generated in occupational safety education. For example, the total Educational Resource Center (ERC) program concept would be evaluated in this context. Successes within any Center or among all Centers would have to be viewed cumulatively from a national perspective, not from a single institutional perspective.

SUMMARY OF THE REACTOR PANEL DISCUSSION

John V. Grimaldi, Ph.D.
University of Southern California

The panel elicited its own views and those of the audience, in a forum format. In this setting there was no opportunity to reach a formal consensus regarding the preferred direction(s) for occupational safety and health research and education—nor was such a conclusion intended.

Instead, the discussion during this portion of the program was expected to supplement the opinions expressed formally in the course of the symposium's preceding presentations. The emphasis divulged during the reactor session was anticipated to be strongly positive or negative. No middle ground was sought and none seemed to materialize.

Two of the panel members subsequently submitted a written statement of their positions. These authors (E. H. Stockdale and M. F. Biancardi) are represented by their papers which are included as attachments to this summary.

In general it appeared that there was consternation over the heterogeneous nature of occupational safety and health education. In particular, the practitioners were thought to be only partially prepared by the professional training programs that are in place. The complaint, it seems, is that too much education is given in theoretical areas of practitioner performance and not enough in the day to day elements of the work that is required. An example of such practical needs is the requirement of practitioners to communicate effectively so their recommendations will be implemented.

There were some observers who would have preferred a standardized curriculum (or curricula) for the preparation of occupational safety and health specialists. In this regard the greatest divergence of views emerged. Employer representatives appeared to seek specifics for inclusion in the curriculum which would satisfy immediate needs that are to be met by the specialists. The professional representatives appeared to seek specifics as well, but looked for a different augmentation of the curriculum. The educators, however, leaned to the desirability of educating the student broadly in his specialty and allowing the specifics sought by the employer to be provided on the job or in a continuing education program after graduation.

It was pointed out that the development of the occupational safety and health specialty is progressing rapidly and that it is far from having reached maturity. In this view it appeared that curriculum standardization would disadvantage the refinement of the field. A standard curriculum would prepare everyone in the same fashion and there would not be much opportunity or encouragement to experiment or allow the experience of practitioner teachers to mold the teaching program that is under evolvement.

The diverse views about what indeed should be the character of the professional education programs lead to the opinion that there is as yet no agreement about the nature of the practitioner's work. In fact, it was opined that before any attempt to decide what the proper elements of practitioner preparation should be, it would be better to define clearly the character of the professional's practice in this field. It was believed that such a definition would give direction to the planning for research in occupational safety and health as well.

COMMENTS BY EARL H. STOCKDALE

GULF SCIENCE AND TECHNOLOGY COMPANY

Several times I have heard the question "What are industry needs?" Based on my safety, fire protection and loss control experience, there is a need for academia to get the safety message across to students in other disciplines who will be leaders and management personnel in the future. This message might include how safety contributes to good management/employee relations, improved morale, the bottom line, and how they can use the safety professional to aid them.

Safety has become of age, equal in rank to other professions. More and more safety, fire protection, and loss control professionals are reporting to plant managers. Today, it is a wonderful opportunity for the young safety professional with administrative and technical capabilities.

The safety professional, then, needs basic knowledge in three primary areas:

1. Administration: What constitutes systematic safety programs, the elements and contents. This knowledge is needed to assist management in tailoring an administratively practical and workable program to fit the plant's needs. Many problems include safety, fire protection and loss control.

2. Technical Expertise: The safety professional must be able to provide technical expertise in the development and application of the plant program elements to guard against injuries, fires and other losses and to minimize losses in the event an accident occurs. In addition, he must be able to handle the various technical inquiries that arise daily. This does not mean that the safety professional must be able to provide answers immediately to all technical safety questions that arise, but rather know sources of information that can be called upon.

3. Analyses: The safety professional must have the analytical ability to audit and evaluate a program to identify specific hazards, problems and weaknesses to determine exactly what needs to be done to improve the program.

A safety professional is a costly man because of his travel and recommendations. Therefore, to be effective he must be a good high caliber man possessing outstanding abilities in the three primary areas stated above.

To carry out the three primary areas of activities effectively, the safety professional must be able to communicate clearly both verbally and in writing. Successful achievement by the safety professional will gain him respect and acceptance with line management and employees; from then on he is usually a very busy man. Acceptance, without force, is essential for the success of every safety professional.

On a higher plane, the same principles apply to the safety professional at the corporate level of a multiple plan corporation or company. However, at the corporate level the safety professional must be able to coordinate the overall program for corporate departments and the executive, by reviewing, promoting, advising, recommending and assisting the various plants or operating elements, in achieving successful safety, fire protection, and loss control.

COMMENTS BY M. F. BIANCARDI
BOARD OF CERTIFIED SAFETY PROFESSIONALS

Yesterday's and today's programs were very helpful to me as a representative of the Board of Certified Safety Professionals. The format of the meeting has been successful in generating dialogue. I commend NIOSH on a job well done.

I have a twofold job to do here. First, to comment on the symposium; and second, to tell you about a project of the Board of Certified Safety Professionals. With respect to the symposium, I offer these reactions and comments:

1. The discussions have confirmed my feelings that our safety house has many windows - but even more than I suspected. And, each of us appears to be looking out a different window, getting a different perspective.

2. I am surprised to find so many with views at the extreme ends of the education spectrum - at the higher graduate levels and highly specialized levels, also at the technician levels. With a couple of exceptions, the dialogue I heard seemed to be concerned with specialized safety education rather than the basic fundamental education needed by the beginning practicing safety professional.

3. I was somewhat disturbed by a willingness that seemed to be exhibited by our educational institutions to accept "floaters" and "rejects" as major sources for students.

4. I can now better appreciate the perspectives that have produced such seemingly divergent safety courses. Although my work as a member of the Board of Certified Safety Professionals is not eased, I can now visualize the purposes of the various kinds of safety curriculum.

Now I should tell you about the window in our safety house through which I am looking. It is one that gives a full view of the CSP (Certified Safety Professional) candidate for the core exam which is conducted by the Board - the person who, eventually, will want to be certified in Comprehensive Practice. Directly outside my window is a large sign on which one question is written:

"What is acceptable academic preparation for the certified safety professional?"

The Board of Certified Safety Professionals has struggled long and hard with this question. It has developed internal guidelines to help Board members review academic qualifications of applicants. The growing number of safety curricula has not simplified the review of these applications to determine academic credentials. So, the Board has asked me to chair an Ad Hoc Committee to develop academic guidelines. The charge of this committee is:

> "To develop narrative descriptions of the academic skills needed to perform the tasks which will face a practicing safety professional certified in comprehensive practice. Such descriptions will be the basis of continuing dialogue with the professional and academia to promote understanding of the profession's academic needs. The descriptions should be suitable for use as a section on academic requirements in the accreditation criteria of an appropriate accreditation organization."

The Ad Hoc Committee plans to have recommendations to submit to the Board at its March 1981 meeting. To help get this job done, we plan to use the data produced by the NIOSH studies relating to safety tasks and skills; technical Report #1, published by the Board; and information and opinions such as those expressed at this meeting.

The Board has great need for these guidelines. We believe that such guidelines can help the academic community. We hope the ensuing product will meet both of these needs.

REACTOR PANEL: AUDIENCE REACTOR COMMENTS

Richard G. Pearson
Department of Industrial Engineering
University of North Carolina at Raleigh

POINT 1

The objectives of the Board of Certified Safety Professionals involving certification of safety professionals (CSP) and accreditation are noble. However, some resistance may be expected from university professors who teach graduate level courses in occupational safety and health and who conduct research in these fields. Many such professors, who carry the degree designation of "Ph.D." after their name, are unimpressed with the qualifications of those who add the designation "CSP" after theirs. Accordingly, there is a disinclination on the part of such faculty to be associated with the CSP movement.

The designation of "CSP" should not automatically be presumed to be a valid indicator of expertise for faculty who teach occupational safety. Other research and professional skills, as evidenced by graduate-level faculty, are critical to the quality education of graduate students, for example, and these should be preeminent in evaluation of the quality of such programs. The statement that an educator is <u>not</u> a "CSP" (as made during a NIOSH study section training grant site visit) is completely irrelevant to the judgment of program quality made by site visitors and by study section members who later vote on the grant proposal.

POINT 2

Exceptions are to be noted to certain of Mr. Molovich's remarks concerning university faculty attitudes toward labor unions and support of union member concerns for occupational safety and health in the industrial workplace. The criticism of university faculty hiding in their ivory towers and neglecting the real problems in the "trenches," while applicable to some, should not be regarded as a universal indictment. Ergonomics faculty at North Carolina State University and at other universities are engaged in field research at industrial sites on occupational safety and health problems involving collaboration with labor unions. Specific problem areas include demanding manual work requiring great amounts of energy expenditure, heat stress, and toxic environments.

It is noted that labor unions, and private organizations representing labor, have submitted numerous grant proposals to the NIOSH study section. The approval record in these cases is poor. The proposals commonly lack good, original ideas and/or suffer from poor experimental design and scientifically-sound procedures. Perhaps unions could profit in these cases by enlisting the cooperation of university faculty in preparing the grant proposal. An example of effective collaboration is research at the University of North Carolina School of Public Health funded by the rubber union to deal with hazards present in their workers' industrial environment.

POINT 3

In response to the comments of another attendee, I should like to address the viewpoint that management is responsible for safety. True, management does have responsibility for development of a safety program. But this does not imply, as inferred, that management and unions have to be adversaries. Unions can, and should, accept responsibility for safety of its members too. In the final accounting a quality safety program should involve the workers to the point that they become responsible for their own safety as well as that of their co-workers. Take the case of field maintenance personnel working at sites remote from corporate offices. Who else but the workers themselves are truly responsible for site safety? Such workers can be viewed as experts at their job and its hazards, and thus can contribute much to a safety program on the basis of their experience through communication with management on such subjects as hazard recognition and control, near-miss reports, and accident-injury situations.

POINT 4

Ergonomics has much to offer in the area of occupational safety and health. Unions can profit by greater acquaintance with this relatively new field of science. Short courses are available through the NIOSH-funded Occupational Safety and Health Educational Resource Centers located at universities throughout the country. Similarly, there are educational resources available through the OSHA "New Directions" centers. Still another possibility is exemplified by the activity of the Italian Ergonomics Society, which offers union-supported training for union members.

EPILOGUE

EPILOGUE

As an epilogue to the conference, a questionnaire was developed by NIOSH for dissemination to symposium participants, soliciting their written response on the issues raised. The responses have been tallied, and a summary of the most salient comments prepared for inclusion in this proceedings. The questions themselves appear in Appendix C.

Educational Program Approaches. Most professionals agree on the merits of different yet meaningful approaches to safety education; some of those approaches (e.g., business, public health, engineering) are presented in this document. Having many approaches to safety education is feasible, since the fundamentals of safety practice cannot be extrapolated from a single discipline. At the graduate level, emphasis on the discipline being used as a vehicle to prepare students for specialization is particularly appropriate. However, for associate and baccalaureate programs a recognized body of fundamental knowledge is essential; this foundation is where disagreement among safety experts is most evident (see summary on core requirements, below).

A balance of management skills, technical competencies, and knowledge of industrial hygiene practices is regarded as a fundamental package by some. Others emphasize the scientific aspects of safety control or of ergonomics and accident injury. According to another, strong business and managerial abilities are more frequently sought in the job market than are engineering skills; safety personnel are regarded as managers--knowledgeable on laws, standards, and loss control techniques.

If technical competencies are less crucial, academia must prepare students to have a multidimensional perspective on the field of safety, which should not be secondary to technical competency. What, then, should constitute the "core" of program requirements?

Core Program Requirements. The McClay paper on core requirements (found in this document) offers recommendations that were favorably viewed by a number of those in attendance. These recommendations were found to follow existing programs closely, in the assessment of some attendees. However, concern was expressed that "core" terminology is too broad to provide curriculum guidance.

The symposium was not designed to resolve debate about what constitutes the fundamental curricular requirements. One useful outcome of the symposium was that attendees have aired their views. This expanded conceptualization of core requirements may be a prelude to future task force activities. A number of courses have been recommended in addition to those presented in the position paper.

It is generally agreed that courses should reflect what safety professionals do in industry. Safety, says one respondent, is a design problem that may be resolved by objective engineering techniques. Others might regard that statement as an oversimplification. Experimental design, ergonomics, engineering economics, and statistics were collectively offered as another approach to core requirements. Other recommendations include:

- Administrative law,
- Quantitative decision theory,
- Security,
- Fire abatement,
- Data reduction and analysis, and
- Labor relations.

Eliminating or reducing field studies in favor of control techniques (i.e., the design of recognized control systems) was also recommended, as was increased emphasis in psychological and behavioral safety implications.

Educational Program Constraints. The symposium was designed to stimulate discussion on constraints to educational programs, in the hope of avoiding pitfalls in future programs and of identifying barriers in existing programs. A number of constraints were identified in the Firenze paper. Respondents to the questionnaire commented on the need to distinguish between undergraduate versus graduate constraints, and such a distinction remains to be made.

Other constraints identified included limited laboratory and equipment resources for research and the lack of internship opportunities. Limited communication between associate-degree programs and four-year programs was also regarded as a barrier—as is the absence of an accrediting body for baccalaureate-level curricula. One participant recommends a concerted effort to improve the instructional materials available in the field as a means of improving transfer of basic concepts to students.

Prerequisites for Incoming Students. Problems in qualifying students to enter occupational safety programs at the graduate and undergraduate level are reported as being generally the same for most institutions. Fitting the student's background into program requirements and achieving acceptable scores on admissions examinations, such as the GRE, are major problems. Good students frequently fail these tests. Another problem is that some occupational safety and health graduate programs require of their applicants no undergraduate course work in occupational safety and health. Thus, graduate work is built on a weak foundation. Also, putting a graduate safety program into an existing department means that course work or prerequisites are required that are not entirely essential for the safety professional. These prerequisites cannot be easily waived in a well-established engineering or business program.

Further, enrollment of qualified students in undergraduate and graduate programs requires liaison with the admissions office of the educational institution. Admissions counselors who interview incoming students must be knowledgeable about the academic requirements of these programs, as well as the demands to be placed on graduates in industry. Students must understand what it means to enter this training. The programs are rigorous, integrating course work and limited occupational experiences so as to ensure progress from entry level to the competency levels required by employers. Each student should enter at a prescribed academic level, have a mature attitude, and be capable of assuming the responsibilities of the occupational employment arena.

Faculty Requirements. Acquiring and retaining qualified safety faculty is difficult. The salary differential between industry and academia is a major problem; academic institutions have been unable to compete.

Moreover, people in the field of safety find it difficult to supply educational institutions with needed personnel, because of the need for academic credentialing. Institutions stress earned degrees and prior teaching experience. Minimal qualifications, nevertheless, still vary (e.g., M.S. with considerable experience; M.S. or Ph.D. in engineering or technology with approximately 5 years of experience; the ability to publish; enrollment in a Ph.D. program in ergonomics or other areas related to safety and health).

Methods suggested to qualify safety faculty candidates who may not meet minimum university standards include:

- Grant programs for teacher education in occupational safety and health;
- Special conferences and institutes, as well as continuing education programs in academic settings;
- Special preparatory programs in safety teaching careers; and
- Rotation of less-experienced faculty into industrial positions (maximum practicum: one year) where on-the-job training can be accomplished.

Program Evaluation. Responses varied to the question on the importance of evaluation in the establishment and growth of occupational safety education. Whether an effective evaluation of occupational safety education programs is possible was discussed, since program goals are varied, and universally accepted criteria are lacking. The importance of evaluation efforts, then, is directly proportional to the criteria used and the qualifications of the evaluators. Accreditation of programs would resolve much of the need for evaluations.

One respondent suggested that quality individuals at quality schools will strive for good programs. Establishing evaluation programs will be most beneficial to new programs or to efforts to become consistent with other programs. In the event that evaluations are undertaken, areas subject to study should include:

- Curriculum,
- Faculty,
- Students,
- Where graduates find employment, and
- Job performance.

The ultimate criterion of a graduate's success is career performance.

Response to the question on who should be responsible for safety program evaluation and the extent of that authority also varied. One view is that the department where the safety program is found should assume responsibility, with additional input from industry and labor, and from students. Others recommended that the program director and an advisory panel comprised of industry, labor, and government take the reins. A nationally-constituted accreditation board, or an independent group funded by student fees were also suggested. The ASSE, AIHA, NIOSH, and others were all recommended, singly, or in combination, as were evaluation teams drawn from other constituencies on campus. Giving the responsibility to those with special interests was cautioned against.

Some methods to consider in the conduct of safety program evaluations include:

- Study and survey graduates, employers, and select internship employers;
- Invite graduates to a seminar at the school, where evaluation activities will be conducted (at the expense of the employer, with special funds available when employers do not reimburse such activities); and
- Develop self-evaluation criteria giving schools the opportunity to contrast their effectiveness against other institutions.

Employer/Labor Inputs. The symposium participants were perhaps most vocal on the question of how responsive academia should be to employer/labor inputs. The issue was regarded as "loaded," since employer/labor inputs are frequently at odds with safety education. However, if these inputs are needs and means of safe production, then most agreed that academia should be very reponsive.

In fact, one respondent expressed the opinion that academia has responded to industry in terms of the product, but that responsiveness in terms of graduate school education is needed, too. Labor, on the other hand, was recognized as having very little input to most college safety programs at this point in time. Despite the fact that students from these schools will be employed by industry and expected to solve problems of concern to both industry and labor, many well-established and well-meaning safety programs will be reluctant to effectively integrate employer and labor inputs into their curriculum. One respondent offered the comment that as long as students can be recruited for jobs, the status quo may remain undisturbed.

On another note, one respondent suggested that educators must be open and listen to and evaluate the feasibility of well-formulated recommendations from labor and industry. Academia cannot address all inputs, since biases on either side are inevitable and must be balanced; the total impact and potential benefit to safety education are prime factors to weigh, however. When the benefits are great enough, changes reflecting labor and industry should be implemented.

Mechanisms that educators may use to integrate employer/labor inputs into their curricula include:

- Interaction among professional societies, trade groups, and special consumer interest groups that promote safety in the workplace;

- Continuing education efforts, such as cooperative summer programs or internship programs, seminars with guest speakers from labor and industry, and theses and dissertations on the interdependence of academia, labor, and industry;

- Contractual research in industrial settings conducted by academia, with inputs from labor and industry;

- Descriptive and exploratory surveys designed to discern the knowledge and capabilities that safety practitioners should have both generally and in specialty occupational settings; and

- Surveys of labor and industry that evaluate the effectiveness of graduate safety professionals in contrast to other safety professionals. Criteria of effectiveness should be based on safety indices and standards established by labor and industry.

Financial incentives were also speculated upon as a means of circumventing satisfaction with the status quo. Principally, however, hard data generated from research efforts were viewed as the best way to have valid inputs from labor and industry and to insure the integration of those inputs into established, as well as newly-created safety programs

Guidance NIOSH Should Offer. It was hoped that the questionnaire would provide some direction from the symposium participants on the kind of guidance NIOSH should offer to faculty of the safety programs it funds. Four ways to modify and improve these programs were reported. These are:

- Stimulate communication among the diverse segments of the field,
- Encourage widespread information dissemination,
- Establish a curriculum board, and
- Assist degree programs having funding difficulties.

NIOSH is in a key position to facilitate communication among the various schools. Serving as a center for information exchange, NIOSH could most effectively disseminate educational resource material and function in a clearinghouse capacity. While encouraging faculty to conduct research that yields hard data, the NIOSH "clearinghouse" would assure that the results of such research were disseminated in print and presented at meetings such as this symposium. Reaction to such research by other arenas in the field, as well as industry and labor, is vital. Feedback on the research from labor and industry would give insights to training deficiencies.

Clarity about curricular needs (to be achieved by conducting previously recommended descriptive studies) should be followed by technical assistance to higher education administrators and business/managerial personnel, giving them counsel from experts. Such technical assistance will be designed to enable this institutional element to develop insights that have major implications for the daily operation of educational and research programs. NIOSH is also requested to further the development of a curriculum board charged with critiquing safety program curricula, and, secondarily, with disseminating results of such critiques that might be of help to other programs.

Finally, concern was reported over funding difficulties of occupational safety and health degree programs. NIOSH is being asked to assist these programs in identifying potential funding sources.

One participant expressed concern that everyone will be looking to NIOSH to provide the next step. Suggestion: NIOSH should turn the tables and suggest what each organization represented at the symposium might contribute to achieving our goals and finding answers to questions on curriculum content, training deficiences, and research needs. Certainly, the entire assembly should be encouraged to continue communication and to become involved in task force activities that will enable the safety profession to tackle these problems. Quests for continuity in this effort have come through loud and clear!

General Reactions

The symposium brought NIOSH together with educators, which was regarded as a step in the right direction. While no universal solution to the safety curriculum problem was achieved, many worthwhile points of view were noted. The Molovich paper, spelling out in heartfelt tones the concerns of labor, was viewed as particularly significant. Unfortunately, time was not available to discuss the differences between labor and academia. Views on educational needs held by labor and by safety personnel in small industries were inadequately addressed, and should be a principal concern at a subsequent meeting.

No ready answers should have been expected, given the varying demands of various safety orientations. An annual meeting, similar to this symposium, would promote continuous assessment of the state of the art of occupational safety and professional practice. Subsequent symposia should be designed as workshops—where working groups set out to meet mutually agreed upon expectations and achieve consensus positions. The intent is to incorporate recommended practices into present curricula and to carry out a review of present practices. Concurrently, methodologies found to be obsolete can be deleted from safety education programs.

In lieu of immediate plans for a subsequent meeting, NIOSH and symposium participants are making every effort to follow up on concerns raised and to maintain contact with each other. Such continuity is a keystone to improved safety education and research programming.

Appendix A

AGENDA

THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

DIVISION OF SAFETY RESEARCH

DIVISION OF TRAINING AND MANPOWER DEVELOPMENT

SYMPOSIUM ON OCCUPATIONAL SAFETY RESEARCH AND EDUCATION

A DIALOGUE BETWEEN TWO COMMUNITIES

AGENDA

SEPTEMBER 3-5 1980 MORGANTOWN, WEST VIRGINIA

Workshop Objectives

- To bring educators and safety researchers together to establish better communication between the two,
- To exchange ideas about research activities and needed curriculum improvements through guided discussion and presentation of papers, and
- To articulate preliminary guidelines for instructional and research programs.

PROGRAM AGENDA

Symposium on Occupational Safety Research
and Education:
A Dialogue Between Two Communities

Tuesday, September 2, 1980

5:00-9:00 Registration

Wednesday, September 3, 1980 **Rooms A & B**

7:00-9:00 Registration

8:45-9:15 **Charge of the Symposium**
Anthony Robbins, M.D.
Director, NIOSH

9:15-9:30 **Labor Needs in Safety Research**
John Molovich
Safety and Health Division of the
United Steel Workers of America

9:30-10:30 **Injury Epidemiology**
Jerry L. Purswell, Ph.D.
Moderator
U.S. Department of Labor, OSHA

Accident Injury Study
Richard G. Pearson, Ph.D.
North Carolina State University at Raleigh
Department of Industrial Engineering

10:30-Noon **Design Safety**

Ralph J. Vernon, Ph.D., P.E.
Moderator
Texas A & M University

Machine Guarding--Design for Safety
Bill Hodson
Research Laboratories and Services Division

Multiple Purpose Machinery
Ralph Vernon, Ph.D., P.E.
Texas A & M University
Department of Industrial Engineering

A Quantitative Approach to Safety Assessment of the Workplace
Paul C. Lu, Ph.D.
Oak Ridge National Laboratory
Health and Safety Research Division

Handles for Sharp Tools
Michael W. Riley, Ph.D.
University of Nebraska, Lincoln
Engineering Department

Accidents and Sociotechnical Systems: Principles for Design
Gordon Robinson
University of Wisconsin, Madison
Department of Industrial Engineering

Noon-1:15 LUNCH

1:15-3:15 **Ergonomics**

Donald Chaffin, Ph.D.
Moderator
University of Michigan
Occupational Health and Safety Engineering Program

Occupational Injuries and Worker Capabilities
Robert Arndt, Ph.D.
University of Wisconsin
Department of Preventive Medicine

Ergonomics at Punch Presses, Survey Study
Christer Bramberger
The Swedish Institute of Production
Engineering Research (IVF)

Strength Testing
W. Monroe Keyserling, Ph.D.
Harvard University
School of Public Health

Stress-Related Risk Factors
Gavriel Salvendy, Ph.D.
Purdue University
Industrial Engineering

3:15-3:30 BREAK

3:30-4:15 **Personal Protective Equipment**

Robert Litster
Moderator
Construction Safety Association of Ontario

Eye Protective Equipment Status
Allan E. Sherr, Ph.D.
American Cyanamid Company

Behavioral Approaches to Protective Equipment Usage
Alex Cohen, Ph.D.
Robert A. Taft Laboratories

4:15-5:00 **Economic Incentives**
Richard Bergman
Moderator
Past Chairman, Presidential Task Force on Occupational Safety and Health

5:00 Open Discussion: Questions and Answers

6:00 KEYNOTE BANQUET **Rooms C & D**

Speaker: Don Millar, M.D.
Associate Director, Center for Disease Control
Atlanta, Georgia

Cash Bar **Fireplace Lobby**

Thursday, September 4, 1980

OCCUPATIONAL SAFETY CURRICULA: NEW DIRECTIONS **Rooms A & B**

9:00-10:00 **Educational Program Approaches**
Howard Ayer, C.S.P.
Moderator
University of Cincinnati

Business
Nester Roos, Ph.D.

Public Health
W. Monroe Keyserling, Ph.D.

Engineering
Ralph Vernon, Ph.D., P.E.

Engineering/Psychology
Richard Pearson, Ph.D.

10:00-10:30 Audience Review and Discussion

10:30-10:45 BREAK

10:45-11:30 **Employer and Labor Inputs**
Robert Allen
Ferris State College

Ellen Roznowski
Empire State College

11:30-Noon Audience Review and Discussion

Noon-1:30 LUNCH

1:30-2:00 **Core Program Requirements:** Associate Degree, Undergraduate, and Graduate Programs
Robert McClay
System's Safety Society

2:00-2:15 Audience Review and Discussion

2:15-3:00 **Faculty Requirements**
Larry Slote, Ph.D.
New York University Center for Safety

3:00-3:15 Audience Review and Discussion

3:15-3:30 BREAK

3:30-4:15 **Educational Program Constraints**
Robert Firenze
R.J.F. Associates, Inc.

4:15-4:30 Audience Review and Discussion

4:30-5:00 Wrap-up: Summary of Today's Findings

5:00 Cash Bar **Fireplace Lobby**

Friday, September 5, 1980

DIALOGUE: ACADEMIA AND RESEARCH **Rooms A & B**

8:30-9:45 **Professional Development and Continuing Education**
Herbert Jones
Central Missouri State University

Susan Mann
American Nurses Association
Continuing Education

9:45-10:30 **Prerequisites for Incoming Students:**
Undergraduate and Graduate Programs
M. M. Ayoub, Ph.D.
Texas Tech. University
Department of Industrial Engineering

10:30-10:45 BREAK

10:45-11:30 **Program Evaluation**
Ronald Baker, Ph.D.
Human Resources Institute

11:30-1:00 **Reactor Panel**
John Grimaldi, Ph.D.
Moderator
University of Southern California

Russell DeReamer
IBM

Jim Harris
United Auto Workers

Gary P. Lia
Division Manager
Liberty Mutual Insurance Company

Susan Mann
American Nurses Association
Continuing Education

Fred Manuel
M & M Protective Consultants

John Molovich
United Steel Workers of America

Charles Tipper
International Brotherhood of Electrical Workers

1:00-1:30 Symposium Wrap-up
Summary and Follow-up Charge

Faculty

General Chairman:

James Oppold, Ph.D.
Director
NIOSH, Division of Safety Research
Morgantown, West Virginia

Symposium Coordinators:

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David Clapp, Ph.D.
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W. Monroe Keyserling, Ph.D.
Ellen Roznowski
Robert McClay
Robert Firenze
Robert Allen

Reactor Panelists:

John Grimaldi, Ph.D., Moderator
Russell DeReamer
Jim Harris
Gary P. Lia
Susan Mann
Fred Manuel
John Molovich
Charles Tipper

Presenters:

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Robert Arndt, Ph.D.
Howard Ayer, C.S.P.
M. M. Ayoub, Ph.D.
Ronald Baker, Ph.D.
Richard Bergman
Christer Bramberger
Donald Chaffin, Ph.D.
Alex Cohen, Ph.D.
Robert Firenze
Bill Hodson
Herbert Jones
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Robert Litster
Paul C. Lu, Ph.D.
Susan Mann
Robert McClay
Donald Millar, M.D.
John Molovich
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Jerry L. Purswell, Ph.D.
Michael W. Riley, Ph.D.
Anthony Robbins, M.D.
Ellen Roznowski
Gordon Robinson
Nester Roos, Ph.D.
Gavriel Salvendy, Ph.D.
Allen E. Sherr, Ph.D.
Larry Slote, Ph.D.
Ralph J. Vernon, Ph.D.

Appendix B

PARTICIPANT LIST

SYMPOSIUM ON SAFETY RESEARCH AND EDUCATION
A Dialogue Between Two Communities

Morgantown, West Virginia
September 3-5, 1980

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Appendix C

POST-SYMPOSIUM QUESTIONNAIRE

QUESTIONNAIRE

The following questions are offered as a possible stimulus to your thinking in generating written input for the NIOSH Symposium on Safety Curriculum. Please do not feel obligated to answer these questions. You may structure your comments in any form you wish.

I. Educational Program Approaches

A. Do you see merit in the varied approaches to safety curricula (e.g., business, public health, engineering, etc.)? Please support your answer with some comments.

B. What guidance do you feel NIOSH should offer to faculty of safety programs (supported by NIOSH funds) toward modifying, improving (?), their programs?

C. Please add other comments.

II. Employer Labor Inputs

A. How responsive do you feel academia should be to employer/labor inputs?

B. Suggest some mechanisms by which educators can usefully integrate employer/labor inputs into their curricula.

C. Other comments.

III. Core Program Requirements

A. Give your comments on core courses recommended by Bob McClay (See Position Papers).

B. Give additional courses, or course content, which you feel is absolutely essential in a safety degree program.

C. Other comments.

IV. Faculty Requirements

A. Relate experiences you may have had in acquiring and retaining qualified safety faculty.

B. What are your minimum expected qualifications for faculty members.

C. Offer any suggestions regarding methods to qualify safety faculty candidates who may not meet minimum university standards.

D. Other comments.

V. Educational Program Constraints

A. Comment on Constraints identified by Firenze as barriers to establishing safety curricula (See Position Papers).

B. Add any additional constraints you feel were omitted by Firenze.

C. Suggest any methods you feel could be effective in avoiding constraints listed by Firenze.

D. Other comments.

VI. Prerequisites for Incoming Students

A. Comment on problems you have had (or that you foresee) in qualifying students to enter occupational safety programs at the undergraduate and/or the graduate levels.

B. Other comments.

VII. Program Evaluation

A. How important is evaluation in the establishment and growth of occupational safety educational programs? Why?

B. Who should be responsible for safety program evaluation? How constituted and what authority?

C. Other comments.

VIII. Reactor Panel

A. Please add any comments you wish regarding addresses given by members of the reactor panel.

B. Add any "reactions" of your own to the operation and outcome of the Symposium.

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