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This report presents the safety research findings and recommendations of Bendix Launch Support Division, which has conducted a year-long study on behalf of the National Institute for Occupational Safety and Health.

The document contains recommendations to conduct research in the general area of industrial/occupational protective clothing aimed toward the development of criteria and performance standards for protective clothing in 27 Industrial/Occupational Areas.

This work is a valuable contribution to the identification of occupational safety research needs and will undergo immediate and careful analysis by appropriate Institute staff. The recommendations contained in this report do not, however, reflect the Institute's final decisions concerning a priority rating method, the rating of protective clothing, or future research objectives. Modifications in these areas will be made as necessary.

This report is believed to be the first organized effort to assess protective clothing in 27 different Industrial/Occupational Areas. As such, it will provide the National Institute for Occupational Safety and Health with a baseline for future research in the area of protective clothing.

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The contents of this report are reproduced herein as received from the contractor except for minor changes to the title page. The opinions, findings, and conclusions expressed are those of the author and not necessarily those of NIOSH. Mention of company or product names is not to be considered as an endorsement by NIOSH.

FOREWORD

This is the final report prepared by the Bendix Corporation, Launch Support Division under the United States Department of Health, Education, and Welfare - Public Health Service, Center for Disease Control, Contract Number HSM-99-73-75, titled:

- Protective Clothing - Assessment of Need

This report is submitted in compliance with special provision article XVIII B. The reporting period is 30 June 1973 through 1 July 1974.

The National Institute for Occupational Safety and Health (NIOSH) Project Officer responsible for the technical direction under this contract is Mr. J. I. Kamin, P. E.

The performance period of the contract is from 30 June 1973 through 1 July 1974.

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PREFACE

This report presents the safety research findings and recommendations of Bendix Launch Support Division, which has conducted a year-long study on behalf of the National Institute for Occupational Safety and Health.

The document contains recommendations to conduct research in the general area of industrial/occupational protective clothing aimed toward the development of criteria and performance standards for protective clothing in 27 Industrial/Occupational Areas.

This work is a valuable contribution to the identification of occupational safety research needs and will undergo immediate and careful analysis by appropriate Institute staff. The recommendations contained in this report do not, however, reflect the Institute's final decisions concerning a priority rating method, the rating of protective clothing, or future research objectives. Modifications in these areas will be made as necessary.

This report is believed to be the first organized effort to assess protective clothing in 27 different Industrial/Occupational Areas. As such, it will provide the National Institute for Occupational Safety and Health with a baseline for future research in the area of protective clothing.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to those organizations and businesses which made their facilities, valuable time, and talents available for use in the completion of this contract.

Special thanks are directed to the following listed organizations.

- Industrial Safety Equipment Association.
- Safety Equipment Dealers Association.
- Those corporations and industries who so graciously opened their facilities to our survey personnel.

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ABSTRACT

This report is the end result of a year-long research effort. The goal of the effort was to provide information to assist NIOSH in the development of criteria and performance standards for specific types of protective clothing to be used in various Industrial/Occupational areas. The project excluded protective clothing worn or used by firefighters, and was limited to torso protective clothing.

From analysis of all the data collected for study in the contract, the following conclusions are drawn:

- Mechanical hazards account for the most injuries in each of the 27 Industrial/Occupational areas. Thermal hazards account for the next highest incidence of injuries, and, in descending order, are: chemical, radiological, electrical, and biological. Accident data places biological injuries as third; however, survey data failed to corroborate this.

- There is a general lack of knowledge on the part of management and employees of the need for protective clothing. Additionally, a large percentage of management and employees who are aware of the need, lack the knowledge to properly select and use protective clothing.

- Even when management acknowledges a need for protective clothing, it does not always attach a high degree of importance to that need.

- Some protective clothing used for chemical and thermal protection can contribute to heat-stress situations by trapping the body heat of workers.

- Some types of protective clothing, especially high-temperature-exposure clothing is bulky to wear and interferes with worker mobility. The present state of the art is not advanced enough to provide insulating qualities efficient enough to reduce the bulk now required for worker protection.

- A large percentage of industry does not supply protective clothing as defined in this study to their workers.

- Protective clothing usage is not stressed in industry.

- No standardized reporting system for accident data is utilized by the various states.

- The first seven Industrial/Occupational areas in the Priority Ranking have a Final Priority Ranking of 300 and above and therefore are of prime concern.

DEFINITIONS

Protective Clothing - Personal apparel used to protect the body from industrial/occupational hazards rather than implying merely protection against soiling. Individual components such as gloves, shoes, helmets, respirators, and eye and face protective devices are included in the protective clothing category only if they are parts of a complete garment or suit which is used to provide the worker with full-body protection. Air-supplied suits are included in the category of protective clothing.

Degree of Environmental Hazards

1st Degree - Exposure to safety and health hazards are negligible - not known to exist.

2nd Degree - Exposure to minor injuries such as abrasions, cuts, and bruises. Health hazards are negligible.

3rd Degree - Exposure to injuries requiring medical attention but without loss of time and without permanent disability. Exposure to occupational health hazards, but of a temporary nature.

4th Degree - Exposure to incapacitating injuries and/or occupational health hazards. Such exposure could result in loss of time and/or permanent partial disability.

5th Degree - Exposure to incapacitating injuries and/or occupational health hazards which could result in extensive lost time and/or major disability or death.

Frequency - Frequency rate is the number of disabling work injuries for each million employee hours worked. The figures were taken, as published, from the Handbook of Labor Statistics, 1972.

Severity - Severity rate is the number of days of disability resulting from disabling work injuries for each million employee hours worked. The figures were taken, as published, from the Handbook of Labor Statistics, 1972.

Mechanical Hazards

1. Struck against, rubbed, or abraided
2. Struck by
3. Caught in, under, or between
4. Fall to same level
5. Fall to different level
6. Overexertion or bodily reaction

Electrical Hazards

1. Alternating current
2. Direct current
3. Static

Thermal Hazards

1. Convected
2. Radiated
3. Conducted

Chemical Hazards

1. Gases and vapors
2. Particulate matter
   (a) Aerosol
   (b) Dust
   (c) Fog
   (d) Fume
   (e) Mist
   (f) Smog
   (g) Smoke
3. Liquids
4. Solids

Radiation Hazards

1. Ionizing radiation
2. Nonionizing radiation

Biological Hazards

1. Skin contact
2. Ingestion
3. Inhalation

Injury - An injury suffered by a person which arises out of and in the course of employment.

Nondisabling Injury - An injury arising out of and in the course of employment in which there is no loss of time beyond the day or shift of occurrence.

Disabling Injury - A work injury resulting in death, permanent impairment, or loss of time beyond the day or shift of occurrence.

Permanent Total Disability - Any injury other than death which permanently and totally incapacitates an employee from following any gainful occupation, or which results in the loss or the complete loss of use of any of the following: (1) both eyes, (2) one eye and one hand, arm, leg, or foot, or (3) any two of the following not on the same limb: hand, foot, arm, or leg.

Permanent Partial Disability - Injury which results in the loss of or permanent impairment of the use of any body part or function in any degree less than permanent total disability.

Temporary Total Disability - Injury which renders the injured person unable to perform work for pay, but from which disability he may expect to fully recover.

Fatality - Any death resulting from an on-the-job accident within 1-year thereafter or following a continuous disability resulting from the accident within a 5-year period.

Occupational Disease - A disease which is due to causes and conditions which are characteristic of and peculiar to a particular trade, occupation, process, or employment.

Days of Disability - Days of disability include standard time charges for deaths and permanent impairments and the number of full calendar days in which the injured persons were not able to work because of temporary total disabilities. The day of injury and the day which the injured workers returned to work are excluded.

Nature of Injury - Identifies the injury in terms of its principal physical characteristics, i.e., fracture, laceration, sprain, etc.

Agency of Injury - Identifies object, substance, exposure, or bodily motion which directly produced or inflicted the injury.

Accident Type - Identifies the manner in which contact with the object or substance causing the accident occurred, e.g., struck against; rubbed or abraided; struck by; caught in, under, or between; contact with temperature or pressure extremes; etc.

Industry - The industry classifications used in this report are in accordance with the Standard Industrial Classification, 1967 Revision, published by the Bureau of the Budget, Executive Office of the President.

Protective Clothing Category

Category 1 - Head and Torso

Hood
Snood
Parka
Helmet Cover

Category 2 - Upper Torso

Bib
Cape Sleeves
Cape Sleeves with Bib
Cape
Shirt
Jacket
Vest

Category 3 - Lower Torso

Chaps
Trousers
Apron, Waist-Type
Apron, Waist-Type, Split-Leg
Waders

Category 4 - Entire Torso

Coat
Coverall
Overall
Apron, Bib
Apron, Bib, Split-Leg
Apron, Sleeve
Suit
Suit, Open-Back
Smock

Category 5 - Specialized Torso

Suit, Survival, Arctic Waters
Suit, Skin-Diving
Air Conditioner, Suit, Vortec
Vest, Buoyant, Work
Suit, Captive or Tunnel
Suit, Environmental, Self-Contained

Protective Clothing Classes

Class A - Ensembles providing complete environmental isolation from serious accident or health hazards where fatal injuries could result. Examples of these ensembles are: (1) the supplied-air, fire-entry suits used in the glass manufacturing industry for entry into the extreme temperatures encountered during repair operations inside glass-making ovens, and (2) the self-contained fuel handlers' ensembles used by rocket propellant technicians during fueling operations.

Class B - Full-body ensembles providing a less extensive standard of protection in an area where the risk of injury or death is less acute. An example of this ensemble is the aluminized fabric proximity suit used by workers in molten metal operations in the foundries and steel mills.

Class C - Partial-body protection required to ensure positive protection to specific parts of the body. Examples of this type of protection are: (1) leaded aprons used in X-ray operations, (2) abrasive hoods with bibs used in sandblasting operations, and (3) welders' cape sleeves with bibs.

Class D - Basic standard of body protection required to avoid personal injury in an environment where hazardous conditions may occur due to the nature of job operations, equipment, or materials involved. An example of this type of protection is the basic work uniform of the worker. It may be a one- or two-piece coverall type, and may be fabricated from several types of natural or man-made fabrics.

INTRODUCTION

This is the Final Report of the Protective Clothing-Assessment of Need contract. Contained in this report are integrated data assessments of information gained from the on-site survey portion of the contract, and information compiled from other sources. Applicable trends are identified as they pertain to the need, use, acceptability, and availability of protective clothing in the 27 Industrial/Occupational areas of the contract.

The overall purpose of the contract was to perform four major tasks. They were:

Task A. Determine the need for various types of protective clothing based on worker exposure to typical working environments in various industries/occupations.

Task B. Evaluate the present state of the art to determine the extent to which the needs can be met by presently available protective clothing, and the areas for which protective clothing is not available.

Task C. Evaluate and define those areas for which protective clothing is presently available but is unsatisfactory because of poor performance and/or its lack of acceptance by the worker.

Task D. Devise a plan for a priority system for the purpose of ranking the need for the various types of protective clothing in the various industries and/or occupations.

For the purpose of this contract, the term, "protective clothing," means personal apparel used to protect the body from industrial/occupational hazards, rather than implying merely protection against soiling. Individual components such as gloves, shoes, helmets, respirators, and eye and face protective devices are included in the protective clothing category only if they are parts of a complete garment or suit which is used to provide the worker with full body protection. Air-supplied suits are included in this category. Firefighting ensembles were excluded from the contract scope.

As mentioned previously, the report encompasses 27 Industrial/Occupational areas or operations. They are:

1. Chemical and allied products
2. Oil refineries
3. Pig iron production
4. Steel mills
5. Metal smelting
6. Beryllium operations
7. Asbestos operations
8. Coal mining
9. Metal mining

10. Uranium mining
11. Rubber and tire production
12. Vehicle production
13. Glass production
14. Construction
15. Bakeries
16. Painting
17. Public utilities
18. Welding operations
19. Abrasive and buffing operations
20. Operations generating silica dust
21. Pesticide and insecticide spraying
22. Machine tool production
23. Metal fabrication
24. Lumber and wood products
25. X-ray operations
26. Operations involving bacteria
27. Operations involving heat stress

For evaluation purposes, the hazards in the above Industrial/Occupational areas were divided into the following six broad categories:

- Mechanical
- Thermal
- Chemical
- Radiological
- Electrical
- Biological

These six categories of hazards are defined under "Definitions."

The four major tasks defined by the contract and summarized previously in this Introduction were accomplished as shown in the following four paragraphs. Detailed discussions of the performance of these tasks and the resultant findings will be presented in the main body of the report.

In performing Task A, protective clothing versus exposure, a literature search and an extensive field survey were conducted.

Task B, evaluation of the present state of the art, was accomplished through a specifications and standards research effort.

Task C, suitability and acceptance of protective clothing, was accomplished by contacts with manufacturers/suppliers of protective clothing, labor unions, trade associations, and professional societies.

Task D, priority ranking of protective clothing, was accomplished by using data from Tasks A, B, and C.

The intent of this report is to lay a foundation for the National Institute for Occupational Safety and Health (NIOSH) to conduct research and experimental work in the general area of industrial/occupational protective clothing aimed toward the development of criteria and performance standards for specific types of protective clothing in the various industries and occupations contained herein.

CONTRACT REQUIREMENTS

As stated in the Introduction, the overall purpose of this contract concerned itself with four major tasks. These were:

- Determining the need for various types of protective clothing based on worker exposure to typical working environments in various industries.
- Evaluating the present state of the art to determine the extent needs could be met by presently available protective clothing and determining the areas where protective clothing is unavailable.
- Evaluating and defining areas where protective clothing is presently available but is unsatisfactory because of poor performance or lack of worker acceptance.
- Establishing a plan for priority ranking the need for various types of protective clothing in the various industries.

Assessing the need for protective clothing necessarily began with establishing the hazard to be protected against. Many industries share common employee hazards such as noise, crushing, and limb trapping. However, some industries exhibit hazards inherent only in that operation or process, e.g., the handling of caustic or toxic materials creates environments harmful to man that require a self-contained atmospheric protective ensemble for job performance.

Bendix initiated a research and analysis effort to provide HEW/NIOSH with reliable information on the need for protective clothing in all the pertinent industrial/occupational environments. A Protective Clothing Need versus Exposure analysis for the 27 Industrial/Occupational areas was performed by researching the literature listed below:

- Best's Loss Control and Underwriting Manual
- Best's Environmental Control and Safety Directory
- American National Standards Institute documents
- Military Technical Orders and Specifications
- NASA, Agriculture Department, A.E.C., and Labor Department publications

The Kennedy Space Center Technical Library, local public libraries, and university libraries were also used to research protective clothing requirements for particular work environment exposure hazards.

The following organizations were contacted by letter and asked for specific information relating to protective clothing needs and availability:

- State Workmen's Compensation bureaus
- Bureau of Mines
- U. S. Bureau of Labor Statistics
- National Safety Council
- American Society of Safety Engineers
- American Chemical Society
- American Industrial Hygiene Association
- American Institute of Chemical Engineers
- American Foundrymen's Association
- Industrial Safety Equipment Association
- Safety Equipment Dealers Association

To supplement the above research, a physical survey was developed and conducted in six geographical areas. Figure 1 on the following page portrays the geographical areas visited.

The training of the two field survey representatives consisted of a review of sound interviewing and surveying techniques. Emphasis was placed on proper questioning and the requirement to interview the workers as well as members of management. Also stressed was the requirement to be very observant of operations and to record their impressions and observations. The contract was reviewed in the areas of definitions, requirements, and goals. Company policy regarding travel and general trip management was discussed. The final phases of the training effort were concerned with performing a pilot survey in the Bendix Technical Support Shops at Kennedy Space Center, Florida, critiquing the training program, and assisting in the formatting of the field survey questionnaires.

The design of the survey form attempted to satisfy three requirements:

- To gather as much pertinent data as practical.
- To make the data adaptable for use by field survey representatives.
- To be applicable for use in a limited mail survey.

The form was used during a pilot test survey. The test revealed the form to be unwieldy due to a lack of continuity which required the Surveyor at times to move back and forth from one page to another. Also, a large amount of writing was required to record the answers to questions.

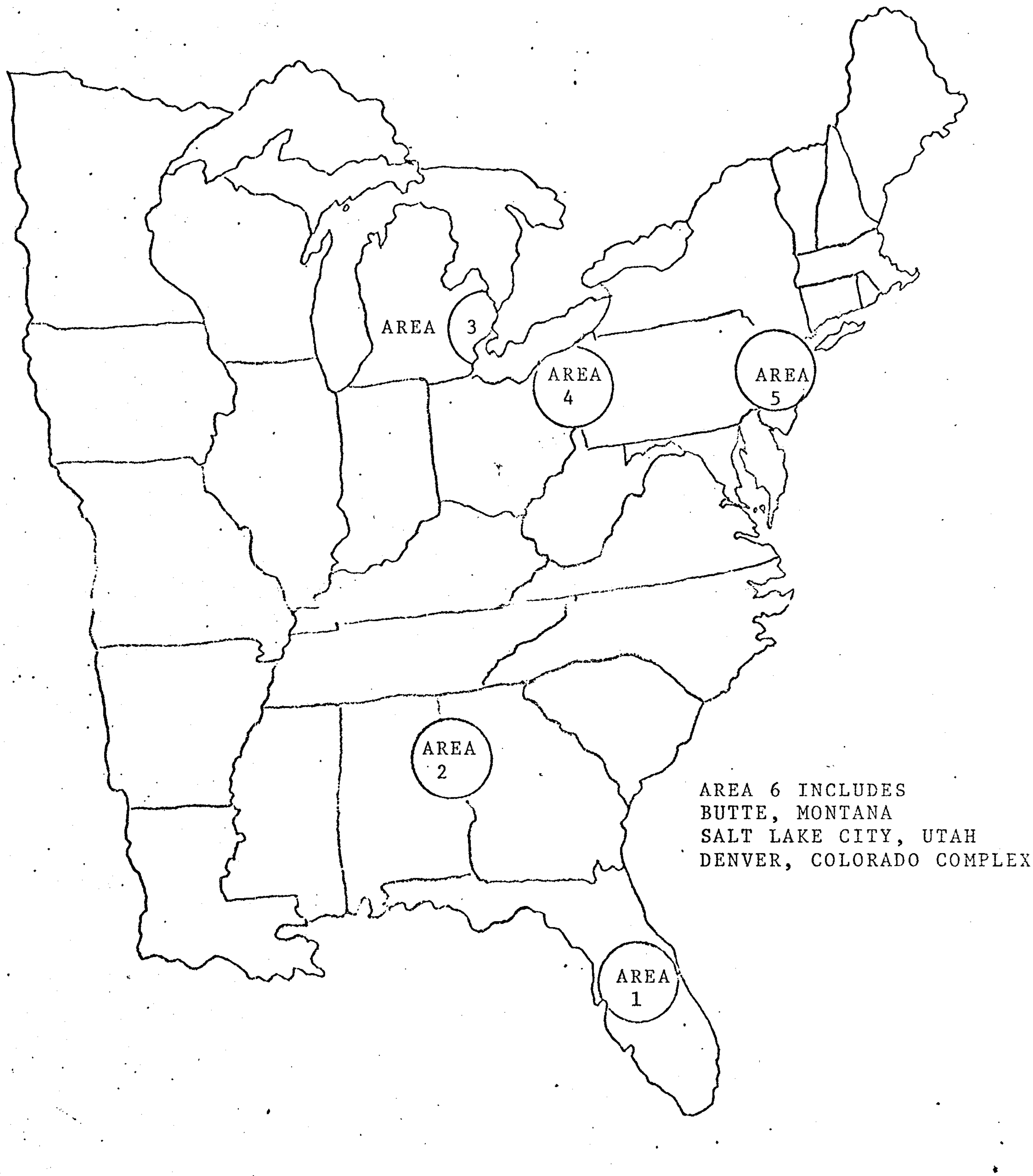


FIGURE 1.

SURVEY AREAS

In the form redesign, the problem of lack of continuity was reviewed and portions were rearranged to achieve a more logical flow. The techniques of check-the-block, underline, or circle-the-key-word were used. This allowed the form to be abbreviated without the chance of loss of desired data.

Experience has taught us that requesting permission from a company to perform a survey is best accomplished by telephone. With this understanding, contacts with companies to be surveyed were made using the following guidelines:

- Contact a minimum of 30 companies in each survey.
- Strive for an even distribution between large and small companies. (For this consideration, a figure of 50 employees was used for the dividing point between large and small.)
- Attempt to visit companies where employees are exposed to numerous types of hazards. This was accomplished by reviewing the manufacturing processes which exposed employees to the greatest number of the hazards we were interested in surveying, and selecting those companies employing these processes.
- Attempt an even distribution among the Industrial/Occupational areas or operations. This was accomplished by tabulating occupational areas or operations surveyed in each geographical area.

A total of 130 companies were surveyed to accomplish the survey portion of the contract. A survey narrative including photographs obtained during the survey was prepared for each of the survey sites visited. All of the survey narratives are presented in Volume II of this report.

The format of the narrative reports was designed to give the reader as complete a picture as possible of the data obtained from the field surveys. Section I of the narrative contains a company summary which gives the number of workers employed and the products produced by the company, and states whether the production processes were manual or automated. A discussion is also presented on the protective clothing policies of the company. The discussion includes such data as whether protective clothing is made available to employees; a description of the clothing maintenance program, if any; and whether protective clothing requirements are periodically reviewed. If company policy permitted the interviewing of employees, the employees' comments regarding protective clothing are included. Deficiencies in protective clothing design, as identified by workers, are also noted.

The Survey Representative's observations and comments are presented in Section II of the narrative report. Items included are: observations of the work environment, such as noise and lighting levels; a description of the hazards to which workmen were exposed; and a description of the production operations at the facility. Comments on the Survey Representative's evaluation of presently used clothing, and recommendations for additional protection are included.

Section III of the narrative contains photographs of work practices within the facility. It should be noted that photographs were not taken in all instances due to prohibitions against photography by either company management or employees. Section IV presents the conclusions reached by the Survey Representative from interviews with workers and management, and personal observations during the survey visit.

Field surveys were conducted in Area 1 (Florida), Area 2 (Atlanta, Georgia and Birmingham, Alabama), Area 3 (Detroit, Michigan), Area 4 (Cleveland, Akron, and Youngstown, Ohio and Pittsburgh, Pennsylvania), Area 5 (New Jersey and New York), and Area 6 (the Western slopes in Colorado and Utah). Total worker population of the plant facilities surveyed was 93,343.

Debriefings were conducted after surveys were completed in each geographical area. These were accomplished to ensure observations and impressions were recorded in detail while recollections of the surveys were still fresh in the minds of the survey team. This also served to identify problem areas encountered so that remedial efforts could be effected.

In addition to the above survey and literature research, all 52 Bendix Divisions were contacted for specific injury data relating to the use/non-use of protective clothing. The result of this request was a review of OSHA 101 Forms from the Bendix Divisions; this data is presented later in this report.

TASK A - DETERMINING THE NEED FOR PROTECTIVE CLOTHING

INTRODUCTION

The need for various types of protective clothing, based on worker exposure to typical working environments in various industries, was determined by using the combined data from the on-site survey portion of the contract, specifications currently available from government sources, Bendix Corporation accident experience, various states' Workmen's Compensation experience, and publications listed earlier in this report.

As discussed previously, a field survey was conducted in six geographical areas within the United States. A Survey Form was prepared to ensure the Survey Representatives collected the needed information to effect a proper analysis. This Survey Form, which provided all the data needed to evaluate each task, is shown on the following pages.

For the purpose of this contract, only torso protective clothing was considered. This necessitated limiting all State and Bendix Corporation accident data to that part of the body. A sketch showing the definitions of each body part is presented on page 14.

It was felt that identifying and categorizing the hazards stated in the contract was of primary importance. The six types of hazards (mechanical, thermal, chemical, radiological, electrical, and biological), may be considered as Level 1 hazards. A cursory search of several safety engineering texts revealed no standardized breakdown of the Level 1 hazards into secondary and tertiary levels. A logical and systemized method of categorization was necessary to:

- Ensure a thorough research effort.
- Ensure logical interpretations and valid recommendations.
- Act as a valuable tool in accident data analysis.

The Hazard Index Table presented in Appendix I establishes the different levels of detail for each Level 1 hazard. For example, Level 1 is the broadest category (mechanical, thermal, etc.). Level 2 establishes greater stages of detail by identifying hazard type, Agency involved, and nature of injury. Level 3 further details Level 2 by giving specific information on hazard types, Agencies, and injuries.

To define the degree of environmental hazards connected with or adjacent to jobs in each Occupational/Industrial area, the following definitions of hazard severity were established:

- 1st Degree - Exposure to safety and health hazards are negligible.

This degree is self-explanatory in meaning no hazards were known to exist.

- 2nd Degree - Exposure to minor injuries, such as abrasions, cuts, bruises. Health hazards are negligible.

DEPARTMENT OF HEALTH EDUCATION AND WELFARE, HEALTH SERVICES AND MENTAL HEALTH ADMINISTRATION, NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH CONTRACT HSM 99-73-75

PART A

Code No.: ____________ Date: ____________

S.I.C.: ____________

Survey Representative: ____________

Company Name: ____________

Address: ____________

Telephone No.: ____________

Technical Contact & Title: ____________

Number of Employees: ____________

Company Products Involved: ____________

Industrial/Occupational Area: ____________

1. Description of operation being performed: ____________

2. Is operation manual or automated? ____________

   Explain: ____________

1. Operation (Job) Manual/Automated:

____

____

____

2. Hazard - thermal, electrical, biological, radiological, chemical, mechanical.

   b. Body area requiring protection: ____________________

   9. Is mechanical protection available? ____________________

   Describe: ____________________________________

   ____

3. What protective clothing is available? List - separate for each task.

____

____

____

____

____

____

____

4. Hazardous operations performed without protective clothing.

5. Is protective clothing required, supplied, maintained and how by company? ____________________, ____________________,

____________________, ____________________________

____

____

6. Does clothing cause added risk? ____________________________

____

____

7. Workers' rating of apparel. (Explain)

Inadequate

Adequate

More than Adequate

Suggestions for Improvements

8. Surveyors' rating.

Available & Adequate ______________________________

Available but Inadequate ______________________________

____

Not Available ______________________________

Lacks User Acceptance ______________________________

____

12. Are protective clothing needs periodically evaluated and revised?

____

a. If yes, by who and how? ______________________________

____

____

Code No.: ____________

13. Survey Representative's observation and comments:

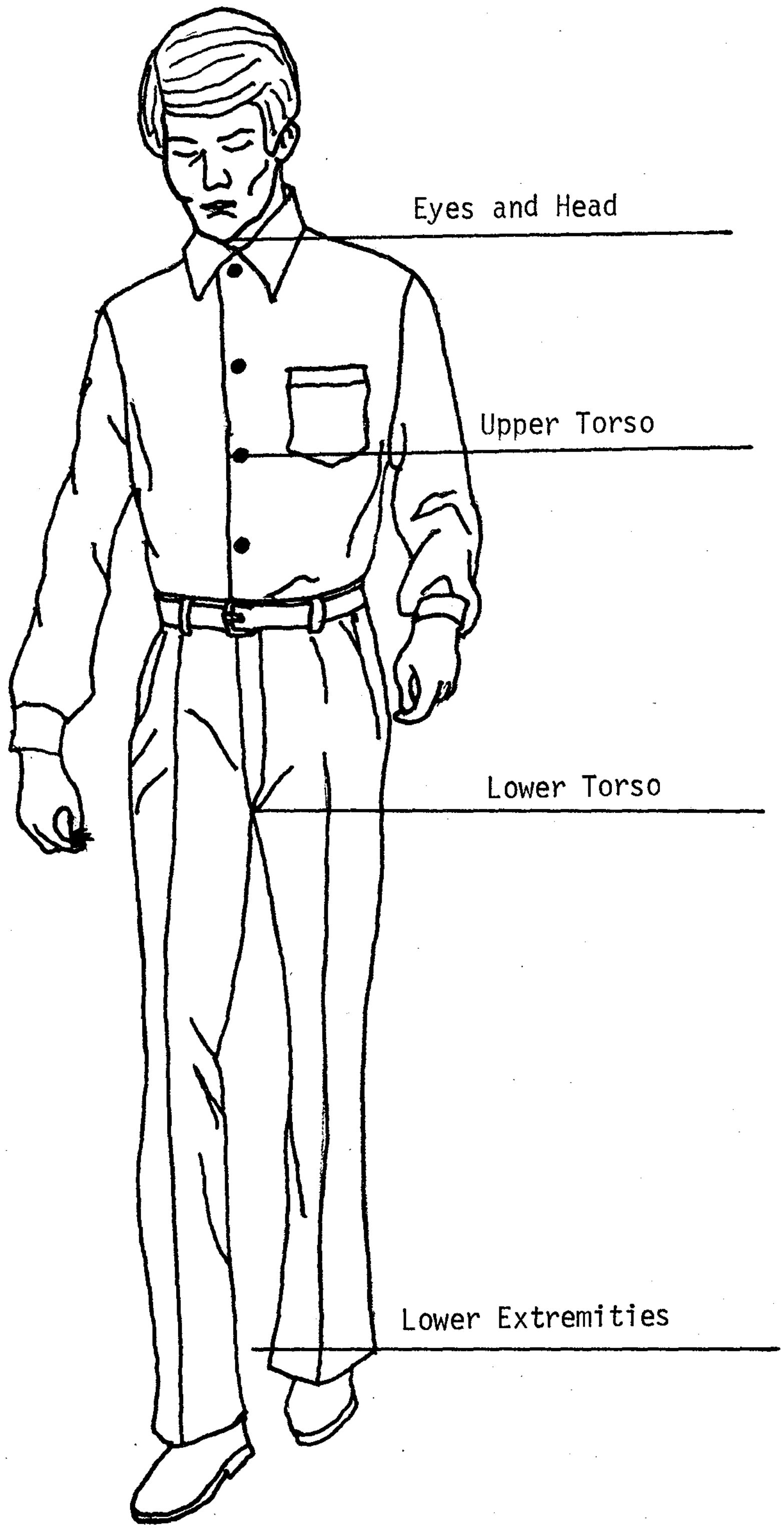


Figure 2

PROTECTIVE CLOTHING,

PART OF BODY DEFINITION

This degree was established in the knowledge that many industrial processes expose the worker to only the most minor injuries. An example of this situation would be a completely automated manufacturing facility where worker protection was attained by isolation.

- 3rd Degree - Exposure to injuries requiring medical attention but without loss of time and without permanent disability. Exposure to occupational health hazards, but of a temporary nature.

The third-degree definition was established with the fact in mind that in many industries or occupations, workers are subject to light- or moderate-hazard exposures where injuries may occur but of a sufficiently moderate nature to not cause lost time. An example of this situation would be a partially automated light manufacturing activity.

- 4th Degree - Exposure to incapacitating injuries and/or occupational health hazards. Such exposure could result in loss of time and/or permanent partial disability.

This degree was established by the fact that some Industrial/Occupational areas exhibit exposure hazards of such a severity that lost time injuries and partial disabilities may be expected if accidents occur during the course of operations.

- 5th Degree - Exposure to incapacitating injuries and/or occupational health hazards which could result in extensive lost time and/or major disability or death.

The fifth-degree definition was established knowing that some highly dangerous operations are performed in industry which expose workers to major disability or death.

Since identifying hazards and establishing degrees of hazards in the various Industrial/Occupational areas was the starting point for any determination of need for protective clothing, the field surveys played an important role in accomplishing this task. Using the Hazard Severity listing explained previously, hazard severity exposure levels were constructed for each of the facilities surveyed. The severity levels were assigned by analysis of the total working environment of the facility visited and were based on information gained from the surveys. In each case, the degree of hazard was based on the most probable hazard exposure.

A Hazard Severity Matrix was then constructed for each Industrial/Occupational area with the exception of Heat-Stress Operations and Public Utilities. Each of the six hazards specified in the contract is identified by its initial at the top of the matrix. Thus:

- M = Mechanical hazards
- T = Thermal hazards
- C = Chemical hazards

- R = Radiological hazards
- E = Electrical hazards
- B = Biological hazards

The relevant companies surveyed in each area are identified by their company codes down the left side of the matrix. A degree of hazards was then assigned to each of the hazards observed at the facility surveyed.

Evaluation of the current availability and suitability of protective clothing was accomplished after defining the existing hazards in the Industrial/Occupational areas and the currently available protective clothing for hazard protection. When an item of protective clothing was unable to be identified for a specific hazard, it was inferred none was available.

For ease of protective clothing identification,a protective torso wear classification system was constructed. The list below identifies each category and gives examples of the types of apparel included in each.

- Category 1 - Head and Torso

  Hood
  Snood
  Parka
  Helmet Cover

- Category 2 - Upper Torso

  Bib
  Cape Sleeves
  Cape Sleeves with Bib
  Cape
  Shirt
  Jacket
  Vest

- Category 3 - Lower Torso

  Chaps
  Trousers
  Apron, Waist-Type
  Apron, Waist-Type, Split-Leg
  Waders

- Category 4 - Entire Torso

  Coat
  Coverall
  Overall
  Apron, Bib
  Apron, Bib, Split-Leg

Apron, Sleeve
Suit
Suit, Open-Back
Smock

- Category 5 - Specialized Torso

  Suit, Survival, Arctic Waters
  Suit, Skin-Diving
  Air Conditioner, Suit, Vortec
  Vest, Buoyant, Work
  Suit, Captive or Tunnel
  Suit, Environmental, Self-Contained

Current availability of protective clothing was identified by letter and telephone contacts with protective clothing manufacturers and by requests for catalogs, brochures, and technical data on their products. Manufacturers were identified through literature searches.

Hazard Level Protection Classifications for protective clothing were established to aid in the evaluations. To this end, the following classifications were defined:

- Class A - Ensembles providing complete environmental isolation from serious accident or health hazards where fatal injuries could result. Examples of these ensembles are: (1) the supplied air fire entry suits used in the glass manufacturing industry for entry into the extreme temperatures encountered during repair operations inside glass-making ovens, and (2) the self-contained fuel handlers' ensembles used by rocket propellant technicians during fueling operations.

- Class B - Full body ensembles providing a less extensive standard of protection in an area where the risk of injury or death is less acute. An example of this ensemble is the aluminized fabric proximity suit used by workers in molten metal operations in the foundries and steel mills.

- Class C - Partial body protection required to ensure positive protection to specific parts of the body. Examples of this type of protection are: (1) leaded aprons used in X-ray operations, (2) abrasive hoods with bibs used in sandblasting operations, and (3) welder's cape sleeves with bibs.

- Class D - Basic standard of body protection required to avoid personal injury in an environment where hazardous conditions may occur due to the nature of job operations, equipment, or materials involved. An example of this type of protection is the basic work uniform of the worker. It may be a one- or two-piece coverall type, and may be fabricated from several types of natural or man-made fabrics.

There is some relationship for evaluation purposes to the degree of hazard and the class of clothing. It is logical to assume that Class C and D clothing items, because they do not provide the extent of protection that Class A and B provide, would be better suited for less hazardous exposure protection. In most cases, Class A and B clothing could be expected to provide protection against 4th- and 5th-degree hazards, and Class C and D clothing to protect against 2nd- and 3rd-degree hazards. The nature of hazards inherent in the industries studied, and the various worker occupations included do not lend themselves to more detailed analysis. This will have to await further NIOSH study and analysis for further research efforts.

Identification of areas where clothing is available, but is unsatisfactory due to poor performance or lack of worker acceptance, was completed using survey data gained from worker interviews. The information obtained from the interviews is the best source available to provide worker acceptance criteria and also performance criteria. Analysis completed of accident data available from states' Workmen's Compensation offices and other sources was not detailed enough to meet protective clothing performance assessment needs. The focal point of work injury data assessment should be to identify the ability of protective clothing to eliminate or reduce the possibility of injury to the worker. In order to do this, the following information must be available or obtainable:

- The items of protective clothing, if any, being utilized during the accident/injury.
- The propriety of the items of protective clothing being utilized for the degree of hazards encountered during job performance.
- The extent of injuries incurred.
- Events leading to the accident/injury.

This data was not obtainable from available accident data, nor was it available from other sources which were tried such as:

- Trade Unions
- Protective Clothing Manufacturers
- Hospitals

Each Industrial/Occupational area as it relates to determining the need for protective clothing is discussed on the following pages.

CHEMICAL AND ALLIED PRODUCTS

A total of 13 companies were surveyed in the chemical and allied products Industrial/Occupational area. The worker population of the sample was 10,946. Chemical and mechanical hazards were the most prevalent, with chemical hazards being the most severe observed. The thermal hazards encountered in the manufacturing processes were noted in five of the 13 companies surveyed. Radiological, electrical, and biological hazards were negligible in this industry sample.

Protective clothing needs may be expressed as the following:

- Mechanical - The use of heavy leather or similar-material clothing, such as aprons, cape sleeves, chaps, jackets, or pants may be indicated for material handling.

- Thermal - The use of flame-resistant basic work uniforms may be indicated to protect workers from flash fires. The use of aluminized and nonaluminized flame-proof clothing may be indicated around high-temperature processes.

- Chemical - The use of complete environmental ensembles is indicated during hazardous chemical handling operations. The use of chemical-impervious clothing such as aprons, coats, hoods, suits, trousers, and sleeves is indicated during lesser exposure.

Using the hazards severity listing previously explained, hazard severity exposure levels were constructed for each of the facilities surveyed. The matrix on the following page identifies, the hazard in its relative severity for each of the companies surveyed. As can be seen, 4th-degree chemical hazards predominate in the sample. Only one 5th-degree chemical severity was identified. In this particular facility, self-contained atmospheric protective ensembles were used during both chemical transfer and handling operations, due to the extreme toxicity of the materials involved. A 2nd-degree chemical severity classification can be noted for Company Code 3-8. This facility was almost completely automated and chemical exposure to workers was, for the most part, completely eliminated.

Mechanical hazards, as noted in the matrix, were as prevalent as chemical ones in the industry sample. However, they were not, on the average, as severe. Third-degree mechanical hazard classifications were assigned to seven of the 13 facilities surveyed. For the most part, mechanical hazards were concentrated in the material transfer and handling operations. Housekeeping played an important part in the determination of mechanical hazards severity classifications. Facilities that were automated, or well maintained and orderly were noted to have a marked decrease in mechanical hazard exposure. For example, the Survey Representative comments in the narrative for Company Code 2-12 state that the manufacturing plant was crowded, wet, poorly ventilated, and poorly lighted. The air was heavy with steam and chemical fumes. Employees were exposed to such hazards as

Figure 3

HAZARD SEVERITY MATRIX

CHEMICAL AND ALLIED PRODUCTS

COMPANY CODE	M	T	C	R	E	B
1-12	3	1	4	1	1	1
1-27	2	1	4	1	1	1
1-28	2	1	4	1	1	1
2-9	4	1	4	1	1	1
2-10	3	1	4	1	1	1
2-12	3	3	4	1	1	1
2-16	3	1	3	1	1	1
2-18	2	4	4	1	1	1
2-22	2	3	3	1	1	1

Figure 3

HAZARD SEVERITY MATRIX

CHEMICAL AND ALLIED PRODUCTS (CONTINUED)

COMPANY CODE	M	T	C	R	E	B
3-8	2	1	2	1	1	1
3-16	3	2	3	1	1	1
4-1	3	1	5	1	1	1
4-11	3	3	3	1	1	1

Average Hazard Severity = 3.1290

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

wet floors, slippery footing, falls, and open, moving machinery. This particular facility was given a 3rd-degree hazard severity rating for mechanical hazards.

The Survey Representative's comments on Company Code 1-27, however, stated that this particular chemical blending and packaging company was very clean, well lighted, and functionally designed. There were chemical safety showers and eye-bath stations located inside and outside the central plant. Emergency equipment, posted instructions and directions, and warning devices were placed at strategic locations throughout the work area. Because of the cleanliness and orderliness of this particular facility, the mechanical hazards involved were substantially reduced. Therefore, this particular facility was given a 2nd-degree hazard severity rating.

Five of the 13 industries surveyed exhibited thermal hazards in their production processes. These hazards originated from steamlines and cooking vats used in the preparation of adhesive formulas, or, in one case, a "glass furnace" used in the production of inorganic paint pigments. (A 4th-degree severity rating was assigned to the "glass furnace" operations due to the high radiant and ambient heat exposures inherent in the charging and tapping of the furnace.) A 3rd-degree hazard classification was assigned to these hazards which were those that could normally be expected working around hot steamlines and the hot materials emerging from the cooking vats. From inspection of the Hazards Severity matrix, it can be seen that thermal hazards, while not as prevalent as chemical and mechanical hazards, do present a problem in some chemical processes.

Radiological, electrical, and biological hazards were negligible in all the companies surveyed in this sample.

Bendix accident data was not available in this Industrial/Occupational area as the Corporation does not engage in these production processes.

Florida accident data was analyzed for protective clothing torso related injuries. This was defined as those injuries to the trunk, excluding strains, sprains, or hernias, as these injuries cannot be prevented by protective clothing. Florida in 1971 reported 40 percent of all injuries were of this nature. Therefore, 40 percent of the trunk injuries can be classified as not being related injuries. The data for the Chemical and Allied Products Industry shows the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Chemical and Allied Products	541	47	5.2

Pennsylvania data was analyzed in the same manner as Florida's. Approximately 30 percent of the injuries reported were strain, sprain, or hernia natures. The data shows that Pennsylvania in April 1973 reported the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Chemical and Allied Products	128	43	23.5

During the field surveys, observations were made by the Field Survey Representative to determine current protective clothing practices in the industry. It was noted that:

- Protective clothing was worn in 10 of the 13 Chemical and Allied Products manufacturing companies, even though protective clothing wear was required by the company in only nine of them.

- Eleven of the companies surveyed in this Industrial/Occupational area supplied protective clothing to their workers.

- Protective clothing caused added risk in one of the companies surveyed.

During the surveys, workers were interviewed to determine their assessments of the protective clothing supplied them. Sixty-two percent of the workers rated the protective clothing given them as providing adequate protection for their needs. Eight percent rated the protective clothing as inadequate. The major complaint was that the protective clothing was too hot and bulky to wear in some operations. In three of the 13 companies surveyed, employee interviews were not permitted; therefore, comments for them cannot be included in the workers' ratings.

The information listed below reflects the number of companies shown in the sample that had available and adequate clothing, had available but inadequate clothing, or did not supply clothing to their workers. It can be seen that:

- In only five of the 13 companies surveyed, adequate protective clothing was made available to the workers.

- Five of the companies made protective clothing available to their workers, but the clothing was inadequate to protect workers from the hazards involved.

- Two of the companies surveyed did not provide protective clothing to their workers.

In all cases where protective clothing was available but inadequate, the inadequacy was not that there was no protective clothing available on the market to protect against the hazards encountered. Rather, protective clothing was not supplied or chosen correctly in all chemical production or handling operations.

As an example, the Surveyor for Company Code 1-27 mentions that production workers were provided items of protective clothing. However, employees involved in transfer of bulk hazardous chemicals were not provided any protective clothing. Also, the Surveyor for Company Code 1-28 notes that in the transfer of liquid chemicals, employees were supplied rubber gloves, aprons, and respirators. He felt that these were inadequate, and that more splash gear, such as face shields and protection for the lower extremities, should be utilized.

It was interesting that the companies that did not supply protective clothing to workers were among those with the highest-ranked chemical and mechanical hazards. For instance, Company Code 2-10, a company which formulates bulk pesticides, provides no protective clothing to workers at the facility. The Surveyor indicates that protective clothing was definitely required to protect worker from spillage and splash of the chemicals used in the formulation of the pesticides.

The chart on the following page identifies the protective clothing needed to protect workers from the hazards which are normally associated with the Chemical and Allied Products Industry.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	3rd	Apron, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
		Chaps, Heavy Material	yes
		Jackets, Heavy Material	yes
		Pants, Heavy Material	yes
Thermal	4th	Shirt, Flame-Resistant	yes
		Pants, Flame-Resistant	yes
		Suit, Flame-Resistant	yes
		Overall, Flame-Resistant	yes
		Coverall, Flame-Resistant	yes
		Coat, Flame-Resistant/Aluminized	yes
		Jacket, Flame-Resistant/Aluminized	yes
		Pants, Flame-Resistant/Aluminized	yes
		Suit, Flame-Resistant/Aluminized	yes
		Overall, Flame-Resistant/Aluminized	yes
		Coverall, Flame-Resistant/Aluminized	yes
		Hood, Flame-Resistant/Aluminized	yes
		Apron, Flame-Resistant/Aluminized	yes
		Cape Sleeves, Flame-Resistant/Aluminized	yes
Chemical	5th	Coat, Chemical-Resistant	yes
		Jacket, Chemical-Resistant	yes
		Pants, Chemical-Resistant	yes
		Suit, Chemical-Resistant	yes
		Overall, Chemical-Resistant	yes
		Coverall, Chemical-Resistant	yes
		Hood, Chemical-Resistant	yes
		Apron, Chemical-Resistant	yes
		Cape Sleeves, Chemical-Resistant	yes
		Suit, Environmental, Chemical-Resistant	yes

Table 1

PROTECTIVE CLOTHING NEEDS

I/O Area Chemical and Allied Products

OIL REFINERIES

Three oil-refining facilities were surveyed during the Field Survey portion of the contract. The worker population of the sample was 2,360. Mechanical, thermal, and chemical hazards were noted to be the most prevalent, with electrical hazards and radiological hazards next in order. The predominant hazards of oil-refining operations are:

- Mechanical - Maintenance of equipment, slippery surfaces, falls from various heights, material handling.
- Thermal - Hot liquids in various stages of process, furnaces, hot piping, and fires or explosions.
- Chemical - Fumes and splashes of petroleum products during refining.
- Radiological - Radioactive tracing devices used in fluid piping system of refinery.

Protective clothing needs for workers involved in oil-refining processes are primarily centered on thermal and chemical hazard protection. Needs for the worker are:

- Mechanical - The use of protective clothing fabricated of leather or heavy material in the form of split-leg aprons, jackets, and pants for maintenance and material handling.
- Thermal - The use of insulated and aluminized, fire-resistant clothing is indicated for work around hot piping and furnaces. The need for fire-resistant general work clothing is evident.
- Chemical - The use of petroleum-resistant, impermeable clothing such as aprons, coats, and trousers is indicated. For more hazardous operations, the use of specialized equipment such as complete environmental protection ensembles should be used.
- Radiological - The need for radiation clothing was not established due to the low radioactivity levels of the tracer devices and employee isolation when items are in use.

The Hazard Severity matrix on the following page presents the degree ranking for each hazard observed at the facility visited. The rankings are explained as follows:

- Thermal hazards were ranked as 4th degree in each facility visited. This ranking was due to the elevated temperatures used during the refining and cracking process, and the fire hazards inherent in the petroleum products being produced.
- At two of the facilities, 3rd-degree rankings for mechanical hazards were made, and a 2nd-degree ranking was made at one. The 2nd-degree ranking was due to the highly automated processes

Figure 4

HAZARD SEVERITY MATRIX

OIL REFINERIES

COMPANY CODE	M	T	C	R	E	B
5-1	3	4	3	1	1	1
5-2	2	4	3	1	1	1
5-3	3	4	3	2	1	1

Average Hazard Severity = 3.1000

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

at Company Code 5-2. The 3rd-degree rankings for Company Codes 5-1 and 5-3 were given because both plants were undergoing major facility modernization and enlargement. This significantly increased the mechanical risks to workers.

- Chemical hazards were prevalent at all three facilities. Petroleum distillates can cause toxic reactions ranging from dermatitis of the skin to depression of the central nervous system. Chemical hazards were ranked as 3rd degree at the three refineries surveyed.

- Radiological hazards were apparent at only one of the facilities visited. Company Code 5-3 employed radioactive tracing devices in the piping systems of the plant. Hazards were minimized by employee isolation, procedural safeguards, and by the very low radioactivity of the tracing devices. A ranking of 2nd degree was given this hazard.

Bendix Corporation accident data was not available for oil refining operations.

Florida accident data was analyzed for protective clothing torso related injuries. This was defined as those injuries to the trunk, excluding strains, sprains, and hernias, as these injuries cannot be prevented by protective clothing. Florida in 1971 reported that 40 percent of all injuries were of this nature. Therefore, 40 percent of the trunk injuries can be classified as not being related injuries. The data for oil refining operations shows the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Petroleum Refining and Related Industries	91	6	4.0

Pennsylvania data for April 1973 was analyzed in the same manner as Florida's. Pennsylvania, however, reports 30 percent of the injuries are strains, sprains, or hernias. The data shows:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Petroleum and Coal Products	48	14	20.4

Analysis of the field survey data for oil refineries revealed the following:

- Protective clothing was required, supplied by the company, and worn in all cases.

- The Surveyor rated the clothing as available and adequate in all cases.

- One complaint was noted on an item of accessory equipment. Workers of one refinery stated that the airline-supplied respirator reduced vision and caused added risk.

In all three facilities there were general protective clothing programs in effect. One plant was considering issuing "Nomex" material, two-piece general work clothing to protect its workers from thermal injuries which could be sustained during a flash fire or explosion. Special-purpose protective clothing was supplied by all the companies surveyed for maintenance and repair operations. One chemical protection ensemble consisted of a one-piece, plastic-coated work suit, gloves, boots, hood, and supplied-air respirator for tank cleaning and repairs. Another ensemble for thermal protection was a modified firefighter aluminized suit and hood for hot furnace work.

The Protective Clothing Needs chart on page 30 identifies the types of protective clothing required.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	3rd	Apron, Heavy-Material	yes
		Jacket, Heavy-Material	yes
		Pants, Heavy-Material	yes
		Chaps, Heavy-Material	yes
Thermal	4th	Shirt, Fire-Resistant	yes
		Pants, Fire-Resistant	yes
		Coverall, Fire-Resistant	yes
		Jacket, Fire-Resistant/Aluminized	yes
		Coat, Fire-Resistant/Aluminized	yes
		Pants, Fire-Resistant/Aluminized	yes
		Hood, Fire-Resistant/Aluminized	yes
		Suit, Fire-Resistant/Aluminized	yes
		Coverall, Fire-Resistant/Aluminized	yes
		Overall, Fire-Resistant/Aluminized	yes
Chemical	3rd	Pants, Chemical-Resistant	yes
		Coat, Chemical-Resistant	yes
		Jacket, Chemical-Resistant	yes
		Hood, Chemical-Resistant	yes
		Coverall, Chemical-Resistant	yes
		Overall, Chemical-Resistant	yes
		Apron, Chemical-Resistant	yes
Radiological*	2nd		

*The need for radiation clothing was not established.

Table 2

PROTECTIVE CLOTHING NEEDS

I/O Area Oil Refineries

STEEL MILLS AND PIG IRON PRODUCTION

As four of the six steel mills surveyed performed pig iron production processes, the two Industrial/Occupational areas will be combined for ease of data assessment. Total worker population of the facilities visited was 19,838. Worker population of the facilities producing pig iron as part of their production processes was 19,600. Hazards observed were similar in both processes. The hazards were:

- Mechanical - Material handling, overhead operations, slips and falls, and entrapment in moving machinery.
- Thermal - High ambient temperatures, high radiant heat, molten metal splash, and slag.
- Chemical - Adverse smoke and dust emissions.
- Electrical - Electrically fired furnaces.

Protective clothing needs may be listed as:

- Torso protection from light-to-moderate exposures to mechanical hazards. Protective clothing can be in the form of split-leg aprons, cape sleeves, jackets, and trousers of leather or similar heavy material. Leather items of apparel also provide good thermal protection for light-to-moderate exposures.
- Needs for thermal protection are heavy, fire-resistant fabric or leather aprons, leggings, cape sleeves, jackets, trousers, and hoods. For extreme radiant heat exposures, aluminized materials may be indicated. A basic fire-resistant work uniform is also indicated.
- Chemical needs are limited to respiratory protection devices, since the major hazard is inhalation.
- Electrical hazards in this industry are best protected against by isolation and guarding. Electrical hazards would be a factor only during maintenance of the electrical furnaces. This would normally be done with the associated power circuits locked out. If work was accomplished with energized circuits, the use of upper torso protection would be indicated.

The Hazard Severity matrix on the following page presents the rankings given for the various hazards observed. Mechanical hazards were ranked as 3rd degree in three of the companies surveyed. A 4th-degree rank was assigned Company Code 2-24, as the facility was undergoing extensive modernization; therefore, mechanical hazards were increased. Company Code 3-13 was given a 2nd-degree rank as the facility was almost totally automated. Worker exposure to hazards was, for the most part, eliminated. The low ranking for automated plants is felt to be justified by the elimination of hazards through isolation. If a hazard can be eliminated or controlled, then it is

Figure 5

HAZARD SEVERITY MATRIX

STEEL MILLS AND PIG IRON PRODUCTION

COMPANY CODE	M	T	C	R	E	B
2-23*	3	4	3	1	3	1
2-24*	4	4	3	1	3	1
3-5*	3	4	3	1	3	1
3-12	3	4	3	1	1	1
3-13	2	1	2	1	1	1
3-32*	3	4	3	1	3	1

*Pig Iron Production was part of Steel Mill Production processes.

Average Hazard Severity = 3.1904

Legend

M = Mechanical
T = Thermal
C = Chemical

R = Radiological
E = Electrical
B = Biological

logical that its severity will be decreased, and also the need for the worker to be protected will be decreased. It is not known whether automated facilities are typical in this Industrial/Occupational area as a large enough statistical base was not present in the number of facilities visited.

Thermal hazards were prevalent in five of the six facilities. These hazards were ranked as 4th degree due to the nature of iron and steel production. Company Code 3-13 had thermal hazards ranked as 1st degree because its automated facilities eliminated worker exposure.

Chemical hazards in the form of dusts and smoke were ranked as 3rd degree in five of the six companies. Again, as the automated facilities at Company Code 3-13 greatly reduced worker exposure, this facility was ranked as a 2nd degree.

Electrical hazards were noted at four of the six sites. These sites used electrically fired furnaces for their operations. Hazards were ranked as 3rd degree.

Bendix accident data was not available for these Industrial/Occupational areas as the Corporation does not engage in pig iron or steel mill operations.

Florida accident data was analyzed for protective clothing torso related injuries. This was defined as those injuries to the trunk, not including strains, sprains, or hernias. As was stated, Florida reports 40 percent of its accidents are of this nature.

Florida data for pig iron and steel mill operations reveals:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Blast Furnaces and Steel Mills	14	3	12.9

Pennsylvania data was not available for these industries.

Analysis of survey information revealed that protective clothing was company-supplied, was required wear, and was worn in five of the six companies surveyed. No added risk involvement through the use of protective clothing was identified, and workers were unanimous in their acceptance of the protective clothing supplied.

Analysis of protective clothing policies of the companies surveyed indicates that five of the companies provided clothing which adequately protected their employees. One company did not require the use of protective clothing because worker safety was accomplished by isolation and automation.

A Protective Clothing Needs chart is shown on the following page.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	4th	Shirt	yes
		Trousers	yes
		Coverall	yes
		Overall, Heavy Material	yes
		Suit, Heavy Material	yes
		Apron, Waist-Type or Bib-Type, Heavy Material	yes
		Apron, Split-Leg, Waist-Type or Bib-Type	yes
		Chaps, Heavy Material	
Thermal	4th	Shirt, Fire-Resistant	yes
		Trousers, Fire-Resistant	yes
		Coverall, Fire-Resistant	yes
		Overall, Fire-Resistant	yes
		Suit, Fire-Resistant	yes
		Coat, Aluminized, Fire-Resistant	yes
		Jacket, Aluminized, Fire-Resistant	yes
		Pants, Aluminized, Fire-Resistant	yes
		Coverall, Aluminized, Fire-Resistant	yes
		Overall, Aluminized, Fire-Resistant	yes
		Suit, Aluminized, Fire-Resistant	yes
		Aprons, Waist-Type or Bib-Type, Fire-Resistant	yes
		Leggings, Fire-Resistant	yes
		Cape Sleeves, Fire-Resistant	yes
		Hood, Fire-Resistant	yes
Chemical	3rd	Hood, Air-Supplied	yes
		Hood, Respirator-Equipped	yes
Electrical	3rd	Cape Sleeves, Nonconductive	yes

Table 3

PROTECTIVE CLOTHING NEEDS

I/O Area Steel Mills and Pig Iron Production

METAL SMELTING

Metal smelting is defined as the extraction of metal from its basic ore through the use of heat and fluxing agents. This process was observed at each of the four steel mills surveyed that performed pig-iron production processes. The pig iron produced at these facilities was derived both from scrap iron and native iron ores. Hazards observed were:

- Mechanical - Entrapment in moving machinery, slips, falls, material handling, and overhead operations.
- Thermal - Molten metal splash, slag, high ambient, and radiant heat.
- Chemical - Smoke and dust emissions.
- Electrical - Exposure to high-voltage potentials from electrically fired furnaces.

Protective clothing needs are:

- Torso protection from light-to-moderate exposures to mechanical hazards. Protective clothing can be in the form of split-leg aprons, cape sleeves, jackets, and trousers of leather or similar heavy material. Leather items of apparel also provide good thermal protection for light-to-moderate exposures.
- Thermal protection in the form of heavy, fire-resistant fabric or leather aprons, leggings, cape sleeves, jackets, trousers, and hoods. For extreme radiant heat exposures, aluminized materials may be indicated. A basic fire-resistant work uniform is also indicated.
- Chemical protection, limited to respiratory protection devices, since the major hazard is of an inhalation nature.
- Electrical hazards, in this industry best protected against by isolation and guarding. Electrical hazard would be a factor only during maintenance of the electrical furnaces. This would normally be done with the associated power circuits locked out. If work was accomplished with energized circuits, the use of upper torso protection would be indicated.

The Hazard Severity matrix on the following page presents the rankings given for the various hazards observed. Mechanical hazards were ranked as 3rd degree in three of the four companies surveyed. A 4th-degree rank was assigned Company Code 2-24, as the facility was undergoing extensive modernization. Thermal hazards were all ranked as 4th-degree hazards due to worker exposure to molten metals, and high ambient temperatures during the smelting process. Chemical hazards were ranked as 3rd degree in all the companies due to dust and smoke emissions. All four of the surveyed companies exhibited 3rd-degree electrical hazards due to exposure to the electrically fired furnaces.

FIGURE 6

HAZARD SEVERITY MATRIX

I/O AREA: METAL SMELTING

COMPANY CODE	M	T	C	R	E	B
2-23	3	4	3	1	3	1
2-24	4	4	3	1	3	1
3-5	3	4	3	1	3	1
3-32	3	4	3	1	3	1

Average Hazard Severity = 3.3125

LEGEND

M = MECHANICAL
T = THERMAL
C = CHEMICAL
R = RADIOLOGICAL
E = ELECTRICAL
B = BIOLOGICAL

Bendix accident data was not available for the Metal Smelting Industrial/ Occupational areas as the Corporation does not engage in this production process.

Florida accident data was analyzed for protective clothing torso related injuries. These were defined as those injuries to the trunk, not including strains, sprains, or hernias. As was stated, Florida reports 40 percent of its accidents are of this nature.

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Secondary Smelting and Refining	8	1	7.5

Pennsylvania data was not available for this industry.

The companies surveyed supplied protective clothing to their workers and required them to wear it. The Surveyor rated all the companies visited as having adequate protective clothing available. No additional risk was noted from the use of protective clothing; however, workers in Company Code 2-24 registered complaints that the clothing worn was too hot and confining.

The Protective Clothing Needs chart shown on the following page shows the types of protective clothing required.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	4th	Apron, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
		Jacket, Heavy Material	yes
		Trousers, Heavy Material	yes
Thermal	4th	Shirt, Fire-Resistant	yes
		Trousers, Fire-Resistant	yes
		Suit, Fire-Resistant	yes
		Overall, Fire-Resistant	yes
		Coverall, Fire-Resistant	yes
		Pants, Fire-Resistant/Aluminized	yes
		Coat, Fire-Resistant/Aluminized	yes
		Jacket, Fire-Resistant/Aluminized	yes
		Suit, Fire-Resistant/Aluminized	yes
		Overall, Fire-Resistant/Aluminized	yes
		Coverall, Fire-Resistant/Aluminized	yes
		Apron, Fire-Resistant/Aluminized	yes
		Cape Sleeves, Fire-Resistant/Aluminized	yes
		Hood, Fire-Resistant/Aluminized	yes
Chemical	3rd	Hood, Air-Supplied/Respirator-Equipped	yes
Electrical	3rd	Cape Sleeves, Nonconductive	yes

Table 4

PROTECTIVE CLOTHING NEEDS

I/O Area Metal Smelting

BERYLLIUM OPERATIONS

Beryllium operations are those processes for machining and forming metal products made of beryllium. Because of its lightness, strength, and resistance to corrosion, beryllium is becoming a common-use metal. It has, however, severe hazardous properties that demand worker protection to those who are involved in beryllium operations. It has been declared by industry to be an unquestionably toxic agent and to be among the most chemically toxic elements in industrial use today.

Some of the hazardous characteristics found when considering beryllium operations are:

1. Chronic reactions may occur as long as 10 years after exposure.

2. Beryllium has pronounced effects on lungs and may cause metabolic disturbances and anemia.

3. A worker may carry enough of the element home, on his clothes, to result in sickness to members of his family.

4. There have been recorded many cases of dermatitis directly attributable to beryllium and its compounds.

5. When soluble salts contact cuts or abrasions on the skin, deep ulcers may form which heal slowly and may require surgical decision to effect healing.

6. Workers are exposed to "beryllium intoxication," a severe systemic disease that can result from the inhalation of beryllium oxides and soluble compounds.

Field Survey Representative evaluation of beryllium operations in the companies surveyed discloses the following hazards:

- Mechanical - Common machining and metal-forming operations.

- Chemical - Industry had only minor hazards, part of which was due to a high state of cleanliness when processing beryllium products. Ventilation was excellent, and effective dust-collecting systems and particle shields were used on every production machine. Coveralls and protective clothing accessories were issued by the companies on a daily basis. Change rooms were provided with vacuums and showers. Used clothing was decontaminated daily.

Protective clothing needs for Beryllium Operations are indicated in the following listing:

- Mechanical - The use of aprons, cape sleeves, leggings, and chaps may be indicated for protection from the injuries associated with machining and metal-forming operations.

- Chemical - The use of disposable clothing or easily decontaminated clothing is indicated for protection from beryllium dusts and particles. These items may be shirts, suits, trousers, overalls, coats, jackets, hoods, and coveralls.

The Hazard Severity matrix on the following page readily reflects the excellent control of hazards in the surveyed companies. Mechanical and chemical hazards had the highest severity rating; they were rated only as 2nd degree which is not a significant severity. The matrix indicates that surveyed industries have effectively isolated the worker from beryllium hazards.

Florida accident data for 1971 was reviewed to determine the torso protective clothing related injuries. Analysis of the data is presented below. As the Beryllium Operations Industrial/Occupational area is not readily identifiable from state accident data, the rates for Miscellaneous Fabricated Metal Products were used. This decision was based on the assumption that beryllium is a metal and the involved operations would be similar to other metal operations.

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Miscellaneous Metal Products	61	16	15.7

Pennsylvania data available was not sufficient to relate to Miscellaneous Fabricated Metal Products.

New York data assessment for the years 1966 through 1970 indicates the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Miscellaneous Fabricated Metal Products	1,664	426	4.3

Two companies involved in beryllium operations were surveyed. The worker population of the industrial sample was 340.

Survey notations were that both companies supplied protective clothing to their workers, and required them to wear it.

Adequate protective clothing was available, and user acceptance was noted at both facilities visited.

The Protective Clothing Needs chart on page 42 shows that needs range from extensive to minimal, depending on worker exposure to a beryllium environment. Full protection may be required in extreme instances; however, basic protection was found to be adequate in the facilities surveyed. If mechanical dust collectors are not used, respirator protection is necessary.

FIGURE 7

HAZARD SEVERITY MATRIX

I/O AREA: BERYLLIUM OPERATIONS

COMPANY CODE	M	T	C	R	E	B
3-30	2	1	2	1	1	1
4-2	2	1	2	1	1	1

Average Hazard Severity = 2.0000

LEGEND

M = MECHANICAL
T = THERMAL
C = CHEMICAL
R = RADIOLOGICAL
E = ELECTRICAL
B = BIOLOGICAL

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	2nd	Apron, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
		Leggings, Heavy Material	
		Chaps, Heavy Material	yes
Chemical	2nd	Shirts, Disposable	yes
		Suits, Disposable	yes
		Trousers, Disposable	yes
		Overall, Disposable	yes
		Coverall, Disposable	yes
		Coat, Disposable	yes
		Jacket, Disposable	yes
		Hood, Air-Supplied or Respirator-Equipped	yes

TABLE 5

PROTECTIVE CLOTHING NEEDS

I/O Area Beryllium Operations

ASBESTOS OPERATIONS

Exposures to asbestos operations pose similiar problems to those of Silica Dust Generating Operations. Asbestos is a silicate; specifically, it is the name for several hydrated silicates of magnesium having a fibrous nature. It is used in the manufacture of protective clothing, valve packings, automotive brake linings, and clutch facings, and is used extensively in the construction industry for heat insulation, fireproofing, and cements.

The chief hazard of asbestos exposure is inhalation. The inhalation of asbestos dust causes asbestosis, a form of pneumoconiosis, and it has been identified as a carcinogen, causing lung and gastrointestinal cancers.

Mechanical hazards are present from the use of machines in asbestos mixing and forming operations.

Protective clothing needs in asbestos operations are generally limited to full-body protection and respiratory protection from asbestos dusts. The clothing, in the form of a one-piece coverall, must be capable of being adequately laundered or disposed of after each use.

Protective clothing for mechanical hazards may also be indicated in the forms of aprons, sleeves, jackets, chaps, and trousers of leather materials.

A Hazard Severity matrix constructed for the facilities surveyed that displayed asbestos operations is shown on the following page.

Chemical hazard severities were ranked as 3rd degree in both companies. These rankings were arrived at in consideration of the safeguards that were prevalent in the companies. In Company Code 2-7, the Surveyor notes that "The work areas were void of all debris." Overhead hooded exhaust fans vented dust from the asbestos operations. Company Code 4-16 used a different approach to asbestos dust control. Where, in Company Code 2-7 operations were manual, and dust was controlled by ventilation measures, Company Code 4-16 production processes were completely automated and asbestos dust was eliminated by the use of asbestos imported from Great Britain, and coated by a special British process.

Analysis of Bendix accident data that was available revealed that of the 98 accidents reported that could be related to this area, 38 were strains, sprains, or hernias. Approximately 73 percent of the remaining 60 injuries were mechanical hazard involvements; 25 percent were contributed to chemical hazards. The thermal hazard injury was documented. There were 15 total temporary disability cases noted, with 194 days lost time reported.

The bar chart on page 45, presents the injury percentage distribution by nature, and reflects the following:

Figure 8

HAZARD SEVERITY MATRIX
ASBESTOS OPERATIONS

COMPANY CODE	M	T	C	R	E	B
2-7	2	1	3	1	1	1
2-14	2	1	3	1	1	1

Average Hazard Severity = 2.5000

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

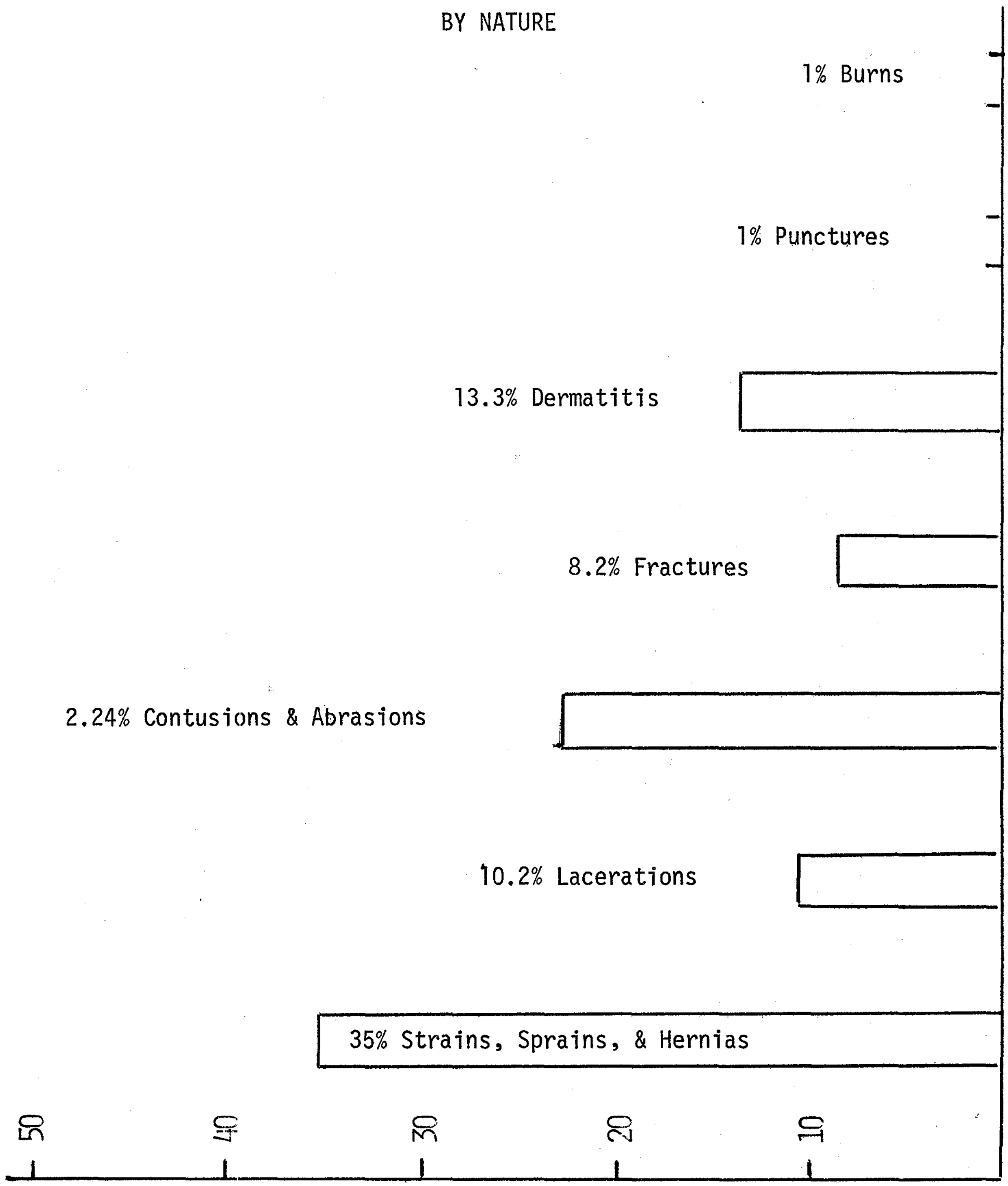
Figure 9

BENDIX INJURY DATA

ASBESTOS OPERATIONS

INJURY PERCENTAGE DISTRIBUTION

BY NATURE



Will not total 100% due to rounding.

(%)

- Strains, sprains, and hernias were instrumental in 35 percent of the injuries reported.

- Lacerations accounted for 10.2 percent.

- Contusions and abrasions accounted for 22.4 percent.

- Fractures were noted for 8.2 percent.

- Dermatitis injuries accounted for 13.3 percent.

- The natures of burns and punctures each totaled 1 percent.

The injury percentage distribution by body area chart on page 47 shows the following comparisons:

- Upper extremities were the most involved body area with 40.8 percent of the injuries.

- Eyes and head, and lower extremities both showed 12.2 percent.

- Torso injuries was last ranked with 9.8 percent.

Accident data for asbestos operations was not sufficiently identified for analysis; therefore, a similar industry based on hazard involvement was chosen. This industry is identified as Miscellaneous Non-Metallic Mineral Products.

Florida accident data for 1971 contains information on injuries in this industry group. Analysis of the data was performed using the 40 percent figure of strain, sprain, and hernia natures to determine the torso protective clothing related injuries. Data indicates the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Abrasive and Miscellaneous Mineral Products	23	1	2.6

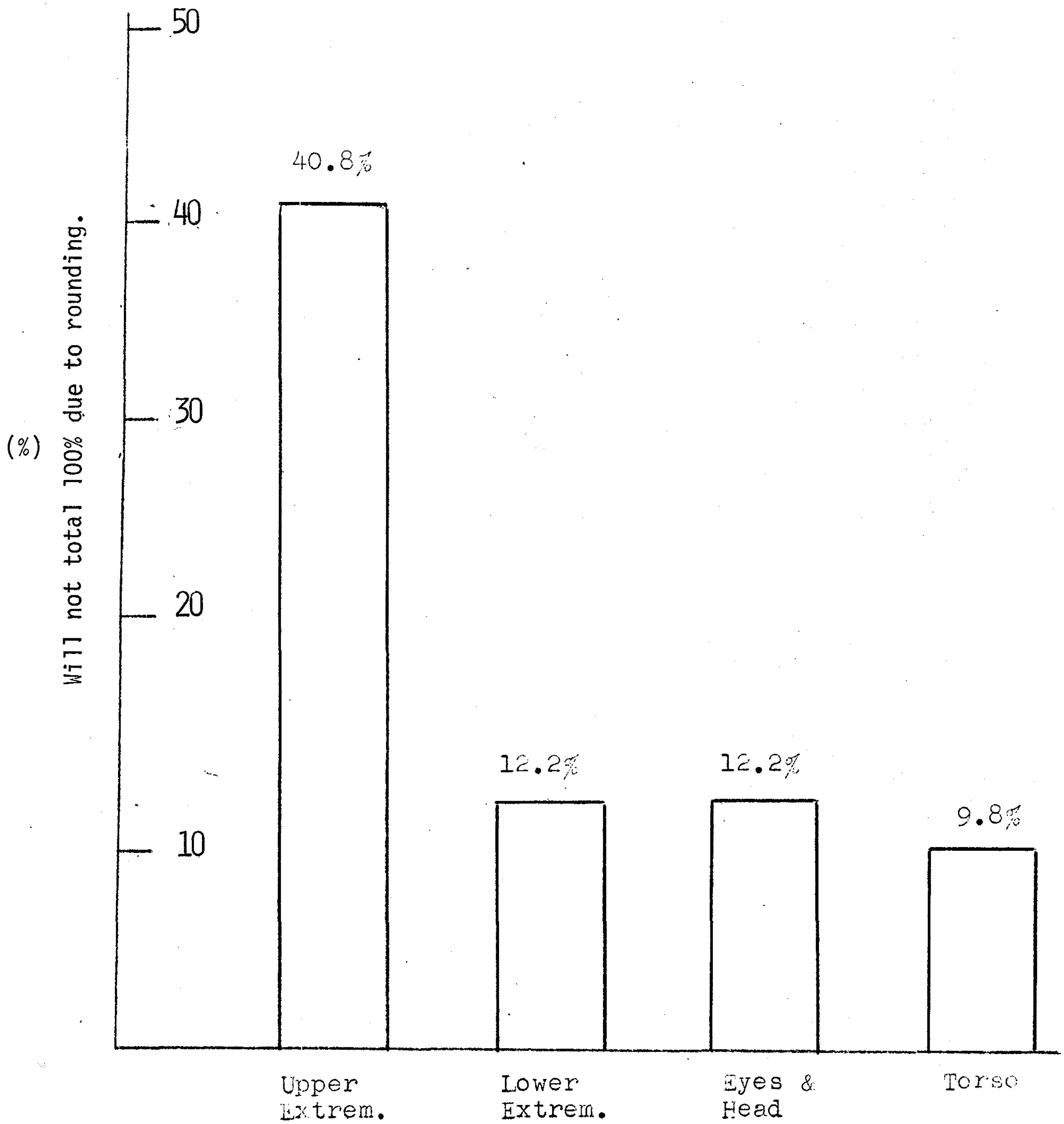
Pennsylvania data available did not give sufficient information to relate to asbestos operations.

New York data assessment for the years 1966 through 1970 indicates the following after consideration of a 78.4 percent incidence of strain, sprain, or hernia injuries in the Miscellaneous Non-Metallic Mineral Products, including the Asbestos Industry.

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Misc. Non-Metallic Mineral Products, Incl. Asbestos	2,431	690	6.1

Figure 10

BENDIX INJURY DATA
ASBESTOS OPERATIONS
INJURY PERCENTAGE DISTRIBUTION
BY BODY AREA



During the surveys of the two companies, it was determined that neither of the companies supplied nor required protective clothing, nor was it worn by the workers. Workers interviewed stated that the lack of protective clothing was acceptable to them, as asbestos hazards were guarded against by isolation or mechanical means. The Survey Representative's comments indicated that protective clothing was not made available to workers. Both facilities appeared to have no asbestos dust hazard; however, this would have to be determined by air sampling and analysis.

The Protective Clothing Needs chart on page 49 indicates the types of clothing required for worker protection.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	2nd	Trousers, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
		Apron, Heavy Material	yes
		Chaps, Heavy Material	yes
		Jackets, Heavy Material	yes
Chemical	3rd	Coverall, Disposable	yes
		Hood, Air-Supplied	yes
		Hood, Respirator-Equipped	yes

Table 6

PROTECTIVE CLOTHING NEEDS

I/O Area Asbestos Operations

COAL MINING

Two coal mining sites were surveyed during the contract period. Total worker population of the mines was 525.

Hazards which may be associated with the mining process are:

- Mechanical - Falling rock, explosions, mine structural failure, and heavy moving equipment.
- Chemical - Inhalation of coal dusts which may cause black lung disease, a form of pneumoconiosis.
- Thermal - Heat stress involvement, compounded by the use of hot, heavy, impermeable protective clothing.

Protective clothing needs for protection of the miners are as follows:

- Mechanical - The use of heavy leather or similar material pants, aprons, leggings, and jackets may be indicated for protection against light-to-moderate mechanical exposure hazards.
- Thermal - Protective clothing against heat-stress involvement is limited to lightweight coveralls.
- Chemical - Protection can be supplied by dust-filtering respirators and hoods. Where water seepage is a problem, raingear may be necessary.

The Hazard Severity matrix on the following page gives the degree ranking for each hazard noted at the mines visited. An explanation of the rankings follows:

- Mechanical - A 4th-degree ranking was assigned mechanical hazards noted at both sites. The ranking was due to the dangers inherent in the mining industry.
- Thermal - Hazards at the two facilities were both 3rd degree. The rankings were assigned because of the heat-stress involvement that was compounded by the use of hot, heavy protective clothing.
- Chemical - Exposure hazards were ranked as 4th degree at both sites. This was determined by the large amount of dust produced by cutting, drilling, and explosive operations.

Bendix accident data was not available for coal mining as the Corporation does not engage in this activity.

Pennsylvania data for coal mining was extracted using the 30 percent figure for strain, sprain, and hernia injury natures. The data reveals:

Figure 11

HAZARD SEVERITY MATRIX

COAL MINING

COMPANY CODE	M	T	C	R	E	B
2-30	4	3	4	1	1	1
4-17	4	3	4	1	1	1

Average Hazard Severity = 3.6667

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Anthracite Mining	43	11	17.9
Bituminous Coal and Lignite Mining	214	64	20.9

Protective clothing policies of the companies were analyzed and the following information gained:

- Protective clothing was supplied by the companies.
- Protective clothing was required and was worn by the miners.
- Protective clothing did not add risk to the operations.

Workers interviewed stated the protective clothing supplied was acceptable for their needs. The Surveyor's rating was that the clothing needed for worker protection was available and adequate.

Protective clothing needs are indicated by the chart on page 53.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	4th	Pants, Heavy Material	yes
		Leggings, Heavy Material	yes
		Jackets, Heavy Material	yes
		Apron, Kickback	yes
Thermal	3rd	Coverall, Lightweight	yes
Chemical	4th	Hood, Air-Supplied, Respirator-Equipped	yes
		Coat, Raingear	yes
		Jacket, Raingear	yes
		Hood, Raingear	yes
		Pants, Raingear	yes
		Overall, Raingear	yes
		Coverall, Raingear	yes

Table 7

PROTECTIVE CLOTHING NEEDS

I/O Area Coal Mining

METAL MINING

Metal mining, or the excavation in earth to extract metal-bearing ores, is commonly accomplished by strip mining, open pit mining, or shaft mining. The mining of uranium even though it is a metal is excluded from metal mining as it is covered under "Uranium Mining."

Field Survey Representative evaluation of metal mining operations discloses the following hazards:

- Mechanical - Explosions, falling rocks, mine structure failure, heavy moving equipment, and use of mechanical devices or machinery comprise this category.
- Chemical - Inhalation of dusts which may cause a form of silicosis is the primary chemical hazard.
- Thermal - Heat-stress involvement, compounded by the use of hot, heavy, impermeable protective clothing is the chief hazard.

The needs for protective clothing are limited by the nature of mining operations and the hazards to which workers are exposed. Protective clothing for mechanical hazards is dependent on the operations being performed. Because of ventilation and working conditions in the mines surveyed, most workers were displeased with any type of clothing which would interfere with their movements or comfort. However, handtool injuries, and eye, hand, or body injuries during rock drilling operations would indicate the need for light-to-moderate hazard protection, which could be attained by using heavy canvas, leather, or other suitable protective clothing. Crushing injuries from the operation of hauling equipment, and serious injuries from explosions and failure of hoisting equipment cannot be adequately protected against by present clothing. In some instances, air-supplied or respirator-equipped hoods may be needed to protect against flying particles and dust inhalation hazards. In areas where water or wetness is a problem, raingear may be indicated.

Respiratory problems from dusts, gases, or vapors may require the use of respiratory protective devices. Control of this hazard is best accomplished by proper exhaust ventilation, wet drilling, and wetting of crushed rock to prevent dusts.

Thermal hazard involvement was chiefly of a heat stress nature, which was compounded in some mines by workers' use of raingear protective clothing because of wet conditions. The use of man-cooling devices in this area is not deemed feasible as they have many limitations in a mobile work environment.

Five companies involved in metal mining were surveyed. The worker population of the industrial sample was 392.

The Hazard Severity matrix on the following page illustrates the degree ranking for each hazard noted at the mining operations surveyed. Inspection

Figure 12
HAZARD SEVERITY MATRIX

METAL MINING

COMPANY CODE	M	T	C	R	E	B
2-21	3	3	4	1	1	1
6-1	4	3	3	1	1	1
6-2	3	2	3	1	1	1
6-4	4	3	3	1	1	1
6-6	3	2	3	1	1	1

Average Hazard Severity = 3.0666

Legend

M = Mechanical
T = Thermal
C = Chemical

R = Radiological
E = Electrical
B = Biological

of the Hazard Severity matrix reveals:

- Mechanical hazards were assigned 3rd- and 4th-degree severity ratings because of the inherent dangers associated with mining.

- Thermal hazards at the mines were of 2nd- and 3rd-degree severity. This was primarily based on the heat-stress involvement created by the use of hot and heavy protective clothing.

- Chemical hazards were ranked 3rd and 4th degree because of the generation of considerable airborne particles from cutting, drilling, and explosive operations.

- Radiological, electrical, and biological hazards are all 1st degree because they were negligible.

Bendix accident data was not available for metal mining operations as the Corporation does not engage in this type of operation.

Florida 1971 accident data was analyzed for injuries related to torso protective clothing. These injuries are defined as those injuries to the trunk excluding strains, sprains, or hernias. Forty percent of all injuries were of this nature. Florida data reveals:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Metal Mining	3	1	20

Pennsylvania data for April 1973 was analyzed in this manner. Pennsylvania reports 30 percent of their injuries are strains, sprains, or hernias. Data analysis shows:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Mining and Quarrying N.E.C.	33	7	14.8

Analysis of the survey information revealed the following data:

- Available and adequate protective clothing was found in one of the mines.

- Available but inadequate clothing was found in three of the mines.

- No protective clothing was available in one of the mines.

One of the surveyed mining operations illustrated additional risk if the available protective clothing was used.

User nonacceptance of protective clothing was evident in one of the surveyed mines. Of the five mines surveyed, only two used protective clothing.

The evidence of additional risk and nonacceptance was noted by those workers who used hot, heavy, impermeable clothing which created possible heat-stress involvement.

Analysis of protective clothing utilization during the surveys shows that protective clothing was required, supplied, and worn in two of the mines.

The Protective Clothing Needs chart is shown on page 58.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	4th	Shirt	yes
		Trousers	yes
		Coverall	yes
		Overall, Heavy Material	yes
		Suit, Heavy Material	yes
		Apron, Kickback, Waist-Type or Bib-Type	yes
		Apron, Kickback, Split-Leg, Waist-Type or Bib-Type	yes
		Chaps, Heavy Material	yes
Chemical	4th	Hood, Air-Supplied	yes
		Hood, Respirator-Supplied	yes
		Jacket, Water-Impermeable	yes
		Paints, Water-Impermeable	yes
		Suit, Water-Impermeable	yes

Table 8

PROTECTIVE CLOTHING NEEDS

I/O Area Metal Mining

URANIUM MINING

Three uranium mining sites were surveyed during the contract period. The sites were all located in Montana, Utah, and Colorado. This fact causes varying conditions in the mines. Mines located in the higher country are normally dry mines, and dust conditions are more prevalent, while those mines further down in elevation are usually wet, with water seepage, and are generally less dusty.

Hazards associated with the uranium mining process are those normally associated with shaft mining, with the added danger of radiological exposures. The hazards are:

- Mechanical - Falling rock, explosions, mine structural failure, and material-handling equipment.
- Chemical - Inhalation of dusts, which may cause silicosis. Where the mining facility also processes the ores, chemical hazards exist in the spilling and splashing of the large quantities of caustics and acids used.
- Thermal - Heat-stress involvement compounded by the use of hot, heavy, impermeable protective clothing.
- Radiological - Ionizing radiation in the form of radon daughters formed during the decay of uranium. The major danger is in the inhalation of radioactive particles and gases.

Protective clothing needs in uranium mines closely parallel those of metal mines, which have been previously discussed. Radiation protection was noted to be almost nonexistent in the mines. According to information gained from talks with workers and management, protection was not required due to the low background radiation levels. Workers were observed wearing respiratory protective devices during drilling operations; however, this was done not to protect against inhalation of radioactive substances, but rather as a defense against the oil vapors given off by the air-driven drilling machines.

The Hazard Severity matrix on the following page presents the degree ranking for each hazard observed at the facility visited. The rankings were assigned to the facilities visited based on the following:

- A 4th-degree ranking was assigned mechanical hazards observed at Company Code 6-3. This ranking was because of the generally run-down condition of the mine. Lighting was poor, and the equipment ill-maintained. This appreciably increased mechanical hazards at the facility. The other two facilities were given 3rd-degree rankings, as they were better equipped and maintained.
- Thermal hazards at the three facilities varied from 3rd to 4th degree. The 4th-degree ranking was made for conditions at Company Code 6-5 that were not present at the others. This mining facility

Figure 13

HAZARD SEVERITY MATRIX

URANIUM MINING

COMPANY CODE	M	T	C	R	E	B
6-3	4	3	3	4	1	1
6-5	3	4	4	4	1	1
6-7	3	3	3	4	1	1

Average Hazard Severity = 3.5000

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

also processed the ores to extract both uranium and vanadium metals. The processes involved the use of boilers, roasting ovens, and hot chemicals. Company Codes 6-3 and 6-7 were given 3rd-degree rankings because the thermal hazards encountered were from heat-stress involvement, compounded by the use of hot, heavy, impermeable protective clothing.

- Chemical hazards for Company Code 6-5 were ranked as 4th degree because the processing of ores utilized sulfuric acid, caustics, and soda ash in large quantities. In the two remaining facilities, 3rd-degree chemical hazards existed due to the generation of dusts in the mining process. Higher rankings were not given as both of these mines were "wet" mines which tended to hold down dusts in most of the tunnel areas.

- All three facilities were given 4th-degree radiological hazards due to the inherent inhalation hazards of radioactive gases and dusts.

Bendix accident data was not available for Uranium Mining Operations as the Corporation does not engage in this type operation.

State Workmen's Compensation data available did not lend itself for discussion in the Uranium Mining Industry. For this reason, accident data for Metal Mining was used.

Protective clothing policies of the companies were analyzed and the following information gained:

- Company Codes 6-3 and 6-5 supplied protective clothing in the forms of rubber- or neoprene-coated fabric ensembles consisting of two-piece suits, gloves, and boots. Special acid-wear ensembles were provided at Company Code 6-5. Protective clothing was not supplied at Company Code 6-7.

- Protective clothing wear was enforced and was worn by employees of Company Codes 6-3 and 6-5, while wear was not enforced or worn by the employees of Company Code 6-7.

Surveyor assessments of the availability and adequacy of protective clothing at the facilities indicate that:

- Clothing was available and adequate at two companies.

- Clothing was not available at one company.

Protective clothing was not noted to cause additional risk except where the hot, heavy, impermeable clothing utilized added to heat-stress involvement. Employees rated all the protective clothing utilized as not acceptable for this reason, and because it hindered their mobility.

Protective clothing needs are presented in the chart on page 62.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical*	4th	Shirt	yes
		Trousers	yes
		Coverall	yes
		Overall, Heavy Material	yes
		Suit, Heavy Material	yes
		Apron, Kickback, Waist-Type or Bib-Type	yes
		Apron, Kickback, Split-Leg, Waist-Type or Bib-Type	yes
		Chaps, Heavy Material	yes
Chemical*	4th	Hood, Air-Supplied	yes
		Hood, Respirator-Supplied	yes
		Jacket, Chemical- and Water-Impermeable	yes
		Pants, Chemical- and Water-Impermeable	yes
		Suit, Chemical- and Water-Impermeable	yes

*Clothing listed will also provide protection from most radiological hazards which may be present in the mining operation.

Table 9

PROTECTIVE CLOTHING NEEDS

I/O Area Uranium Mining

RUBBER AND TIRE PRODUCTION

A total of four companies were surveyed in the Rubber and Tire Production Industrial/Occupational area. Mechanical, thermal, and chemical hazards are the most common in this industry.

Hazards which may be encountered during rubber and tire production are as follows:

- Mechanical - Moving machinery, material handling, and knife cuts.
- Thermal - Live steam and curing processes to temperatures of 340° F.
- Chemical - Inhalation of dusts from grinding operations, fumes from chemicals used in processing, and spills and splashes of organic solvents and other chemicals.

Protective clothing needs may be expressed by the following list of articles:

- Mechanical - Heavy canvas split-leg bib aprons for material handling.
- Thermal - Heavy, fire-resistant fabric, asbestos or leather bib aprons. Heavy, fire-resistant fabric, asbestos or leather cape sleeves or jackets.
- Chemical - Chemical-resistant, impervious-material aprons or pants. Chemical-resistant, impervious-material cape sleeves or jackets. Air-supplied hoods, respirator, or chemical-cartridge respirator as needed for fume and dust inhalation hazards.

The Hazard Severity matrix on page 64 identifies the ranking of each hazard observed by company code. An explanation of the ranking follows:

- Mechanical hazards were ranked as 2nd degree in three of the four companies surveyed due to the automation of most manufacturing processes. A 3rd-degree ranking was given Company Code 3-6 because of the dangerous practice of manually cutting moving sheets of rubber as they emerged from forming rollers.
- Thermal hazards were prevalent in all four sites visited and were ranked as 3rd-degree hazards due to work operations around hot molds and steamlines.
- Chemical hazards were also ranked as 3rd-degree hazards due to fume inhalation and mixing and batching operations.

Bendix accident data was not available for analysis as the Corporation does not engage in production processes of this nature.

Review of Florida accident data was conducted. Analysis was performed in the same way as explained previously. Florida reported in 1971 that 40 percent of all injuries were of a strain, sprain, or hernia nature. The data analysis is presented below:

Figure 14

HAZARD SEVERITY MATRIX
RUBBER AND TIRE PRODUCTION

COMPANY CODE	M	T	C	R	E	B
3-6	3	3	3	1	1	1
3-7	2	3	3	1	1	1
3-26	2	3	3	1	1	1
4-12	2	3	3	1	1	1

Average Hazard Severity = 2.7500

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Rubber and Miscellaneous Plastic Products	304	29	5.7

Pennsylvania data was not available.

Analysis of survey information revealed that protective clothing was company-supplied, required wear, and worn by the employees in only one of the four companies visited, and, in that company, the clothing supplied was inadequate for worker protection.

The Protective Clothing Needs chart on the following page indicates the protective clothing required for worker protection.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	3rd	Apron, Heavy Material Chaps, Heavy Material Cape Sleeves, Heavy Material Jacket, Heavy Material Trousers, Heavy Material	
Thermal	3rd	Apron, Fire-Resistant/Aluminized Jacket, Fire-Resistant/Aluminized Cape Sleeves, Fire-Resistant/Aluminized	
Chemical	3rd	Apron, Chemical-Resistant Coat, Chemical-Resistant Jacket, Chemical-Resistant Pants, Chemical-Resistant Suit, Chemical-Resistant Overall, Chemical-Resistant Coverall, Chemical-Resistant Hood, Air-Supplied	

Table 10

PROTECTIVE CLOTHING NEEDS

I/O Area Rubber and Tire Production

VEHICLE PRODUCTION

Vehicle production such as automobile manufacturing utilizes every conceivable manufacturing process; therefore, every variety of hazard exists. Vehicle production also employs more workers than any other single production category; therefore, employee exposure to hazards has a high potential. However, because of the need to maintain high production schedules, employees must be protected and hazards eliminated. For this reason, hazard control is a primary consideration in all vehicle production facilities. This means that even though there are large numbers of hazards and a large population of workers, the degree of hazard to the employee is lower than in other-type production processes that do not regard worker efficiency as high.

Some of the common processes found in vehicle production are:

- All welding processes, but primarily arc and resistance welding.
- All machining processes including drilling, milling, boring, grinding, shearing, planing, shaping, turning, and threading.
- Metal forming processes such as forming, rolling, calendering, forging, and stamping of both hot and cold metal.
- Metal finishing processes including grinding, polishing, buffing, and honing.
- Subassembly and final assembly processes requiring routine installation efforts.
- Molten metal processes including steel and iron production, die casting, and nonferrous metal production.
- Many manufacturing processes related to nonmetal products such as fabrics, rubbers, plastics, paints, and glass parts.

Because the production of vehicles is so expansive, detailed evaluation of protective clothing needs in all areas is not covered under the Vehicle Production category. Many of the above processes are analyzed separately; therefore, this discussion of vehicle production is mainly concerned with final-part fabrication and assembly.

Hazards identified under Vehicle Production are:

- Mechanical - Falls, falling objects, sharp edges, handtool use, conveyor entrapment, and compressed air are examples of existing mechanical hazards.
- Thermal - Thermal hazards include hot objects and hot environments which may cause heat stress.
- Chemical - Toxic gases, fumes, and dusts from welding operations, and skin irritation from solvents or cleaning solutions are some of the chemical hazards.
- Radiological - This includes ultraviolet and infrared radiation generated during welding operations.

- Electrical - Electrically powered handtools, welding machinery and the existence of electrical lines in the work area are possible source of hazards.

- Biological - Negligible

Protective clothing needs for workers in Vehicle Production are:

- Mechanical - The use of heavy leather or suitable material, split-leg aprons, kickback aprons, pants, jackets, and hoods for protection during grinding, material handling, and metal-forming operation.

- Thermal - The use of welders' ensembles is indicated during welding operations; the use of flame-resistant and aluminzed fabrics is indicated during heat treating and forging operations. Clothing may be in the form of jackets, aprons, pants, and hoods.

- Chemical - The use of chemical-impervious clothing for protection against acid and caustic splashes in metal cleaning and pickling operation is indicated. The use of disposable clothing or equivalent is indicated to protect workers from paint fumes and mists during painting operations.

- Radiological, electrical, and biological hazards are such that basic work clothing is adequate.

The Hazard Severity matrix on the following page was compiled from the three companies observed. Thermal, chemical, and radiological hazards were the most prevalent because of the considerable amount of welding operations used in vehicle component fabrication. Mechanical and electrical hazards were next but with low severity ratings. Biological hazards were nonexistent.

Bendix accident data for vehicle production was limited to motor vehicle parts and accessories. Total accidents related to this industry were 216 of which 146 were protective-clothing-related. The remaining 70 were strain, sprain and hernia injuries. The bar chart on page 70 presents the injury percentage distribution by nature. The chart indicates the following:

- Unknown natures accounted for 24.5 percent of the total.

- Strains, sprains, hernias accounted for 17.5 percent.

- Bruises and contusions were instrumental in 14.6 percent.

- Lacerations and punctures were noted in 12.9 percent.

- Fractures accounted for 12.0 percent.

- Other nature was identified in 7.7 percent.

- Crushing injuries accounted for 6.3 percent.

- Occupational dermatitis was evident in 2.5 percent.

Figure 15

HAZARD SEVERITY MATRIX
VEHICLE PRODUCTION

COMPANY CODE	M	T	C	R	E	B
2-1	2	3	3	3	2	1
3-1	2	3	3	3	2	1
3-28	2	3	3	3	1	1

Average Hazard Severity = 2.6429

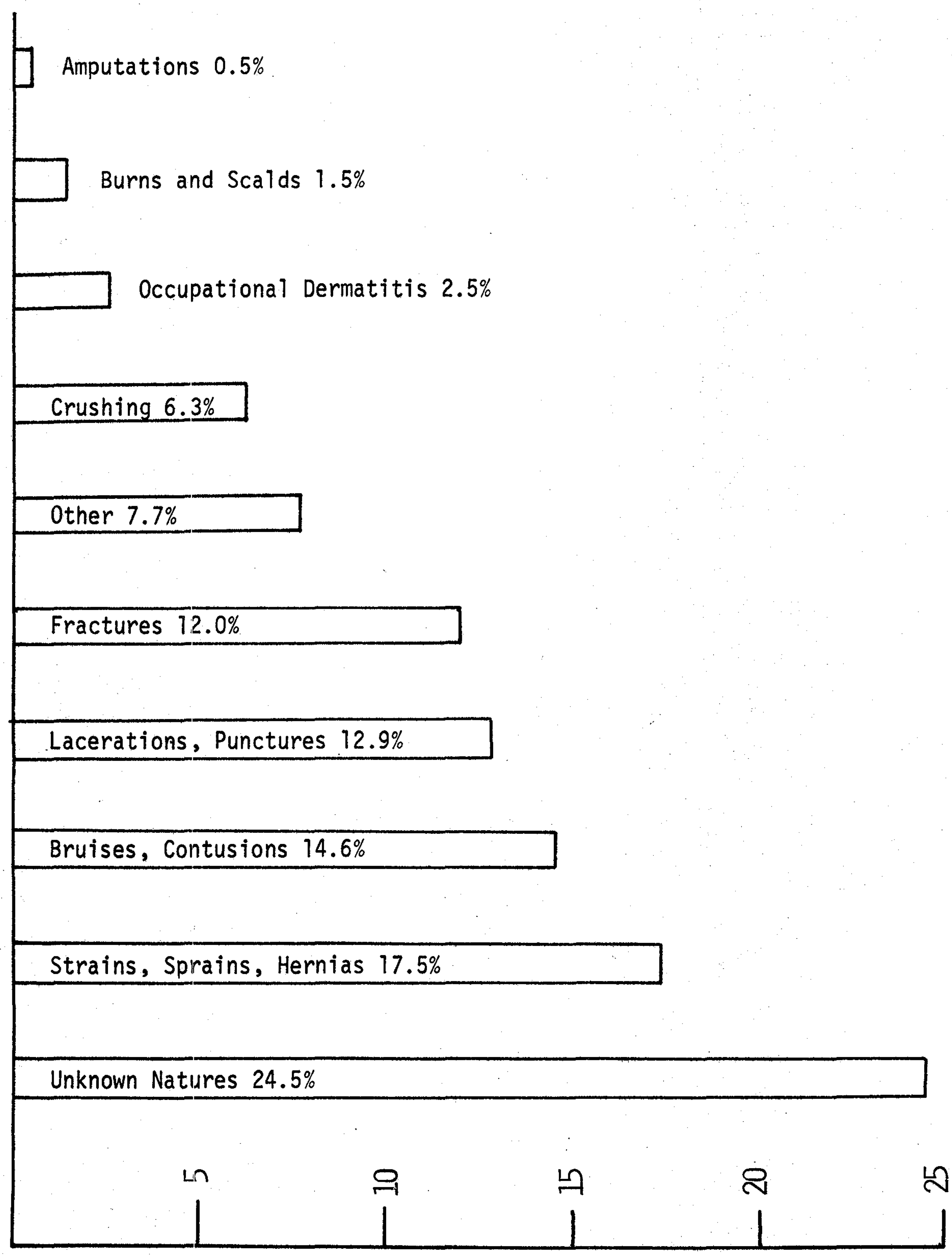
Legend
M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

Figure 16

BENDIX INJURY DATA

MOTOR VEHICLE PARTS AND ACCESSORIES

INJURY PERCENTAGE DISTRIBUTION BY NATURE



Will not total 100% due to rounding.

- Burns and scalds accounted for 1.5 percent.
- Amputations accounted for 0.5 percent.

The bar chart on page 72 shows the injury percentage distribution by body area. The following information is displayed:

- Upper extremities were involved in 55.6 percent of the total.
- Lower extremities were next with 27.8 percent.
- Head and eye were involved in 12.0 percent
- Torso was ranked last with 4.5 percent.

Florida accident data was analyzed for protective clothing torso related injuries. These were defined as those injuries to the trunk excluding strains, sprains, or hernias, as these injuries cannot be prevented by protective clothing. Florida in 1971 reported 40 percent of all injuries were of this nature. Therefore, 40 percent of the trunk injuries can be classified as not being related injuries. The data for Vehicle Production operations shows the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Motor Vehicles and Equipment	106	4	2.3

Pennsylvania reports 30 percent of the reportable injuries as strains, sprains, or hernias. Analysis of the data for April 1973 indicates:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Transportation Equipment	305	75	17.2

Observations made by the Field Survey Representative during the surveys of the three industrial sites were:

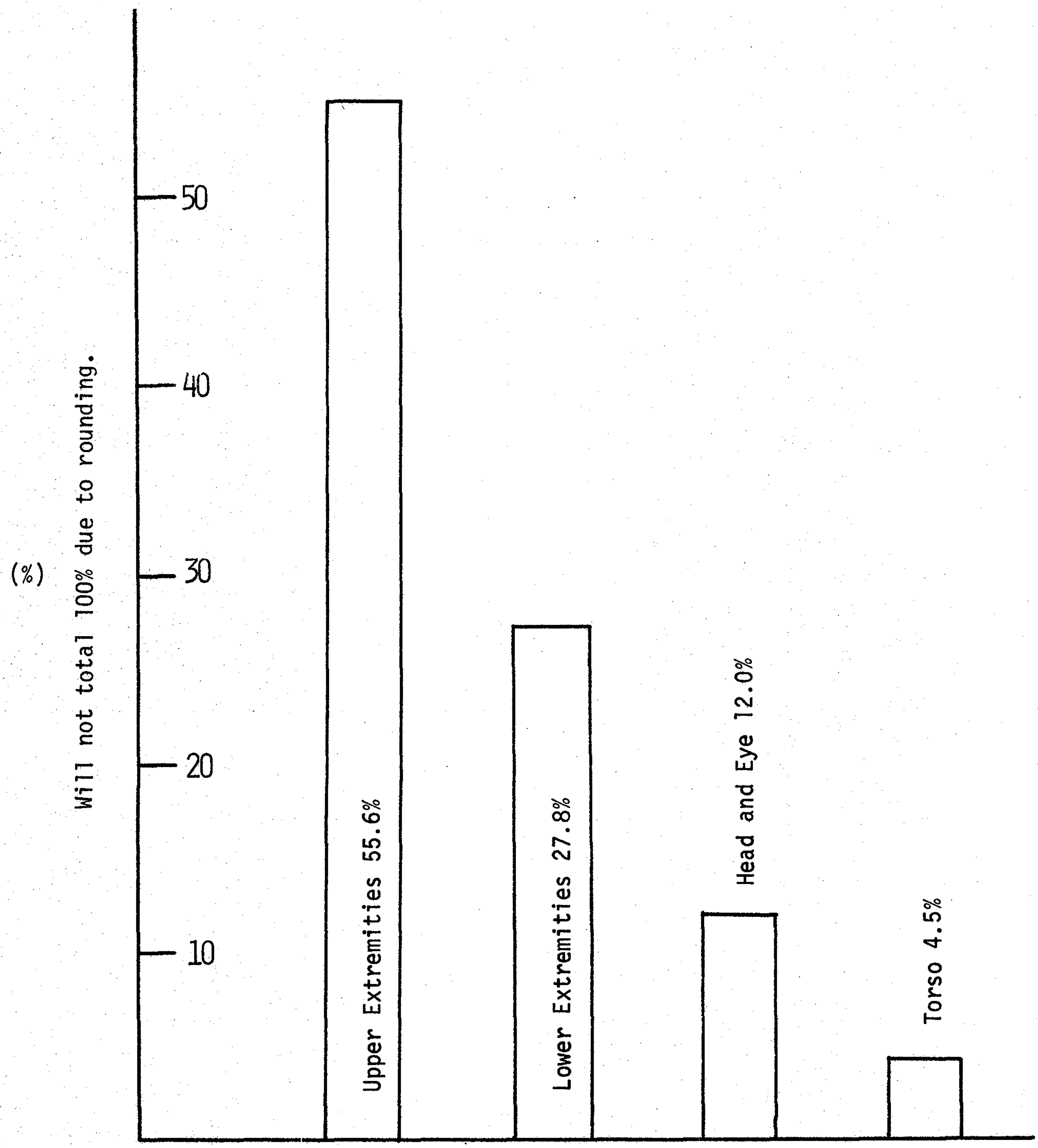
- Protective clothing was required, supplied by the company, and worn by the employees in all cases.
- All the companies had available and adequate clothing.
- There was no additional risk in the use of protective clothing.

Figure 17

BENDIX INJURY DATA

MOTOR VEHICLE PARTS AND ACCESSORIES

INJURY PERCENTAGE DISTRIBUTION BY BODY AREA



Protective clothing needs in vehicle production vary with type of process being done and the workers' environment. The Protective Clothing Needs chart on page 74 indicates the types of clothing required to adequately protect vehicle production employees.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	2nd	Apron, Heavy Material	yes
		Apron, Kickback, Heavy Material	yes
		Pants, Heavy Material	yes
		Jacket, Heavy Material	yes
		Hood, Heavy Material	yes
Thermal	3rd	Apron, Fire-Resistant	yes
		Cape Sleeves, Fire-Resistant	yes
		Jacket, Fire-Resistant	yes
		Coat, Fire-Resistant	yes
		Chaps, Fire-Resistant	yes
		Pants, Fire-Resistant	yes
		Hood, Fire-Resistant	yes
		Jacket, Fire-Resistant/Aluminized	yes
		Coat, Fire-Resistant/Aluminized	yes
		Apron, Fire-Resistant/Aluminized	yes
		Pants, Fire-Resistant/Aluminized	yes
		Hood, Fire-Resistant/Aluminized	
		Coverall, Fire-Resistant/Aluminized	yes
		Overall, Fire-Resistant/Aluminized	yes
Chemical	3rd	Shirt, Disposable	yes
		Trousers, Disposable	yes
		Suit, Disposable	yes
		Coverall, Disposable	yes
		Coat, Chemical-Resistant	yes
		Jacket, Chemical-Resistant	yes
		Pants, Chemical-Resistant	yes
		Suit, Chemical-Resistant	yes
		Overall, Chemical-Resistant	yes
		Coverall, Chemical-Resistant	yes
		Hood, Chemical-Resistant	yes

Table 11

PROTECTIVE CLOTHING NEEDS

I/O Area Vehicle Production

GLASS PRODUCTION

Glass production represents a broad range of worker involvement from the handcrafting of fancy glassware to the mass manufacturing of plate glass and glass containers. The total process, whether manual or automated, requires receiving and handling of raw materials, material mixing, charging gas fire furnaces, gathering and molding molten glass, grinding, polishing, etching, washing, packaging the finished product, and final shipping.

The hazards identified during surveys of glass production operations are:

- Mechanical - Mechanical hazards were apparent in the areas of machinery, conveyors, grinding, cutting, crushing, and other handling and forming processes.
- Thermal - Torches, furnaces, welding, hot forming machines, poor ventilation, and hot-glass handling.
- Chemical - Toxic fume inhalation, silica dust inhalation, and chemical handling.
- Radiological - Negligible.
- Electrical - Negligible but existent as associated with machinery controls.
- Biological - Negligible.

Protective clothing needs will be discussed by hazard. They are:

- Mechanical - The use of upper- and lower-torso protective clothing fabricated of leather or other suitable material is indicated. Examples are cape sleeves, coats, jackets, aprons, chaps, and pants.
- Thermal - The use of full ensembles of fire-entry suits is indicated during oven repair operations; the use of upper- and lower-torso and full-body protection is indicated for high radiant heat operation. Examples of these items are asbestos, and aluminized flame-retardant materials.
- Chemical - The use of chemical-resistant impervious clothing such as aprons, sleeves, pants, and jackets for chemical protection is indicated.

The Hazard Severity matrix on page 76 was compiled from field survey data. Mechanical and chemical hazards are ranked the same with a 3rd-degree severity. Thermal hazards are the highest ranked, with an assigned 4th degree of severity. Radiological, electrical, and biological hazards are negligible.

Bendix data was not available for this Industrial/Occupational area.

Figure 18

HAZARD SEVERITY MATRIX
GLASS PRODUCTION

COMPANY CODE	M	T	C	R	E	B
5-4	3	4	3	1	1	1
5-5	3	4	3	1	1	1

Average Hazard Severity = 3.3333

Legend
M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

Florida for the year 1971 reported the following data:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Glassware, Pressed or Blown	25	4	9.6

Pennsylvania data was not available in this industry.

Observations made by the Surveyors regarding current protective clothing practices revealed the following:

- Protective clothing was worn in one of the companies.
- Protective clothing was required in one of the companies.
- Protective clothing was provided in one of the companies.
- Protective clothing was available and adequate in one of the companies.

Within the companies, there was no evidence of additional risk if protective clothing was worn.

Workers at both companies requiring protective clothing voiced total acceptance of the protective clothing worn.

The Protective Clothing Needs chart on page 78 illustrates the types of protective clothing required.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	3rd	Cape Sleeves, Heavy Material	yes
		Coat, Heavy Material	yes
		Jacket, Heavy Material	yes
		Apron, Heavy Material	yes
		Chaps, Heavy Material	yes
		Pants, Heavy Material	yes
Thermal	4th	Shirt, Fire-Resistant	yes
		Pants, Fire-Resistant	yes
		Suit, Fire-Resistant	yes
		Coveralls, Fire-Resistant	yes
		Jacket, Fire-Resistant/Aluminized	yes
		Coat, Fire-Resistant/Aluminized	yes
		Pants, Fire-Resistant/Aluminized	yes
		Overall, Fire-Resistant/Aluminized	yes
		Coverall, Fire-Resistant/Aluminized	yes
		Apron, Fire-Resistant/Aluminized	yes
		Cape Sleeves, Fire-Resistant/Aluminized	yes
		Suit, Fire-Resistant/Aluminized	yes
		Suit, Insulated, Fire-Resistant/Aluminized, Self-Contained	yes
Chemical	3rd	Coat, Chemical-Resistant	yes
		Jacket, Chemical-Resistant	yes
		Pants, Chemical-Resistant	yes
		Suit, Chemical-Resistant	yes
		Apron, Chemical-Resistant	yes
		Coverall, Chemical-Resistant	yes
		Overall, Chemical-Resistant	yes

Table 12

PROTECTIVE CLOTHING NEEDS

I/O Area Glass Production

CONSTRUCTION

The construction industry involves a variety of processes with light, medium, and heavy work. These processes begin with site preparation and progress through various building phases until a complete structure is produced. Some of the specific phases of construction are:

- Site preparation, including the use of earth-moving equipment, surveying techniques, and material handling and storage.
- Foundation construction.
- Frame preparation, using steel, concrete, wood, and other raw materials.
- Plumbing, heating, and electrical installation.
- Floor and roof construction.
- Interior and exterior finishing, including glass installation, painting, plastering, paneling, and floor finishing.
- Landscaping and road or parking lot construction, including asphalt operations.

The hazards identified by the Survey Representative in visiting construction operations are:

- Mechanical - Power-tool usage, heavy equipment operations, vehicle maintenance, and stump blasting.
- Thermal - Hot tar application, and heat-stress involvement from working outside, welding operations.
- Chemical - Contact with tar, and tar fume inhalation, paint fumes.
- Radiological - Negligible; however, may exist if construction welding is performed.
- Electrical - Negligible, but may be present in the use of power handtools.
- Biological - Negligible.

Protective clothing needs in the construction industry are many and varied because of the many skills and occupations involved. In many cases protective clothing usage is not the answer to worker protection. This is true in instances of operations around heavy equipment where crushing injuries are common and in falls from heights. Worker protection can be enhanced by the use of clothing in material handling operations, hot tar applications, and painting operations to name a few. Since the welding, asbestos, abrasive and buffing, and painting occupational areas are defined in depth in other discussions, these items will not be treated here. Protective clothing needs will be separated by the phases of construction previously mentioned. These are:

- Site preparation - The use of high-visibility clothing is indicated for workers around earth-moving equipment. This may be accomplished by the use of Day-Glo or fluorescent-colored vests. In brush and timber clearing, using chain saws, ballistic nylon chaps may be required.

- Foundation construction - Material handling requires the use of leather or similar heavy-material upper and lower torso protection against cuts, punctures, abrasions, etc. This may be accomplished by split-leg aprons, jackets, chaps, trousers, and cape sleeves of a suitable material.

- Frame preparation - The use of leather or similar heavy material is indicated for upper and lower torso protection against mechanical hazards encountered during material handling.

- Plumbing, heating, and electrical installations - Suitable mechanical protective clothing is indicated as is upper torso protection from electrical hazards during electrical installation around energized circuits. Chemical protection may be indicated during plumbing and heating installations of asbestos insulation of piping.

- Floor and roof construction - The use of upper and lower torso protection against hot tars used in building roof construction may be provided by asbestos or other insulative material, jackets, trousers, leggings, cape sleeves, etc.

- Interior and exterior finishing - Glass installation may require the use of leather or similar heavy material for upper and lower torso protection against lacerations and punctures from glass breakage.

- Landscaping, road, or parking lot construction - The use of items previously described in site preparation phases is indicated.

The Hazard Severity matrix on the following page was compiled from data attained at the surveyed areas. Mechanical hazards are the highest ranked with an assigned 4th-degree severity. Thermal and chemical hazards are ranked the same with a 3rd-degree severity. Radiological, electrical, and biological hazards are negligible.

A total of 306 Bendix accident reports were reviewed from four separate facilities engaged in the production of mobile homes. Although this industry does not classify as a construction industry area, the processes involved in the making of mobile homes was considered to be a close approximation of the construction industry. Accidents attributable to sprains,

Figure 19

HAZARD SEVERITY MATRIX

CONSTRUCTION

COMPANY CODE	M	T	C	R	E	B
1-36	4	3	3	1	1	1
2-2	4	3	3	1	1	1

Average Hazard Severity = 3.3333

<u>Legend</u>

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

strains, or hernias accounted for 145 of the total, or 47.4 percent. Mechanical hazard involvement was the most common encountered, with 161 of the protective clothing related total. Thermal and chemical hazards each accounted for two and radiological for one injury. The bar charts on the following pages reflect the total of all four facilities.

The bar chart on page 83 presents the injury percentage distribution by nature. The chart indicates the following:

- Puncture injuries accounted for 44.1 percent of the total protective clothing related natures. (This high percentage was attributable to the high incidence of accidents with compressed-air-powered pneumatic nailers.)
- Lacerations were responsible for 31.7 percent.
- Abrasions and contusions, and foreign object in eye nature were both third ranked with 9.3 percent.
- Fractures were involved in 1.9 percent.
- Burns comprised 1.24 percent.
- Conjunctivitis and amputation natures were last with .62 percent.

The bar chart on page 84 shows the injury percentage distribution by body area. The following information is displayed:

- Upper extremities were involved in 66.5 percent.
- Lower extremities, and eyes and head were each involved in 16 percent.
- Torso was involved in .62 percent.

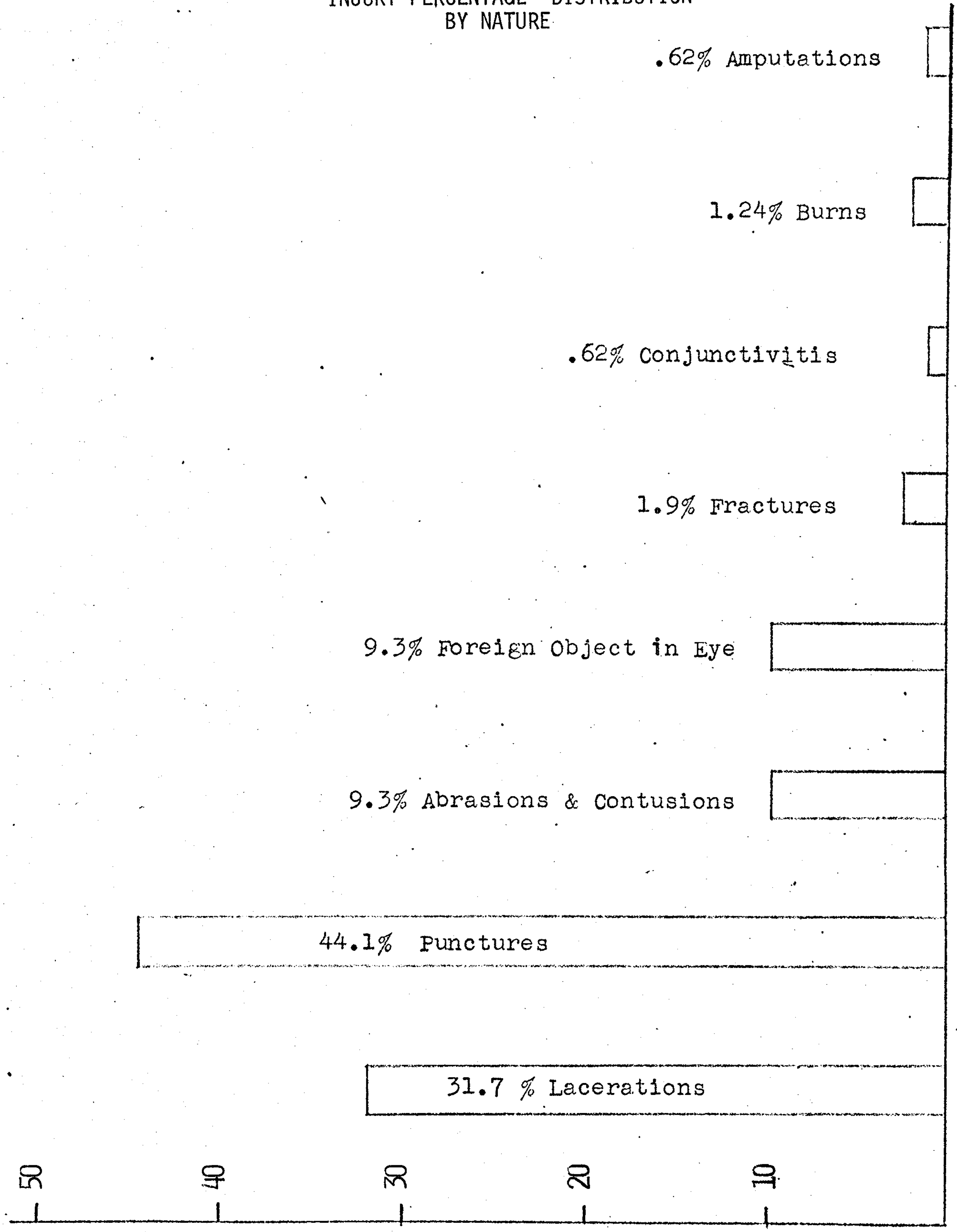
Florida 1971 accident data was analyzed for injuries related to torso protective clothing. These injuries are defined as those injuries to the trunk excluding strains, sprains, and hernias. Forty percent of all injuries were of this nature. Florida data reveals:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Contract Construction	14,134	1,175	5.0

Pennsylvania data reports 30 percent of its documented injuries are strains, sprains, or hernias. Pennsylvania analysis shows:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
General Building Contractors	336	85	17.7

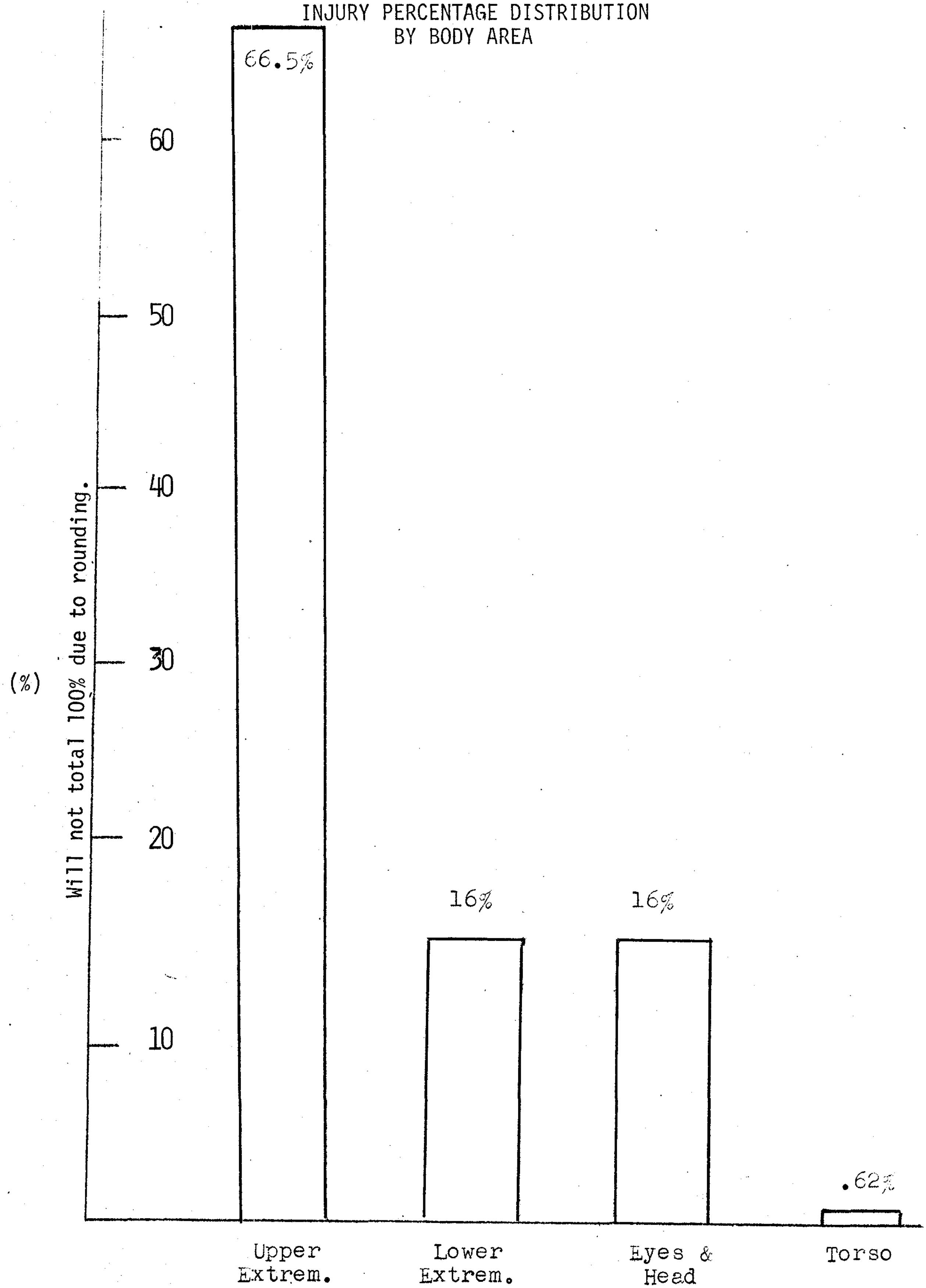
Figure 20
BENDIX INJURY DATA
CONSTRUCTION
INJURY PERCENTAGE DISTRIBUTION
BY NATURE



Will not total 100% due to rounding.

(%)

Figure 21
BENDIX INJURY DATA
CONSTRUCTION
INJURY PERCENTAGE DISTRIBUTION
BY BODY AREA



Heavy Construction Contractors	133	30	15.8
Special Trade Contractors	476	35	5.1

Observations made by the Survey Representatives regarding current protective clothing practices revealed the following:

- Protective clothing was not worn in either of the two companies.
- Protective clothing was not required by either of the companies.
- Protective clothing was not provided by either of the companies.

The Protective Clothing Needs chart on page 86 displays needs related to the entire construction industry.

Hazard	Degree	Protective Clothing Required	Available from Pro . Clothing Mfgrs.
Mechanical	4th	Shirt	yes
		Trousers	yes
		Coverall	yes
		Overall, Heavy Material	yes
		Suit, Heavy Material	yes
		Apron, Kickback, Waist-Type or Bib-Type	yes
		Apron, Kickback, Split-Leg, Waist-Type or Bib-Type	yes
		Chaps, Heavy Material	yes
		Vest, High-Visibility	yes
		Coat, High-Visibility	yes
		Pants, High-Visibility	yes
		Cape Sleeves with Bib or Without Bib	yes
		Hood, Heavy Material	yes
Thermal	3rd	Shirt, Fire-Resistant	yes
		Trousers, Fire-Resistant	yes
		Coverall, Fire-Resistant	yes
		Overall, Fire-Resistant	yes
		Suit, Fire-Resistant	yes
		Coat, Insulated, Fire-Resistant	yes
		Jacket, Insulated, Fire-Resistant	yes
		Trousers, Insulated, Fire-Resistant	yes
		Apron, Waist-Type or Bib-Type, Fire-Resistant	yes
		Apron, Split-Leg, Waist-Type or Bib-Type, Fire-Resistant	yes
Chemical	3rd	Hood, Air-Supplied	yes
		Hood, Respirator-Equipped	yes
		Shirt, Disposable	yes
		Trousers, Disposable	yes
		Coverall, Disposable	yes
		Overall, Disposable	yes
		Suit, Disposable	yes
		Hood, Chemical- and Water-Impermeable	yes
		Jacket, Chemical- and Water-Impermeable	yes
		Pants, Chemical- and Water-Impermeable	yes
		Suit, Chemical- and Water-Impermeable	yes
Electrical	1st	Cape Sleeves, Nonconductive Material	yes

Table 13. PROTECTIVE CLOTHING NEEDS I/O Area Construction

BAKERIES

Bakery operations are those processes involved in the preparation of food goods by dry heat, especially in an oven. Ingredients are received and stored in bulk, products are measured and mixed, and final products are baked, wrapped, and shipped.

Field Survey Representative evaluation of bakeries illustrates the following hazards:

- Mechanical - Slippery floors, unguarded machinery, and heavy lifting.
- Thermal - High temperatures in all bakery operations.
- Electrical - Negligible but possible if electrically operated equipment is not properly grounded.

Protective clothing needs are primarily limited to thermal hazards. The use of aprons, pants, leggings, coats, jackets, and cape sleeves of aluminized, flame-resistant materials are indicated along with the use of basic flame-resistant-material work uniforms.

The Hazard Severity matrix on page 88 illustrates excellent control of hazards except thermal hazards. The need to handle hot products and to be involved with high-temperature ovens warranted a 3rd-degree severity rating. Mechanical hazards were assigned a 2nd-degree severity rating because of their existence in the baking operation; however, mechanical hazard elimination was apparent.

Bendix accident data was not available for this Industrial/Occupational area as the Corporation does not engage in this type production.

Florida data for the year 1971 was analyzed and related to torso protective clothing, using the 40 percent value for strain, sprain, and hernia natures. The analyzed data indicates:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Bakery Products	201	22	6.6

Two bakeries were surveyed with a total worker population of 34. One bakery had available but inadequate clothing, and one bakery had no protective clothing available.

Within the surveyed bakeries, there was no evidence of additional risk related to protective clothing use.

User acceptance of protective clothing was witnessed at one bakery, while the other did not use protective clothing; therefore, acceptance was not a factor.

Figure 22

HAZARD SEVERITY MATRIX

BAKERIES

COMPANY CODE	M	T	C	R	E	B
1-3	2	3	1	1	1	1
1-13	2	3	1	1	1	1

Average Hazard Severity = 2.5000

<u>Legends</u>

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

It should be noted that bakery employees did not regard protective clothing as an effective means of hazard elimination.

Analysis of protective clothing utilization as observed by the Surveyors shows the following:

- Protective clothing was worn in one of the bakeries.
- Protective clothing wear was not required by company policy in the bakeries surveyed.
- Protective clothing was supplied by one of the bakeries.

The Protective Clothing Needs chart is shown on page 90. These items of protective clothing are required only to protect against contact with elevated temperatures.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Thermal	3rd	Apron, Flame-Resistant/Aluminized	yes
		Pants, Flame-Resistant/Aluminized	yes
		Leggings, Flame-Resistant/Aluminized	yes
		Coats, Flame-Resistant/Aluminized	yes
		Jackets, Flame-Resistant/Aluminized	yes
		Cape Sleeves, Flame-Resistant/Aluminized	yes

Table 14

PROTECTIVE CLOTHING NEEDS

I/O Area Bakeries

PAINTING OPERATIONS

The analysis of protective clothing for painting operations takes into consideration three different methods of paint application. These methods are as follows:

1. Airless - Airless paint application is a hydraulic process. The paint is hydraulically pumped through an atomizing orifice at pressures ranging from 900 to 3,000 pounds per square inch. Its primary attribute is great reduction in overspray resulting in better paint utilization. Inherent hazards are paint impingement from the spray causing severe lacerations and injection of paint under the skin.

2. Compressed Air - Paint is applied with compressed air at pressures of 35 to 150 pounds per square inch. This is the most commonly used paint application.

3. Electrostatic - This method utilizes airless or compressed air paint application. However, paint adherence qualities are improved by generating a positive charge on the item to be painted and a negative charge on the atomized paint. This method also reduces overspray significantly. Inherent hazards are the same as with airless application, with added electrical discharge hazards.

Close evaluation of painting operations throughout industry discloses the following related hazards.

- Mechanical - High-pressure painting as used with airless and electrostatic applications can result in lacerations from paint inpingement and paint injection under the skin. Another mechanical hazard is apparent where the worker is involved with conveyor systems because entrapment is possible.

- Chemical - Organic solvents may cause dermatitis to the skin. Respiratory, skin, or digestive absorption of paint or solvents may cause adverse physiological effects such as simple or chemical asphyxiation.

- Thermal - Inadequate ventilation or improperly selected protective clothing may cause heat-stress involvements. Fires during painting operations may occur from spontaneous ignition of spray deposits. Electrostatic spraying may cause a source of ignition from the arcing of items being painted to the electrodes.

- Electrical - Electrical hazards are present in high-voltage static discharges when the electrostatic application is used.

- Radiological - Negligible.

- Biological - Negligible.

Protective clothing needs can be expressed by the hazard involved.

- Mechanical - The use of clothing made of a strong, chemically impervious, fire-retardant material to protect against high-velocity paint streams during airless painting should be required. Clothing types would depend on worker exposure. Such clothing would include aprons, sleeves, jackets, hoods, and trousers.

- Chemical - The use of lightweight, fire-retardant disposable clothing may be indicated in some working environments to protect against paint overspray and solvent contact with workers' skin. Items may include jackets, suits, overalls, coveralls, trousers, and shirts.

- Thermal - The use of basic fire-resistant clothing to protect against flash fires is indicated.

- Electrical - Electrostatic spraying may develop large static electricity potentials during operation; electrically conductive clothing may be indicated to bleed off static charges from workers.

Six companies exhibiting Painting Operations were surveyed. The worker population of the industrial sample was 34,310. The Hazard Severity matrix on the following page reflects the severity ratings of each of the six hazards identified for this study. Mechanical, thermal, and chemical hazards are approximately equal in hazard degree with an average of 2nd-degree severity. Mechanical hazards are somewhat more severe; however, this is caused by environmental conditions rather than direct mechanical hazard. Poor ventilation, faulty equipment, and inadequate housekeeping observed in some of the companies increased the assigned severity rating. Thermal hazards are also dependent on various factors such as poor ventilation, improper protective clothing, and type of paint application. Chemical hazards, where present, are not dependent on auxiliary conditions; therefore, they are considered equally as hazardous as mechanical or thermal hazards. Electrical hazards which can exist were found to be neglibible in the survey samples. Radiological and biological hazards normally are not related to painting operations and were also negligible in the survey sample.

Analysis of Bendix accident data revealed only three injuries that could be attributed to painting operations. All were chemical hazard involvement, and all injuries were to the eyes. In each case, the injury was caused by the painter receiving either paint thinner or paint splashes into the eyes. Two of the accidents were total temporary disabilities with 6 days lost time. In the other case, the degree of injury was unknown.

Analysis of data available from Florida for 1971 was performed on the painting and paper hanging industry. This was considered the closest approximation of this industry available. Using the 40 percent strain, sprain, and hernia nature occurrence figure, the analysis shows:

Figure 23

HAZARD SEVERITY MATRIX
PAINTING OPERATIONS

COMPANY CODE	M	T	C	R	E	B
2-1	2	2	1	1	1	1
2-11	3	1	2	1	1	1
2-15	2	2	3	1	1	1
3-1	3	3	2	1	1	1
3-29	2	2	1	1	1	1
4-13	2	1	3	1	1	1

Average Hazard Severity = 2.3571

Legend
M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Painting and Paper Hanging	215	20	5.6

Analysis of protective clothing utilization during the surveys shows the following:

- Protective clothing was worn in five of the six companies.
- Protective clothing was required by company policy in four of the companies.
- Protective clothing was supplied by the company in five of the cases.
- Available and adequate protective clothing was utilized in three of the companies.
- Available but inadequate protective clothing was utilized in two of the sample companies.
- No protective clothing was available for use in one of the sample companies.

Within the sample, there was no evidence of additional risk related to protective clothing utilization.

User acceptance of protective clothing was evident in all six of the companies sampled.

Protective clothing needs are displayed by the Protective Clothing Needs chart on page 95.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	3rd	Apron, Bib-Type or Waist-Type	yes
		Apron, Split-Leg, Bib-Type or Waist Type	yes
		Cape Sleeves	yes
		Jacket	yes
		Hood, Air-Supplied	yes
		Trousers	yes
Chemical	3rd	Jacket, Disposable	yes
		Suit, Disposable	yes
		Overall, Disposable	yes
		Coverall, Disposable	yes
		Trousers, Disposable	yes
		Shirt, Disposable	yes
Thermal	3rd	Pants, Fire-Resistant	yes
		Shirt, Fire-Resistant	yes
		Overall, Fire-Resistant	yes
		Coverall, Fire-Resistant	yes
		Suit, Fire-Resistant	yes
Electrical	1st	Jacket, Electrically Conductive	yes
		Pants, Electrically Conductive	yes
		Suit, Electrically Conductive	yes

Table 15

PROTECTIVE CLOTHING NEEDS

I/O Area Painting Operations

PUBLIC UTILITIES

Public utilities encompass a large and varied group of industries. The individual industries and their exposure hazards are listed and discussed below:

Water Works Operations (Hazards)

- Mechanical - Conditions causing falls, ditch and trenchwork, exposure to falls from heights, operation and maintenance of pumping equipment, moving vehicles.
- Chemical - Exposure to chlorine and other chemicals related to water treatments.

Sewage Disposal Plants (Hazards)

- Mechanical - Conditions causing falls, ditch and trenchwork, handling and working around heavy equipment.
- Thermal - Explosion and fire involving sewer gases.
- Chemical - Asphyxiation in sewer and tanks, exposure to treatment chemicals such as chlorine.
- Biological - Exposure to raw sewage.

Electric Light or Power Companies (Hazards)

- Mechanical - Falls from heights, hand-held power tools, operation and maintenance tasks.
- Thermal - General climatic conditions, fires from equipment malfunction, boilers, steamlines.
- Radiological - Radiation and nuclear contamination if generating facilities are nuclear powered.
- Electrical - Maintenance on hotlines at 12,000 volts and higher.

Natural Gas Companies (Hazards)

- Mechanical - Falls, operation and maintenance of odorization equipment, pumping, metering and regulating equipment, trenching and pipelaying operations.
- Thermal - Climatic conditions, fires from explosions, leakages, normal welding hazards.
- Chemical - Fume inhalation, asphyxiation.

Garbage or Refuse Collecting Companies (Hazards)

- Mechanical - Exposure to broken glass, sharp and pointed objects, moving vehicles, crushing injuries in mechanisms.
- Thermal - Fires from unknown flammable materials, spontaneous combustion.
- Chemical - Handling of unexpected or unknown caustics, acids, toxic materials.
- Biological - Exposure to germ-laden organic materials.

Protective clothing needs vary with the facility involved. The individual industries and their protective clothing needs are discussed below. Even though many of the types of public utilities were not surveyed, from careful analysis of reference works such as Best's Loss Control and Underwriting Manual it is felt that the protective clothing needs as stated are relevant.

Water Works Operations (Protective Clothing Needs)

- Mechanical - The use of high-visibility coats, jackets, or vests is indicated for protection against vehicular traffic.
- Chemical - The use of impervious aprons, coats, pants, jackets, and suits is indicated for protection against exposures to chlorine and other chemicals used in water treatment.

Sewage Disposal Plants (Protective Clothing Needs)

- Mechanical - The use of high-visibility coats, jackets, or vests is indicated for protection against vehicular traffic.
- Thermal - The use of fire-resistant fabric work clothing is indicated for protection against flash fires.
- Chemical - The use of chemically impervious aprons, coats, jackets, and suits is indicated for protection against exposures to chlorine and other sewage treatment chemicals. Suits may be self-contained or supplied air in oxygen-deficient atmospheres.
- Biological - The use of the items mentioned for protection against chemical hazards will provide biological protection if the items are cleaned and sterilized after exposure. If this is not feasible, disposable items of the same nature should be employed.

Electric Light or Power Companies (Protective Clothing Needs)

- Mechanical - The use of high-visibility coats, jackets, or vests is indicated for protection against vehicular traffic. The use of leather leggings, trousers, or chaps is indicated during pole climbing to protect against splinters.

- Thermal - General-use cold weather clothing is indicated during cold winter months. The use of fire-resistant general work clothing is indicated for protection from flash fires. The use of aluminized fire-resistant clothing is indicated during boiler-tending operations.

- Radiological - The use of impermeable disposable clothing is indicated for "soft" radiation exposure at nuclear generating plants; leaded hoods, aprons, and coats are indicated for exposure to "hard" radiation.

- Electrical - The use of rubber cape sleeves, coats, jackets, pants, and switch-pulling suits is indicated during operations on energized circuits.

<u>Natural Gas Companies</u> (Protective Clothing Needs)

- Mechanical - The use of high-visibility coats, jackets, or vests is indicated for protection against vehicular traffic.

- Thermal - General-use cold weather clothing is indicated during cold winter months. The use of fire-resistant general work clothing is indicated for protection from flash fires. The use of welding ensembles of leather or suitable material is indicated during gas main repairs and other welding operations.

<u>Garbage or Refuse Collecting Companies</u> (Protective Clothing Needs)

- Mechanical - The use of high-visibility coats, jackets, or vests is indicated for protection against vehicular traffic. The use of upper-torso and extremity clothing in the forms of cape sleeves, jackets, and coats of suitable heavy material to provide protection against broken glass and sharp metal edges is indicated.

- Thermal - The use of fire-resistant general work clothing is indicated for protection from flash fires. General-use cold weather clothing is indicated during cold winter months.

- Chemical - The use of heavy chemically impervious cape sleeves, jackets, and coats is indicated to protect against unexpected chemical exposure. This clothing may also provide mechanical and biological protective functions.

From data acquired at the surveyed utility, mechanical and chemical hazards both were ranked as 3rd degree. This was based on evidence of possible serious falls and contact with water purification chemicals. All other hazards were ranked as 1st degree or negligible exposures.

Bendix corporate accident data was not available for this industry as the Corporation does not engage in this activity.

Review of 1971 Florida accident data for torso protective clothing related injuries results were as follows:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Electric, Gas, and Sanitary Services	795	75	5.7

Review of Pennsylvania accident data for torso protective clothing related injuries results were as follows:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Communication and Utilities	148	62	29.3

Observations regarding current protective clothing practices revealed that it was required, supplied, and worn by employees at the utility. The Surveyor's rating of protective clothing use at this facility was that it was available but inadequate.

Workers expressed the opinion that the wearing of some protective clothing articles increased the risk. The specific example cited was the use of boots which entrap heavy gases.

The Protective Clothing Needs chart on page 100 illustrates the types of protective clothing required.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	N/A	Coat, High-Visibility	yes
		Jacket, High-Visibility	yes
		Vest, High-Visibility	yes
		Leggings, Heavy Material	yes
		Trousers, Heavy Material	yes
		Chaps, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
		Jacket, Heavy Material	yes
		Coat, Heavy Material	yes
Thermal	N/A	Shirt, Fire-Resistant	yes
		Pants, Fire-Resistant	yes
		Suit, Fire-Resistant	yes
		Coverall, Fire-Resistant	yes
		Overall, Fire-Resistant/Aluminized	yes
		Apron, Fire-Resistant/Aluminized	yes
		Cape Sleeves, Fire-Resistant/Aluminized	yes
		Hood, Fire-Resistant/Aluminized	yes
		Coat, Insulated, Cold Weather	yes
		Jacket, Insulated, Cold Weather	yes
		Pants, Insulated, Cold Weather	yes
Chemical	N/A	Jacket, Raingear*	yes
		Coat, Raingear*	yes
		Pants, Raingear*	yes
		Suit, Raingear*	yes
		Apron, Chemical-Resistant	yes
		Coat, Chemical-Resistant	yes
		Pants, Chemical-Resistant	yes
		Jacket, Chemical-Resistant	yes
		Suit, Chemical-Resistant	yes
		Suit, Environmental, Chemical-Resistant	yes
		Cape Sleeves, Chemical-Resistant	yes

Table 16

PROTECTIVE CLOTHING NEEDS

I/O Area Public Utilities (Continued)

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Radiological	N/A	Jacket, Disposable	yes
		Coat, Disposable	yes
		Shirt, Disposable	yes
		Pants, Disposable	yes
		Suit, Disposable	yes
		Coverall, Disposable	yes
		Hood, Leaded	yes
		Apron, Leaded	yes
		Coat, Leaded	yes
		Suit, Leaded	yes
		Pants, Leaded	yes
Electrical	N/A	Cape Sleeves, Nonconductive	yes
		Suit, Nonconductive	yes
Biological	N/A	Jacket, Impermeable	yes
		Coat, Impermeable	yes
		Pants, Impermeable	yes
		Suit, Impermeable	yes
		Apron, Impermeable	yes
		Coverall, Impermeable	yes
		Overall, Impermeable	yes

*Available in high-visibility colors.

Table 16

PROTECTIVE CLOTHING NEEDS

I/O Area Public Utilities (Continued)

WELDING OPERATIONS

Welding is a metal-joining process where coalescence is obtained by heat and/or pressure. It may also be defined as a metallurgical bond accomplished by the attracting forces between atoms. Hazard exposures to workers vary with the metal-joining process. Some of the metal-joining processes defined as welding are:

- Soldering - The joining of two pieces of metal with a dissimilar metal in a molten state not exceeding 800°F.
- Brazing - The joining of two pieces of metal with a nonferrous alloy in a molten state at temperatures over 800°F, but lower than the molten temperature of the metal to be joined.
- Gas Welding - All welding processes in which gases are used in combination to obtain a hot flame. The most-used gases are: acetylene, natural gas, and hydrogen in combination with oxygen.
- Arc Welding - The joining of two pieces of metal by heat from an electric arc between the metal and an electrode. The electrode or welding rod is melted and deposited into the joint at temperatures around 10,000°F.

Hazards identified in the welding processes are:

- Mechanical - Sharp metal edges and points, falling objects, and catching between objects.
- Thermal - Molten metal slag, hot objects, hot environments, sparks, and open flames.
- Chemical - Toxic gases, fumes, and dusts which may be generated during welding processes. These materials present inhalation hazards in varying degrees.
- Radiological - Ultraviolet and infrared radiation, which are generated during welding processes such as inert-gas-shielded arc welding, and gas welding.
- Electrical - Welding process using electricity as a heat source. Greatest exposures are during electrode changing, setting up work, or changing work positions.

Protective clothing needs in welding operations vary with the type of process involved, worker environment, and materials being welded. A basic welder's ensemble should consist of flame-resistant gauntlet gloves; apron of asbestos, leather, or other flame-resistant material; and helmet or goggles with appropriate eye-protective lenses. For heavy work, jackets, overalls, spats, leggings, or cape sleeves should be worn, and, in inadequate ventilation or enclosed space, respiratory protection may be indicated. General-work suits should be flame-resistant material, and, where ultraviolet or infrared radiation is a factor, should completely cover the worker.

Dark clothing to reduce reflection should be worn. Cotton clothing is not recommended as it deteriorates quickly under high ultraviolet exposure.

During the field surveys, welding operations were observed either in production processes or maintenance tasks in 26 companies. Total worker population of the companies surveyed was 23,235.

The Hazard Severity matrix presented on the following pages was compiled from 26 companies where welding operations were observed. The matrix indicates only severities of hazards observed in the welding processes.

- Mechanical hazard severities of a 3rd-degree nature were the most numerous with 65 percent.
- Fourth-degree severities of thermal hazards accounted for all noted.
- Eighty-one percent of the chemical hazards ranked were 3rd degree.
- Third-degree severities were 85 percent of the radiological hazards, and 58 percent of the electrical hazards.
- Biological hazards were all 1st-degree severities.

Hazard severities were ranked by observed hazards in the worker environment. Electrical hazards were either 1st or 3rd degree depending on whether arc welding or gas welding processes were involved. No electrical hazards are present in gas welding operations. Radiological severities of a 4th degree existed because of the use of inert-gas-shielded arc welding processes.

It was noted from Bendix accident data that 11 injuries occurred to welders. Mechanical hazard involvement was seen in eight of these, with two radiological and one thermal. Analysis of the data indicates one medical treatment injury was sustained, two total temporary disabilities were involved, and eight degree of injuries were unknown. Five days of known lost time was documented.

The injury percentage distributed by nature is shown on the bar chart on page 107. It indicates the following:

- Fractures was the most numerous nature with 36.4 percent.
- The nature of punctures and flash burns were next with 18.2 percent.
- The three natures of lacerations, burns, and contusions were all 9.1 percent of the total.

The bar chart on page 108 presents distribution by body area. The following data is displayed:

- Upper extremities accounted for 45.5 percent of the body areas involved.
- Lower extremities, and eye and head areas both were involved in 27.3 percent.

Figure 24

HAZARD SEVERITY MATRIX

WELDING OPERATIONS

COMPANY CODE	M	T	C	R	E	B
1-1	2	4	3	3	3	1
1-6	2	4	3	4	3	1
1-11	3	4	4	4	3	1
1-19	3	4	3	3	3	1
1-20	3	4	4	3	3	1
1-23	4	4	4	3	3	1
1-30	2	4	3	3	1	1
1-31	3	4	3	3	1	1
1-32	3	4	3	3	1	1

Figure 24

HAZARD SEVERITY MATRIX

WELDING OPERATIONS (CONTINUED)

COMPANY CODE	M	T	C	R	E	B
2-1	2	4	3	3	3	1
2-6	3	4	3	3	3	1
2-15	3	4	4	4	3	1
2-28	4	4	3	3	3	1
3-8	2	4	3	3	1	1
3-12	3	4	3	3	3	1
3-15	3	4	4	4	4	1
3-17	3	4	3	3	3	1
3-18	3	4	3	3	1	1

Figure 24

HAZARD SEVERITY MATRIX

WELDING OPERATIONS (CONTINUED)

COMPANY CODE	M	T	C	R	E	B
3-22	3	4	3	3	1	1
3-23	3	4	3	3	1	1
3-24	3	4	3	3	1	1
3-28	2	4	3	3	3	1
3-32	4	4	3	3	3	1
4-4	3	4	3	3	1	1
4-5	3	4	3	3	3	1
4-9	3	4	3	3	1	1

Average Hazard Severity = 3.2750

<u>Legend</u>

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

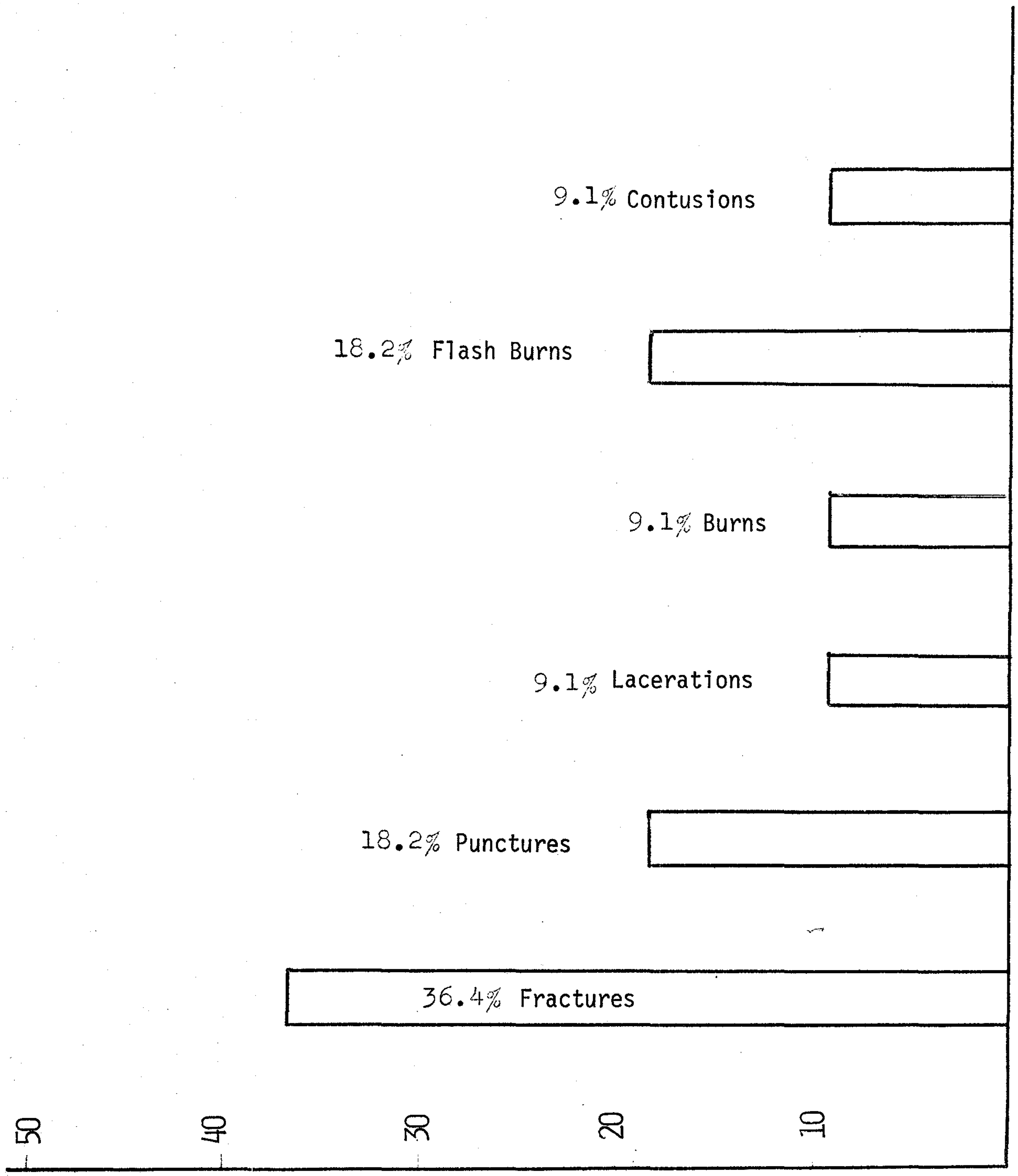
Figure 25

BENDIX INJURY DATA

WELDING OPERATIONS

INJURY PERCENTAGE DISTRIBUTION

BY NATURE



Will not total 100% due to rounding.

(%)

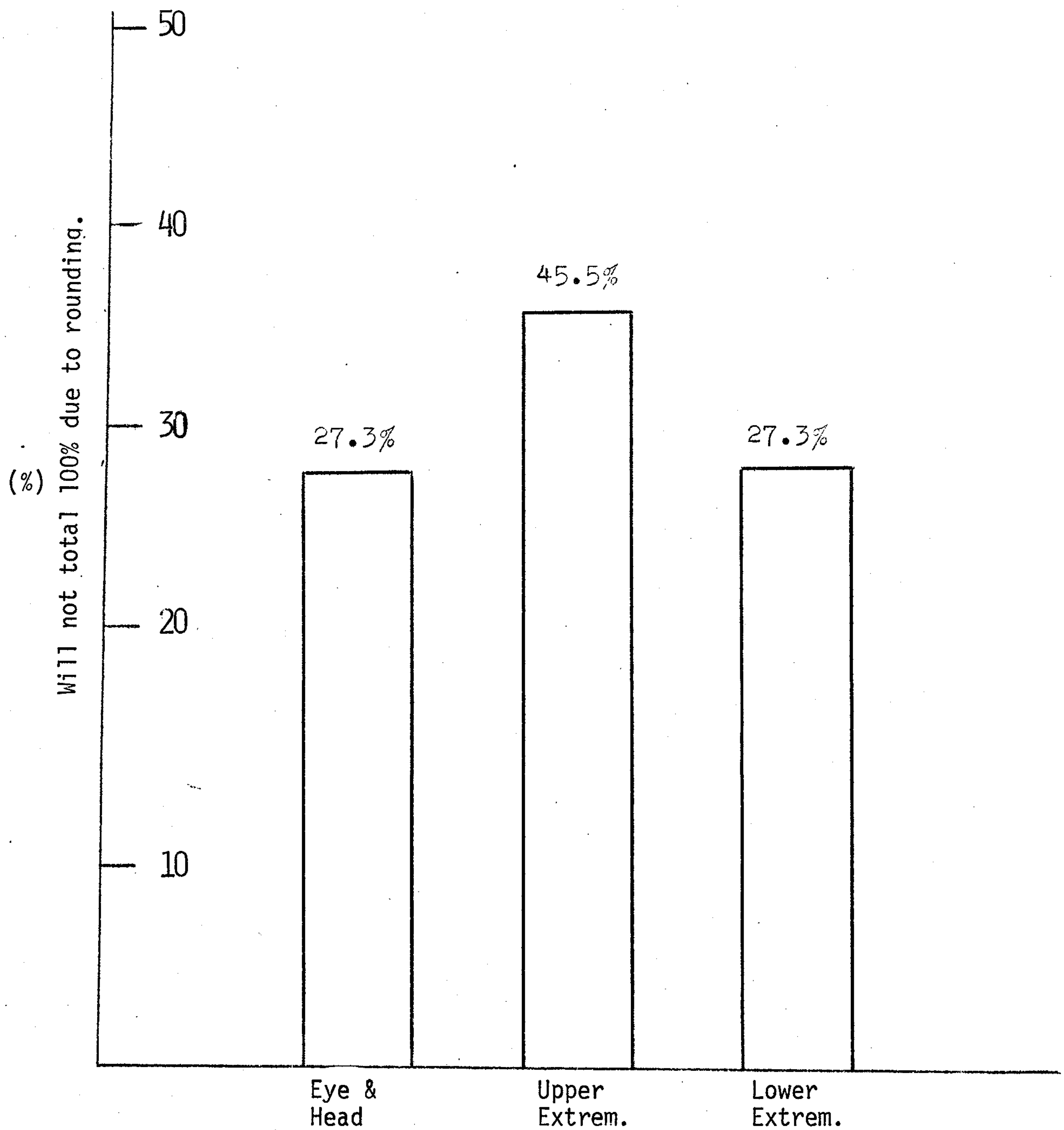
Figure 26

BENDIX INJURY DATA

WELDING OPERATIONS

INJURY PERCENTAGE DISTRIBUTION

BY BODY AREA



- No torso involvement was noted.

State accident analysis for Ohio for the years 1971 and 1972 was performed for torso protective clothing related injuries. Because the processes of forging were deemed a close approximation of welding operations, the data is presented also. Strains and sprains accounted for 35 percent of the Ohio injuries.

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Forging and Hot Metal Stamping	91	20	14.3
Arc Welding	512	47	6.0

Observations made by the Field Survey Representative to determine current protective clothing practices in the industry revealed:

- Protective clothing was observed being worn by welders in 17 of the 26 companies.
- Protective clothing for welders was supplied by 19 companies, but was required wear in only 15 of the companies surveyed.
- Added risks caused by protective clothing were evident in one of the companies.
  (Added-risk complaints were from welders in one company who stated that bulkiness of the welder's ensemble hindered mobility in tight and confined places.)

Surveyor assessment of the availability and adequacy of protective clothing at the facilities indicates that:

- In 14 of the companies, adequate protective clothing was made available to welders.
- Five of the companies made protective clothing available, but it was inadequate for worker protection.
- Of the companies surveyed, seven did not make protective clothing available to their welders.

Protective clothing needs are presented in the chart on page 110.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical*	4th	Jacket, Heavy Fire-Resistant Material	yes
		Cape Sleeves, Heavy Fire-Resistant Material	yes
		Hood, Heavy Fire-Resistant Material	yes
		Apron, Bib-Type or Waist-Type, Heavy Fire-Resistant Material	yes
		Apron Split-Leg, Bib-Type or Waist-Type, Heavy Fire-Resistant Material	yes
		Chaps, Heavy Fire-Resistant Material	yes
		Trousers, Heavy Fire-Resistant Material	yes
Thermal	4th	Shirt, Fire-Resistant Material	yes
		Pants, Fire-Resistant Material	yes
		Overall, Fire-Resistant Material	yes
		Coverall, Fire-Resistant Material	yes
Chemical	4th	Hood, Air-Supplied, or Respirator-Equipped	yes

*Items worn by welders will also provide protection from thermal, chemical, electrical, and radiological hazards encountered during work performance.

Table 17

PROTECTIVE CLOTHING NEEDS

I/O Area Welding Operations

ABRASIVE AND BUFFING OPERATIONS

Abrasive and Buffing Operations are quite common in the manufacturing industry. Abrasion or grinding may be defined as the shaping of material by bringing it in contact with a rotating abrasive wheel belt or disk. It includes surface, internal, external, cylindrical, and centerless operations. Various types of wheels, discs, and belts are utilized in Abrasive and Buffing Operations.

The predominant hazards of Abrasive and Buffing Operations are:

- Mechanical - Chips,particles, and debris from grinding operations. High rotational forces and grinding heat can cause internal stress in grinding wheels which may result in disintegration. The high rotational speeds (polishing and buffing wheel peripheral speeds range from 3,000 to 7,000 surface feet per minute, grindstones from 2,000 to 3,500 surface feet per minute) can create highly dangerous projectiles upon failure. Handheld power grinding tools can cause, through mishandling, severe abrasions and lacerations.

- Thermal - Hot sparks and friction-generated heat in objects being processed.

- Chemical - Abrasive, metallic, and other dusts produced by material processing. The major hazard is inhalation.

Protective clothing needs vary with the type of abrasion or buffing being performed. In light grinding operations such as small bench grinders in machine shops, a bib apron of suitable heavy material, protective sleeves, and face protection is all that should be required. During heavy grinding such as is accomplished in auto body shops with portable, heavy-duty sanders, upper and lower torso protection may be needed to protect workers from contact, through mishandling, with the moving abrasive disks. Also, large concentrations of dusts and fumes from paints, body fillers, lead, and steel are produced during these operations, and, depending on ventilation, may require respiratory protection devices. Disposable clothing or clothing which may be turned in daily for decontamination is indicated in areas where grinding on toxic materials such as beryllium is done. Fire-retardant clothing may be indicated during heavy grinding operations producing large showers of hot sparks.

A total of 38 companies were surveyed which exhibited abrasive and buffing operations in their production processes. Worker population of the facilities was 34,405. The Hazard Severity matrix on the following pages indicates the degree associated with each hazard encountered at the survey sites. Hazard severities were assigned to define the degree of environmental hazards connected with or adjacent to jobs in each facility surveyed.

Hazard severities at the surveyed sites ranged from a high of fourth degree in chemical and mechanical hazards, to a low of first degree in radiological, electrical, and biological hazards.

The analysis of Bendix accident data was undertaken to provide a more complete picture of accident statistics that the states' Workmen's Compensation data lacked. The First Report of Accident Forms from selected facilities in Bendix divisions were reviewed. In most cases this data was

Figure 27

HAZARD SEVERITY MATRIX

ABRASIVE AND BUFFING OPERATIONS

COMPANY CODE	M	T	C	R	E	B
1-4	3	3	3	1	1	1
1-5	4	3	4	1	1	1
1-6	3	2	3	1	1	1
1-7	3	3	4	1	1	1
1-11	3	3	3	1	1	1
1-19	3	2	3	1	1	1
1-20	4	2	4	1	1	1
1-23	4	2	4	1	1	1
1-26	3	3	3	1	1	1

Figure 27

HAZARD SEVERITY MATRIX

ABRASIVE AND BUFFING OPERATIONS (CONTINUED)

COMPANY CODE	M	T	C	R	E	B
1-32	3	3	3	1	1	1
1-34	3	3	3	1	1	1
2-1	3	3	3	1	1	1
2-6	3	2	3	1	1	1
2-14	3	3	4	1	1	1
2-15	3	2	3	1	1	1
2-19	3	3	3	1	1	1
2-25	3	3	4	1	1	1
2-27	3	3	4	1	1	1

Figure 27

HAZARD SEVERITY MATRIX

ABRASIVE AND BUFFING OPERATIONS (CONTINUED)

COMPANY CODE	M	T	C	R	E	B
2-28	3	3	3	1	1	1
2-29	3	3	4	1	1	1
3-1	3	2	3	1	1	1
3-4	3	2	3	1	1	1
3-12	3	3	4	1	1	1
3-15	3	2	3	1	1	1
3-20	3	3	4	1	1	1
3-22	3	2	3	1	1	1
3-23	3	3	3	1	1	1

Figure 27

HAZARD SEVERITY MATRIX

ABRASIVE AND BUFFING OPERATIONS (CONTINUED)

COMPANY CODE	M	T	C	R	E	B
3-26	3	3	4	1	1	1
3-31	3	3	4	1	1	1
4-2	3	2	4	1	1	1
4-4	3	3	3	1	1	1
4-5	3	3	4	1	1	1
4-8	3	3	4	1	1	1
4-9	3	3	3	1	1	1
4-13	2	2	2	1	1	1
4-18	3	2	3	1	1	1

Figure 27

HAZARD SEVERITY MATRIX

ABRASIVE AND BUFFING OPERATIONS (CONTINUED)

COMPANY CODE	M	T	C	R	E	B
5-4	3	2	3	1	1	1
5-5	3	3	4	1	1	1

Average Hazard Severity = 3.0263

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

very complete and detailed; however, some discrepancies were noted in that a portion were not completely filled in.

A total of 26 injuries from all Bendix data available could be related to this Industrial/Occupational area. The bar chart on page 118 presents the injury percentage distribution by nature. The chart indicates the following:

- Unknown nature accounted for 34.6 percent of the total.
- Lacerations were responsible for 19.2 percent of the natures as were Abrasions and Contusions.
- Foreign Object in Eye natures made up 11.5 percent.
- The natures of Fractures and Punctures each accounted for 7.6 percent.

All hazard involvements of the injuries were of a mechanical type.

The bar chart on page 119 shows the injury percentage distribution by body area. The following information is displayed:

- Upper Extremities were involved in the most injuries with 57.4 percent of the total.
- Lower Extremities were next with 15.2 percent.
- Eye and Head, and Unknown body areas were both 11.5 percent.
- Torso was last with 3.8 percent of the injuries to that body area.

Abrasive and Buffing Operations is represented by the following industries as obtained from the State accident data. These areas were:

- Abrasive Products, SIC 3291
- Iron and Steel Foundries, SIC 332
- Glass and Glassware, Pressed or Blown, SIC 322
- Nonferrous Primary Smelting and Refining, SIC 333

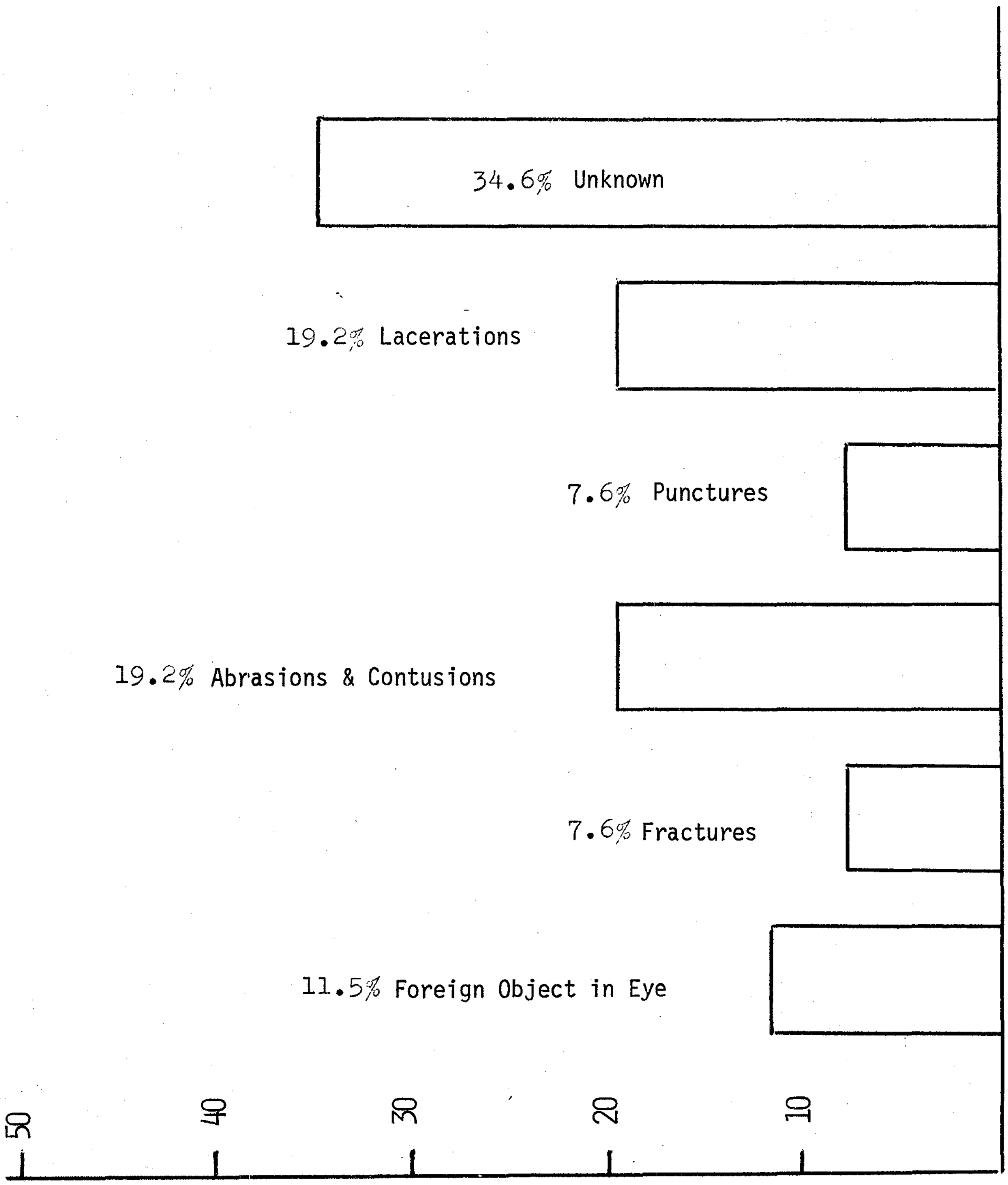
Florida accident data was analyzed for protective clothing torso related injuries. This was defined as those injuries to the trunk, excluding strains, sprains, or hernias, as these injuries cannot be prevented by protective clothing. In 1971, Florida reported that 40 percent of all injuries were of this nature. Therefore, 40 percent of the trunk injuries can be classified as not being related injuries. The data for Abrasive and Buffing Operations shows the following:

Figure 28
BENDIX INJURY DATA

ABRASIVE AND BUFFING OPERATIONS

INJURY PERCENTAGE DISTRIBUTION

BY NATURE



Will not total 100% due to rounding.

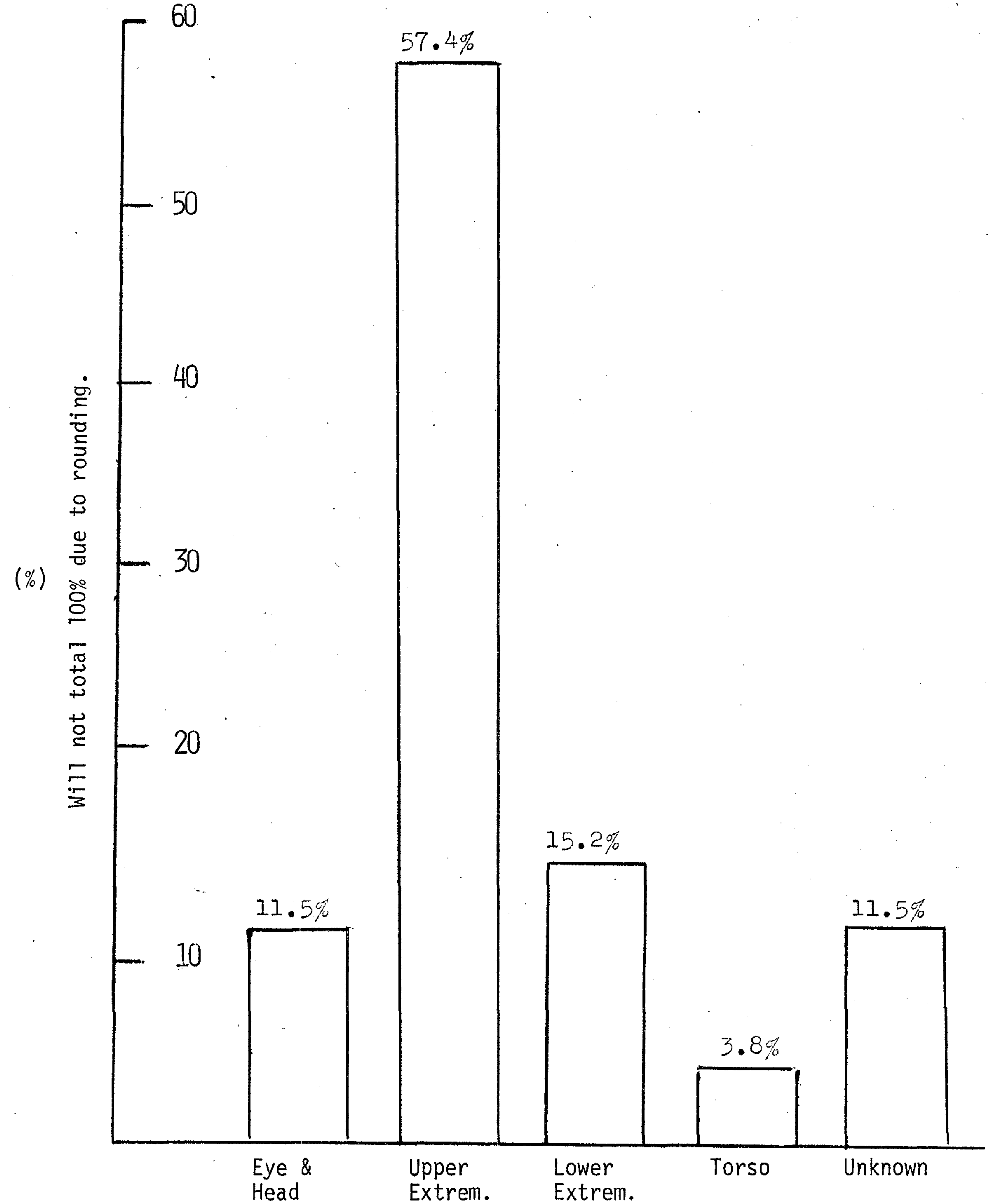
(%)

Figure 29
BENDIX INJURY DATA

ABRASIVE AND BUFFING OPERATIONS

INJURY PERCENTAGE DISTRIBUTION

BY BODY AREA



Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related%
Abrasive Products	23	1	2.6
Iron & Steel Foundries	133	7	3.2
Glass & Glassware, Pressed or Blown	25	4	9.6
Nonferrous Primary Smelting & Refining	19	1	3.2

Pennsylvania data was not available in these industries.

Analysis of the survey data revealed the following information on the protective clothing policies of the companies surveyed:

- Protective clothing was worn in 21 of the sample companies.
- Protective clothing wear was mandatory in 18 of the sample companies.
- Protective clothing was supplied in 23 of the companies.
- Sixteen of the companies had protective clothing available and adequate for worker protection.
- Seven of the companies made clothing available; however, it was not adequate for worker protection.

The addition of worker risk by the use of protective clothing was noted in one company. Workers there complained that gloves worn tended to entangle in moving machinery. User acceptance of use or lack of use of clothing was noted in 25 of the companies. Complaints from workers were documented as:

- Clothing too hot.
- Company did not want to go to the expense.
- Would not wear protective clothing if it was made available.
- Protective clothing not necessary.

The Protective Clothing Needs chart on the next page reveals the types of protective clothing required in Abrasive and Buffing Operations:

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	4th	Shirt	yes
		Trousers	yes
		Coverall	yes
		Overall, Heavy Material	yes
		Suit, Heavy Material	yes
		Hood, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
		Cape Sleeves with Bib, Heavy Material	yes
		Jacket, Heavy Material	yes
		Chaps, Heavy Material	yes
		Apron, Waist-Type or Bib-Type	yes
		Apron, Split-Leg, Waist-Type or Bib Type	yes
Thermal	3rd	Shirt, Fire-Resistant	yes
		Trousers, Fire- Resistant	yes
		Coverall, Fire-Resistant	yes
		Overall, Fire-Resistant	yes
		Suit, Fire-Resistant	yes
Chemical	4th	Shirt, Disposable	yes
		Trousers, Disposable	yes
		Coverall, Disposable	yes
		Overall, Disposable	yes
		Suit, Disposable	yes
		Hood, Air-Supplied	yes
		Hood, Respiration	yes

Table 18

PROTECTIVE CLOTHING NEEDS

I/O Area Abrasive and Buffing Operations

SILICA DUST GENERATING OPERATIONS

Silica Dust Generating Operations are found to occur in such occupations as: mining; the cutting of sandstone and granite; the coal industry; the smelting, refining, and grinding of metals; the manufacture of certain abrasives; the glassmaking industry; and the processing of various forms of free silica. The major exposure hazard to silica dust is inhalation. Inhalation exposures over an extended period of time may lead to silicosis, a chronic disease of the lungs caused by breathing particulate matter containing free or uncombined silica. Its symptoms include shortness of breath, lowered vital capacity, lowered work capacity, and increased susceptability to tuberculosis. The size of the particulate matter inhaled plays an important part in worker susceptability to silicosis.

Protective clothing needs for Silica Dust Generating Operations are primarily for the prevention of dust inhalation, and protection against abrasive blasts from sandblasting and high-velocity particles from powered grinders and sanders. Items which may be required for sandblasters are leather or similar, heavy-material hoods, jackets, pants, suits, and coveralls to protect the workers body during heavy-duty sandblasting. Aprons, and/or cape sleeves may be indicated in other sandblasting operations. Worker exposure to silica dust in other industrial areas may only require respiratory protection.

During the field surveys, eight companies were observed for silica dust hazards. Total worker population for the companies was 11,203. A Hazard Severity matrix for the eight companies surveyed for silica dust hazards is presented on page 123.

Fourth-degree chemical hazards predominate in all but two of the companies surveyed. One of these two companies was a large automobile manufacturer. Metal surfaces to be painted or plated were prepared by a Vacublast process which is an automated sandblasting operation. Worker exposures to hazards were completely eliminated by isolation. All hazard severities for this company were ranked as 1st-degree hazards. The 4th-degree rankings for the other companies were due to the hazards of silica dust exposure.

Mechanical hazards in most cases were ranked as 3rd-degree severities due to worker exposures to high-velocity particles from sandblasting, grinding, and sanding operations; and exposures to hazards from powered grinding, wheels and sanding discs. Two 4th-degree mechanical hazard severities were noted in the shipbuilding and repairing facilities. These relatively high rankings were due to the more severe mechanical hazards from operations normally associated with this type industry. The equipment used in sandblasting is much larger than that used for sandblasting smaller items. Workers are exposed to slips and falls from heights while sandblasting the hulls of ships.

Bendix accident data was not avialable for Silica Dust Generating Operations as the Corporation does not engage in this type operation.

A large number of industries perform operations generating silica dust. The following industries represent the majority of silica dust operations. They are:

Figure 30

HAZARD SEVERITY MATRIX
SILICA DUST GENERATING OPERATIONS

COMPANY CODE	M	T	C	R	E	B
1-5	3	1	4	1	1	1
1-20	4	1	4	1	1	1
1-23	4	1	2	1	1	1
2-15	1	1	1	1	1	1
4-4	3	1	4	1	1	1
4-5	3	1	4	1	1	1
4-8	3	1	4	1	1	1
4-13	3	1	4	1	1	1

Average Hazard Severity = 3.5000

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

- Abrasive Products, SIC 3291
- Nonferrous Primary Smelting and Refining, SIL 333
- Iron and Steel Foundries, SIC 332
- Stone, Clay, and Glass Products, SIC 32

Analysis of Florida data for torso protective clothing related injuries indicates the following for the year 1971:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Abrasive Products	23	1	2.6
Nonferrous Primary Smelting and Refining	133	7	3.2
Iron and Steel Foundries	133	7	3.2
Stone, Clay, and Glass Products	1,159	101	5.2

Survey reports to determine protective clothing policies in the industry where silica dust is a hazard indicated that:

- Protective clothing was worn in seven of the eight companies surveyed.
- Six companies required the wearing of protective clothing.
- Protective clothing was supplied by seven of the eight companies surveyed.
- Four of the companies had adequate protective clothing available for their workers.
- Three companies made clothing available but it was inadequate for worker protection.
- No clothing was made available by one company.

In one of the companies visited, workers voiced dissatisfaction with the protective clothing worn. Their complaint was the common one that it was too hot and uncomfortable to wear. No additive risk factors were noted by the Surveyor because of protective clothing wear.

The Protective Clothing Needs chart on page 125 indicates the types of clothing required.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	4th	Jacket, Heavy Material	yes
		Coat, Heavy Material	yes
		Suit, Heavy Material	yes
		Pants, Heavy Material	yes
		Hood, Heavy Material	yes
		Overall, Heavy Material	yes
		Coverall, Heavy Material	yes
		Apron, Waist-Type or Bib-Type, Split-Leg, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
Chemical	4th	Hood, Air-Supplied	yes
		Hood, Respirator-Equipped	yes

Table 19

PROTECTIVE CLOTHING NEEDS

I/O Area Silica Dust Generating Operations

INSECTICIDE AND PESTICIDE SPRAYING

Health and safety problems in insecticide and pesticide spraying operations have many facets and complexities. There are approximately 900 chemical compounds and over 90,000 formulations which are classified as pesticides. An expanding market for new formulations is being stimulated by increasing pest resistance to heavily used pesticides and increased federal curtailment for ecological reasons.

Insecticide and pesticide spraying operations for the exterminating of insects and rodents may be accomplished in commercial properties, industrial plants, and agricultural lands.

The primary hazard involved is of a chemical nature from systemic poisoning from toxic materials and dermatitis from irritants of mists and dusts.

Protective clothing needs may range from basic protection to complete ensembles with respirators and gloves and boots made of a suitable impervious material.

Two facilities were visited during the survey which exhibited insecticide and pesticide spraying operations. In both cases, the facilities observed were agricultural in nature and were located in the southeast portion of the United States. The Hazard Severity matrix on the following page reflects the severity ratings of each of the six hazards identified in the contract. Chemical hazards were the highest ranked with 4th-degree ratings given for both facilities. It was noted at one facility that workers complained that contact with the insecticide formula produced burns and a sensation of freezing. Thermal hazards were limited to heat-stress dangers that would normally be associated with working in the hot, humid climate of the southeast. Mechanical, radiological, electrical, and biological hazards were found to be negligible in this sample.

Bendix accident data was not available for this Industrial/Occupational Area

Florida accident data for 1971 was researched under the Agricultural Service and Horticultural Industries. This was assumed to be the closest approximation available to insecticide and pesticide spraying operations. The data was analyzed as previously mentioned in other discussions, keeping in mind that 40 percent of the injuries reported were strain, sprain, and hernia injuries. The data indicates:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Agricultural Services	245	25	6.1
Horticultural Services	264	16	3.6

Figure 31

HAZARD SEVERITY MATRIX
INSECTICIDE AND PESTICIDE SPRAYING

COMPANY CODE	M	T	C	R	E	B
1-14	1	2	4	1	1	1
1-16	1	2	4	1	1	1

Average Hazard Severity = 3.0000

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

Pennsylvania data was not available for analysis in this Industrial/Occupational area.

During the field surveys, protective clothing practices were noted which indicated a general lack of knowledge of the hazards inherent in insecticide and pesticide spraying operations. Protective clothing was supplied by one of the two companies surveyed; however, protective clothing was not worn by the workers of either. This was in spite of the fact that the company required and supplied protective clothing to its workers. It was interesting to note that workers expressed a willingness to wear protective clothing at the company which did not supply it, and the workers refused to wear it for any length of time at the company that did. Workers at the latter facility stated that they would wear the clothing if it didn't get so hot. The protective clothing issued them consisted of a two-piece plastic suit with rubber gloves, boots, and a chemical cartridge respirator. Spray workers would start the day wearing the complete ensemble and finish it wearing only the boots.

The Protective Clothing Needs chart on page 129 illustrates the types of protective clothing required.

Table 20

PROTECTIVE CLOTHING NEEDS

I/O Area Insecticide and Pesticide Spraying

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Chemical	4th	Jacket, Chemical-Resistant	yes
		Pants, Chemical-Resistant	yes
		Suit, Chemical-Resistant	yes
		Coverall, Chemical-Resistant	yes
		Overall, Chemical-Resistant	yes
		Hood, Chemical-Resistant, Respirator Supplied	yes

MACHINE TOOL PRODUCTION

Machine tools include all power-driven machines not portable by hand used to shape or form metal by cutting, impact, pressure, electrical techniques, or a combination of these processes.

The National Machine Tool Builders Association has classified some 200 types of machine tools into five basic groups:

- Turning - Shaping a rotating piece with a cutting tool, usually to give a circular cross-section. It is done on engine, turret, and semiautomatic lathes; chuckers; and automatic screw machines.

- Boring - Cutting around hole by drills, boring cutters, or reamers. The most common boring machine is the drill press.

- Milling - Machining a piece of metal by bringing it into contact with a rotating multi-edged cutter. It is accomplished on horizontal and vertical milling machines, gear bobbers, profiling machines, and circular saws and bandsaws.

- Planing - Machining a surface with the cutting tool held stationary while the piece is moved back and forth beneath it. Slotters, broaches, shapers, and key setters come within this classification.

- Grinding - Shaping material by bringing it into contact with a rotating abrasive wheel, belt, or disc.

In most cases, these same types of machines are used in the manufacturing of machine tools. These machines constitute the major mechanical hazards encountered during production.

Thermal hazards are encountered during welding operations, and, if not subcontracted, in casting of machine bases. Chemical hazards are found in painting operations in the forms of dusts and mists, and contacting organic solvents. Infrared and ultraviolet radiation produced during welding operations make up the radiological hazards.

Protective clothing needs for the hazards may be defined as follows:

- Mechanical - The use of heavy leather or similar-material aprons, pants, chaps, jackets, and cape sleeves to provide protection during material-forming and -handling operations.

- Thermal - The use of aluminized fire-resistant clothing may be indicated during casting processes; the use of welders' ensembles is indicated for welding operations.

- Chemical - The use of lightweight disposable clothing is indicated for painting operations. The use of chemical-resistant clothing is indicated when in contact with solvents.

The Hazard Severity matrix on the following page identifies, with the company codes, the hazards observed. The hazards were ranked as to severity; an explanation follows:

- Mechanical - Hazards were ranked as 3rd degree in four of the seven companies, while two of the companies were ranked 2nd degree because of the extensive use of automatic and semiautomatic machines. One 4th-degree ranking was given due to extensive construction being accomplished at the plant. These construction efforts significantly increased mechanical hazards.

- Three of the companies visited did no casting on the premises; therefore, the thermal hazards at these facilities were ranked as 3rd degree, while those exhibiting casting operations were ranked as 4th degree.

- Chemical hazards were ranked as 3rd degree in all facilities due to the sameness of chemical-hazard-producing operations such as painting, grinding, and metal cleaning.

- Radiological hazards from welding operations were common in all facilities and, as such, were ranked as all 3rd degree.

Bendix accident data was not available for this Industrial/Occupational area.

Florida data for 1971 was analyzed for related injuries, as was done in the preceding discussions. The data revealed the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Metalworking Machinery and Equipment	75	6	4.8

Data was not available from Pennsylvania on machine tool production.

Comments from the survey reports indicated that in only two of the seven companies visited was protective clothing supplied to workers. The mandatory wear of clothing was not required at any company, while it was accepted and worn by the workers in one. The addition of risk to workers wearing protective clothing was negligible. Other information gained from the surveys was:

- One of the seven companies had adequate protective clothing available.

- One of the companies made clothing available, but the clothing did not provide adequate protection.

Figure 32

HAZARD SEVERITY MATRIX

MACHINE TOOL PRODUCTION

COMPANY CODE	M	T	C	R	E	B
3-17	3	3	3	3	1	1
3-18	3	3	3	3	1	1
3-21	3	4	3	3	1	1
3-22	2	4	3	3	1	1
3-23	4	4	3	3	1	1
3-24	3	4	3	3	1	1
4-18	2	3	3	3	1	1

Average Hazard Severity = 3.1071

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

- In five of the sample companies, protective clothing was not made available.

The Protective Clothing Needs chart on page 134 portrays the type clothing required to adequately protect the worker.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	4th	Apron, Heavy Material	yes
		Chaps, Heavy Material	yes
		Pants, Heavy Material	yes
		Jacket, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
Thermal	4th	Shirt, Fire-Resistant Material	yes
		Pants, Fire-Resistant Material	yes
		Suit, Fire-Resistant Material	yes
		Overall, Fire-Resistant Material	yes
		Coverall, Fire-Resistant/Material	yes
		Coat, Fire-Resistant Aluminized	yes
		Jacket, Fire-Resistant/Aluminized	yes
		Pants, Fire-Resistant/Aluminized	yes
		Suit, Fire-Resistant/Aluminized	yes
		Overall, Fire-Resistant/Aluminized	yes
		Coverall, Fire-Resistant/Aluminized	yes
		Hood, Fire-Resistant/Aluminized	yes
Chemical	3rd	Shirt, Disposable	yes
		Pants, Disposable	yes
		Jackets, Disposable	yes
		Suit, Disposable	yes
		Overall, Disposable	yes
		Coverall, Disposable	yes
		Jacket, Chemical-Resistant	yes
		Coat, Chemical-Resistant	yes
		Pants, Chemical-Resistant	yes
		Suit, Chemical-Resistant	yes
		Overall, Chemical-Resistant	yes
		Coverall, Chemical-Resistant	yes
		Apron, Chemical-Resistant	yes
Radiological*	3rd		

*Radiological hazards from welding operations may be protected against by normal welder's protective clothing.

Table 21

PROTECTIVE CLOTHING NEEDS

I/O Area Machine Tool Production

METAL FABRICATIONS

There were five metal fabrication industries surveyed. Worker population of the sample was 339. Hazards identified with the industry are:

- Mechanical - Sharp metallic edges, moving machinery, and flying particles from grinding operations.
- Thermal - Hazards normally associated with welding operations which are: hot sparks, molten metal, and open flames.
- Chemical - Metallic dusts, fume inhalation, and skin contact with organic solvents, and paints.
- Radiological - Nonionizing radiation of ultraviolet and infrared.
- Electrical - High-voltage potential during electric arc welding.

Protective clothing needs are:

- Mechanical - The use of leather or similar heavy-material jackets, coats, chaps, aprons, cape sleeves, and pants, are indicated for upper and lower torso protection from light-to-moderate impacts and sharp edges.
- Thermal - A basic fire-resistant work uniform of pants, shirt, suit, or coverall is indicated for protection from open flame. Heavy fire-resistant-material (which may be aluminized) hood, jacket, coat, pants, coverall, overall, apron, and cape sleeves may be indicated depending on worker exposure to hot sparks, molten metal, and open flames.
- Chemical - Chemical-resistant, impermeable coat, pants, suit, overall, coverall, or hood are needed for protection from light-to-moderate chemical exposure. Respiratory protection may be indicated for chemical inhalation hazards.
- Radiological - Protection is required primarily for welders due to nonionizing radiation produced during work operations. Protection is usually afforded by the standard welder's ensemble.
- Electrical - Primarily, welders' hands and arms are exposed during arc welding operations. This can be controlled by use of gloves and sleeves.

The Hazard Severity matrix which ranks hazards observed during the surveys is shown on the following page. The rankings assigned were as follows:

- Mechanical hazards were ranked as 3rd degree in the five companies surveyed.
- Thermal hazards ranged in severity from 2nd to 4th degree.

Figure 33

HAZARD SEVERITY MATRIX

METAL FABRICATIONS

COMPANY CODE	M	T	C	R	E	B
1-6	3	3	3	1	1	1
1-19	3	2	3	1	1	1
3-4	3	4	3	4	3	1
3-19	3	2	3	4	3	1
4-13	3	4	3	1	1	1

Average Hazard Severity = 3.1052

Legend

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

- Chemical hazards were ranked as 3rd-degree hazards in each of the companies surveyed.

- Radiological hazards ranged from 1st degree to 4th degree, due to the use of different types of welding equipment.

- Electrical hazards ranged from 1st-degree severities to 3rd-degree severities, due to the varying types of welding equipment utilized.

Bendix accident data was not available for the metal fabrication Industrial/Occupational area.

Florida data for 1971 was analyzed for torso protective clothing related injuries using the 40 percent figure quoted for strain, sprain, and hernia natures. The data reveals:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Fabricated Metal Products	1,613	142	5.3

Work injuries in Pennsylvania for April 1973 were analyzed for torso protective clothing related injuries, excluding sprains, strains, and hernias. The data reveals:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Fabricated Metal Products	609	137	15.7

Survey information analysis revealed that:

- Protective clothing was available and adequate in one of the five sample companies.

- In two of the sample companies, protective clothing was not available.

- Protective clothing was available and inadequate in one of the sample companies.

- Protective clothing was not required due to elimination of hazards by other means in one of the companies surveyed.

- Protective clothing was supplied in two of the sample companies.

- Protective clothing was required wear in three of the sample companies.

- Protective clothing was worn by employees in only two of the sample companies.

Protective clothing was found to cause increased risk in one of the companies surveyed. User acceptance was noted in four of the companies.

Protective clothing needs are presented in the chart on page 139.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	3rd	Jacket, Heavy Material	yes
		Coat, Heavy Material	yes
		Chaps, Heavy Material	yes
		Apron, Bib-Type or Waist-Type, Heavy Material	yes
		Apron, Kickback, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
		Pants, Heavy Material	yes
Thermal	4th	Trousers, Fire-Resistant	yes
		Shirt, Fire-Resistant	yes
		Suit, Fire-Resistant	yes
		Overall, Fire-Resistant	yes
		Coverall, Fire-Resistant	yes
		Hood, Fire-Resistant/Aluminized	yes
		Jacket, Fire-Resistant/Aluminized	yes
		Coat, Fire-Resistant/Aluminized	yes
		Pants, Fire-Resistant/Aluminized	yes
		Coverall, Fire-Resistant/Aluminized	yes
		Overall, Fire-Resistant/Aluminized	yes
		Apron, Fire-Resistant/Aluminized	yes
		Cape Sleeves, Fire-Resistant/Aluminized	yes
Chemical	3rd	Coat, Chemical-Resistant, Impermeable	yes
		Pants, Chemical-Resistant, Impermeable	yes
		Suit, Chemical-Resistant, Impermeable	yes
		Overall, Chemical-Resistant, Impermeable	yes
		Coverall, Chemical Resistant, Impermeable	yes
		Hood, Chemical-Resistant, Impermeable	yes

Table 22

PROTECTIVE CLOTHING NEEDS

I/O Area Metal Fabrications

LUMBER AND WOOD PRODUCTS

The lumber and wood products Industrial/Occupational area is one of the oldest in the United States and utilizes a multitude of processes to convert trees into finished products. Because of the variety of processes, there is also a variety of hazards. Many of the operations require considerable worker involvement, which increases the degree of hazard.

The Surveys concerned themselves with wood manufacturing from the log stage at the sawmill to the finished-product stage at the furniture factory. They did not evaluate the cutting and handling of trees and logs prior to their arrival at the mill.

Some of the common processes found in the lumber and wood products industry are:

- Timber cutting, bucking, skidding, and transportation to the mill.
- Log handling, debarking, and sawing to produce rough boards.
- Rough lumber processing, including sawing, planing, shaping, turning, sanding, and joining.
- Wood-product manufacturing, including fabrication and construction.
- Wood-product finishing, including final sanding and polishing, painting, and lacquering.

The hazards identified by the Survey Representative in visiting lumber and wood-products operations are:

- Mechanical - Woodworking and handling machinery, poor housekeeping, poor ventilation, and noise.
- Chemical - Spray painting, staining, and other surface finishing.
- Thermal - Negligible.
- Radiological - Negligible.
- Electrical - Negligible and related to only 40 woodworking machines.
- Biological - Negligible.

Protective clothing needs may be summarized as:

- Mechanical - The use of high-visibility, upper torso coverings during heavy equipment operations in the woods, the use of ballistic nylon or similar material chaps for protection against chain-saw cuts, the use of torso protective clothing made of heavy leather or other material in the forms of aprons, cape sleeves, jackets, and trousers for protection during material handling operations, and the use of kickback aprons during sawmill operations.

- Chemical - The use of lightweight disposable clothing for protection against paint mists, spray, and vapors. The use of air-supplied or respirator-equipped hoods for chemical inhalation protection. The use of water-impermeable clothing for protection from inclement weather.

During the field surveys, three companies were visited which were involved in rough-lumber production and furniture manufacturing. Total worker population of the sample was 87.

The Hazard Severity matrix on the following page was compiled from the data attained at the surveyed companies. Mechanical hazards have a 3rd-degree severity rating because of the considerable use of woodworking machinery. Chemical hazards were evident in one company because of considerable furniture-finishing operations. A severity rating of three was assigned based on the probability of dermatitis to workers involved in painting, and the possibility of fume inhalation. Thermal, radiological, electrical, and biological hazards were negligible.

Bendix accidents reviewed in the Lumber and Wood Products area numbered 197. Of those, 65 were strain, sprain, or hernia natures and are not relevant to protective clothing. The chart presents information on the remaining 132. Only six of these accidents involved total temporary disabilities, with 44 known days lost time accrued. Three of the First Report of Accident Forms did not give sufficient information to relate lost time figures, although lost time was noted.

The bar chart on page 143 portrays the injury percentage distribution by nature. The chart shows the following:

- Thirty-three percent of the injury natures were strain, sprain, and hernia.
- Abrasions and contusions were 19.3 percent.
- Punctures were 17.3 percent.
- Lacerations were 15.1 percent.
- Foreign Object in Eye nature accounted for 8.5 percent.
- Fractures were 2.5 percent.
- Burns were 1.5 percent.
- Dermatitis was involved in 1 percent.
- Conjunctivitis and unknown natures were both noted as 0.5 percent.

Figure 34

HAZARD SEVERITY MATRIX
LUMBER AND WOOD PRODUCTS

COMPANY CODE	M	T	C	R	E	B
2-11	3	1	3	1	1	1
2-3	3	1	1	1	1	1
6-8	3	1	1	1	1	1

Average Hazard Severity = 3.0000

<u>Legend</u>

M = Mechanical
T = Thermal
C = Chemical
R = Radiological
E = Electrical
B = Biological

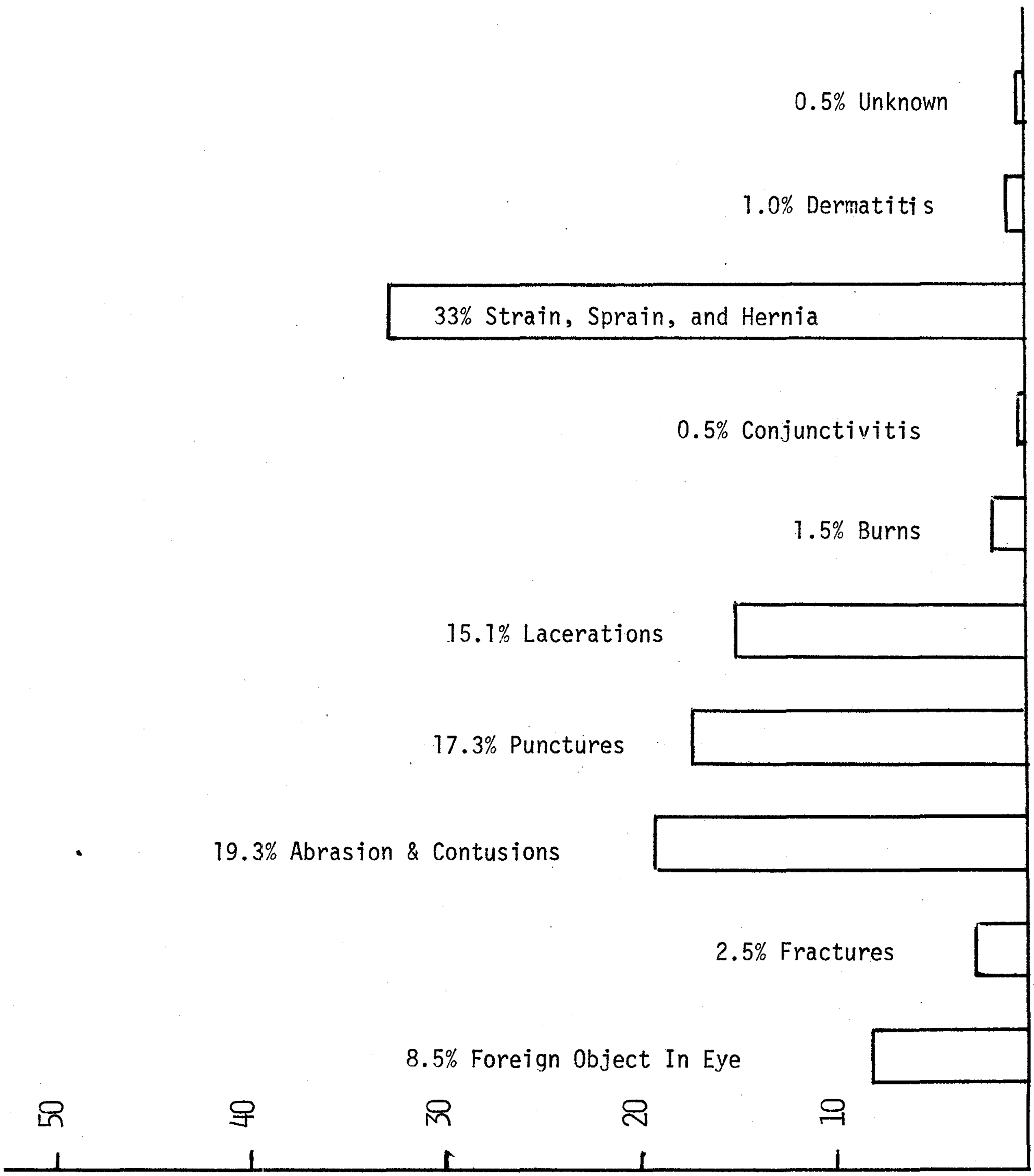
Figure 35

BENDIX INJURY DATA

LUMBER AND WOOD PRODUCTS

INJURY PERCENTAGE DISTRIBUTION

BY NATURE



Will not total 100% due to rounding.

(%)

The bar chart on page 145 indicates the injury percentage distribution by body area. The following information is displayed:

- Upper Extremities were involved in 51 percent of the injuries.
- Eye and head were noted in 20.5 percent.
- Lower Extremities accounted for 17.3 percent.
- Torso involvement was cited in 11.2 percent.

Hazard involvements in the accidents were primarily mechanical, with only three thermal, two chemical, and one radiological involvement noted.

State data for lumber and wood products was from Pennsylvania and Florida. Florida data for 1971 was analyzed for torso protective clothing related injuries and the following was revealed:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Lumber and Wood Products	1,649	139	5.1

Pennsylvania data analyzed for torso protective clothing related injuries indicated for April 1973:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Lumber and Wood Products	136	26	13.4

Observations made by the Survey Representative regarding current protective clothing practices revealed the following:

- Protective clothing was not worn in any of the three companies.
- Protective clothing was not required in any of the companies.
- Protective clothing was not provided by any of the companies.

Additional risk and user acceptability factors were not attainable because of the total lack of protective clothing. Discussion with employees disclosed some employee dissatisfaction with the wearing of safety shoes because the shoes pinched their toes.

The Protective Clothing Needs chart on page 146 illustrates the types of protective clothing needed.

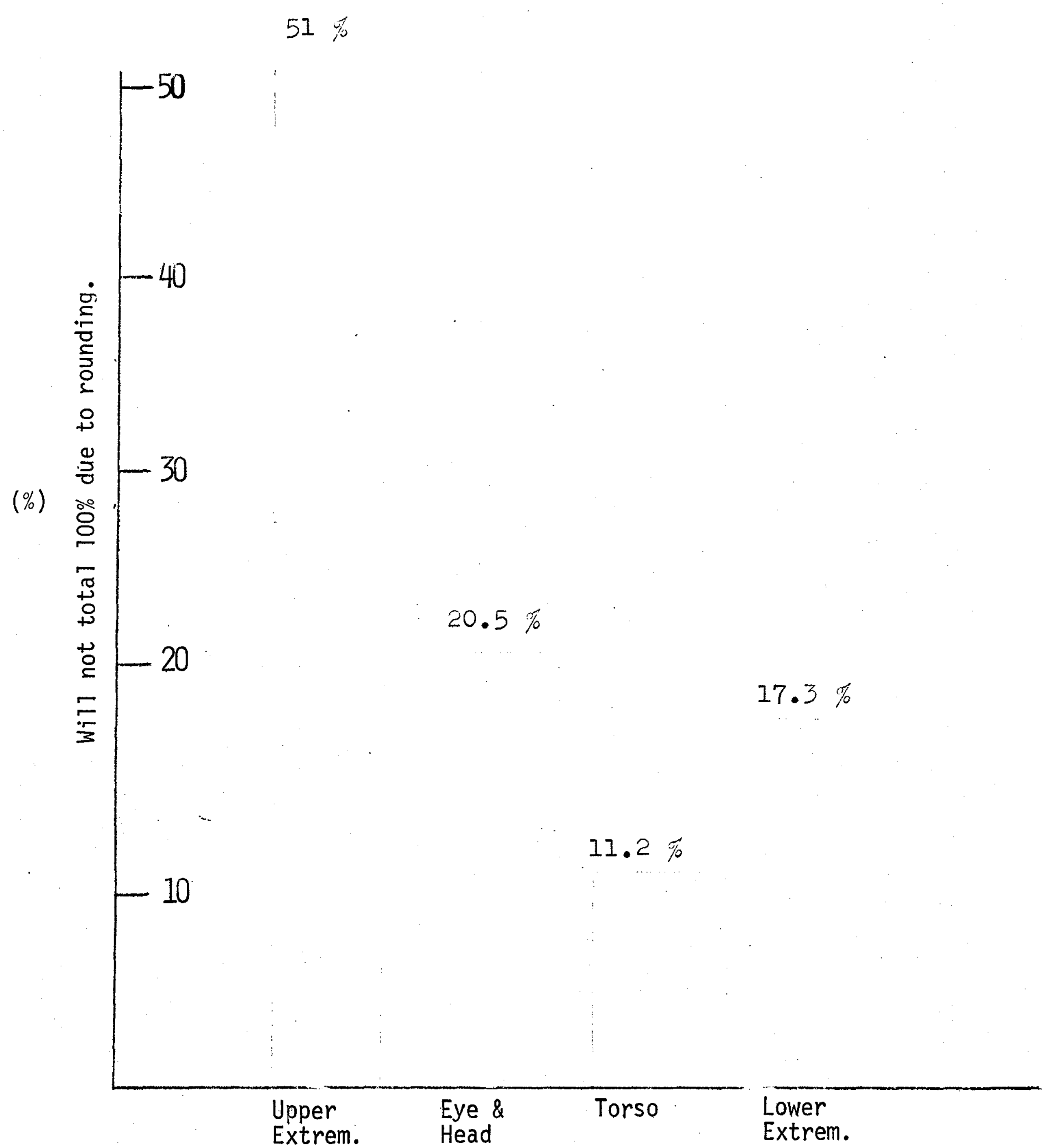
Figure 36

BENDIX INJURY DATA

LUMBER AND WOOD PRODUCTS

INJURY PERCENTAGE DISTRIBUTION

BY BODY AREA



Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Mechanical	3rd	Jacket, Heavy Material	yes
		Trousers, Heavy Material	yes
		Cape Sleeves, Heavy Material	yes
		Chaps, Heavy Material	yes
		Apron, Bib-Type or Waist-Type	yes
		Apron, Kickback, Bib-Type or Waist-Type	yes
		Vest,High-Visibility	yes
		Coat,High-Visibility	yes
		Jacket,High-Visibility	yes
Chemical	3rd	Coat, Disposable	yes
		Shirt, Disposable	yes
		Pants, Disposable	yes
		Overall, Disposable	yes
		Coverall, Disposable	yes
		Suit, Disposable	yes
		Hood, Air-Supplied, or Respirator-Equipped	yes
		Coat, Raingear*	yes
		Jacket, Raingear*	yes
		Pants, Raingear*	yes

*These items may be obtained in high-visibility colors.

Table 23

PROTECTIVE CLOTHING NEEDS

I/O Area Lumber and Wood Products

X-RAY OPERATIONS

X-radiation is an electromagnetic and ionizing radiation. The ability of X-radiation to penetrate an object is dependent on its wavelength and the density of the object being exposed. "Hard" X-rays, or X-rays of short wavelengths will penetrate several inches of steel, while "soft" or X-rays of long wavelengths are less penetrating.

X-ray operations are used in the medical profession for diagnosis and therapy and in manufacturing for nondestructive testing of material. The major hazards in X-ray operations are radiological and electrical.

- Radiological - Ionizing rays from radiological sources. Exposure to these radiations, X-rays in medical diagnosis and therapy, and X-rays and gamma radiation from radium and radioactive isotopes in metallography, can result in severe injuries to workers without warning. As the senses give no warning to such exposures, extreme measures for detection and protection must be taken to provide a safe working environment.

Protective clothing needs for this particular Industrial/Occupational area are limited to the use of protective clothing apparel fabricated of leaded materials. The use of leaded protective clothing, along with shielding and procedural safeguards, is considered adequate for most medical and industrial X-ray applications. Research of available literature indicates that there is no protective clothing within the present state of the art that will protect against the "hard" radiation that may be generated in some radical X-ray therapy and industrial applications. Worker protection is provided in these situations by isolation from the radiological source, and procedural safeguards.

The Hazard Severity matrix on the following page identifies the hazards observed and their relative severities. As can be shown, radiological hazards were ranked primarily as 2nd-degree hazards. This was due to the high degree of safety that was built into the various apparatus used, the use of shielding or distance for worker isolation, and procedural safeguards.

Bendix accident data which included X-ray Operation involvements was not available.

Florida accident data for 1971 was reviewed to determine the percentage of torso protective clothing related injuries. In 1971, Florida reported that 40 percent of all injuries were strains, sprains, or hernias. The data analysis is presented below. As data available was not detailed enough to distinguish X-ray operations, hospital accident data was used.

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Hospitals	805	323	24.1

FIGURE 37

HAZARD SEVERITY MATRIX

I/O AREA: X-RAY OPERATIONS

COMPANY CODE	M	T	C	R	E	B
1-9	1	1	1	2	1	1
1-17	1	1	1	2	1	1
1-22	1	1	1	2	1	1
2-5	1	1	1	2	1	1
2-15	1	1	1	2	1	1
3-2	1	1	1	2	1	1
3-14	1	1	1	2	1	1
3-27	1	1	1	2	1	1

Average Hazard Severity = 2.0000

LEGEND

M = MECHANICAL
T = THERMAL
C = CHEMICAL
R = RADIOLOGICAL
E = ELECTRICAL
B = BIOLOGICAL

Pennsylvania data available was not sufficient to relate to X-ray Operations.

New York data assessments for the years 1966 through 1970 portray the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Hospitals, Non-Government	8,855	3,515	9.1

During the field surveys, eight facilities were surveyed which exhibited X-ray operations. The worker population of the facilities visited was 10,363. Hazards observed were radiological and electrical. Mechanical, thermal, chemical, and biological hazards were insignificant in the sample.

Survey reports on protective clothing policies of the eight facilities surveyed indicated that protective clothing was supplied and its use required in five of the sample industries. Protective clothing was also worn by workers in five of the sample industries. It was not determined by worker interviews whether protective clothing worn increased risk to the worker. User acceptance of the use or lack of use of protective clothing was indicated in six of the sample industries.

From the review of the Surveyors' ratings of protective clothing availability and adequacy, it can be seen that:

- Protective clothing was available and adequate for worker protection in four companies.
- Two of the sample industries made protective clothing available for worker protection but it was inadequate for worker needs. (In one instance, at a hospital, X-ray technicians were provided only leaded aprons for protection during fluoroscopy operations.)
- Protective clothing was not required in two of the sample industries due to complete worker isolation and safety interlocks.

The Protective Clothing Needs chart on the following page lists the items of clothing required for worker protection.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Radiological	2nd	Apron, Leaded	yes
		Jacket, Leaded	yes
		Coat, Leaded	yes
		Pants, Leaded	yes
		Suit, Leaded	yes

Table 24

PROTECTIVE CLOTHING NEEDS

I/O Area X-ray Operations

BACTERIAL INVOLVEMENT

Bacterial involvement Industrial/Occupation areas include laboratories, sewage- and garbage-disposal facilities, hospitals, and some agricultural areas. The presence of bacterium in hazardous amounts is usually known, and proper controls are used. If controls are not used, the areas are normally located away from populated areas. This study is primarily concerned with bacterial involvement in laboratories.

The hazards identified during surveys of laboratories are:

- Chemical - Chemical hazards consisted of possible contact with caustic liquids, primarily acid.
- Biological - Biological hazards were evident by the existence of bacterial cultures being grown.
- Mechanical - Negligible.
- Thermal - Negligible.
- Radiological - Negligible.
- Electrical - Negligible.

Protective clothing needs for bacterial involvement are:

- Chemical - Chemical-resistant, general work clothing with added protection as required through the use of aprons, bibs, cape sleeves, jackets, trousers, and hoods of rubbers, plastics, or other suitable materials.
- Biological - The same items used for protection from chemical hazards; in some instances, disposable suits or complete environmental ensembles.

The Hazard Severity matrix on the following page was compiled from field survey data. It is readily evident that effective hazard controls are used to maintain a minimum degree of severity. Only chemical and biological hazards were ranked, and they were rated with a 2nd-degree severity.

Bendix accident data was not available for analysis as the Corporation does not engage in processes of this nature.

Florida accident data for 1971 was reviewed to determine the percentage of torso protective clothing related injuries. In 1971, Florida reported that 40 percent of all injuries were strains, sprains, or hernias. The data analysis is presented below:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Medical and Dental Laboratories	32	15	28.1

FIGURE 38

HAZARD SEVERITY MATRIX

I/O AREA: BACTERIAL INVOLVEMENT

COMPANY CODE	M	T	C	R	E	B
3-10	1	1	2	1	1	2
4-14	1	1	2	1	1	2

Average Hazard Severity = 2.0000

Legend

M = Mechanical
C = Chemical
T = Thermal
R = Radiological
E = Electrical
B = Biological

Pennsylvania data available was not sufficient to relate to Bacterial Involvement Operations.

New York data assessment for the years 1966 through 1970 indicates the following:

Industry	Injury Total	Trunk Injuries	Torso Protective Clothing Related %
Medical Health Services	3,061	1,169	7.4

During the survey period, two laboratories were visited. Both laboratories were involved in bacterial-related areas, testing for bacterium, or growing bacterial cultures. Total worker population of the sample was 30.

Surveyors noted that all companies visited supplied protective clothing to their workers, and required them to wear it. The protective clothing supplied was judged adequate by the Surveyors, and had total user acceptance. No evidence of additional risk incurred wearing the clothing was noted.

The Protective Clothing Needs chart on page 154 indicates the types of protective clothing required.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Chemical*	2nd	Apron, Chemical-Resistant	yes
		Bib, Chemical-Resistant	yes
		Cape Sleeves, Chemical-Resistant	yes
		Jacket, Chemical-Resistant	yes
		Hood, Chemical-Resistant	yes
Biological	2nd	Shirt, Disposable	yes
		Pants, Disposable	
		Coat, Disposable	yes
		Jacket, Disposable	yes
		Overall, Disposable	yes
		Coverall, Disposable	yes
		Suit, Disposable	yes
		Apron, Disposable	yes
		Suit, Impermeable, Environmental	yes

*These items will also provide a degree of protection from biological hazards if properly decontaminated or disposed of after use.

Table 25

PROTECTIVE CLOTHING NEEDS

I/O Area Bacterial Involvement

HEAT-STRESS INVOLVEMENT OPERATIONS

Heat-stress involvement can occur any time workers are exposed to elevated temperatures, usually around 95^{o} F. Exposure to elevated temperatures may result in one of three body disorders:

1. Heat stroke - caused by malfunction of the thermoregulatory center of the body.

2. Heat exhaustion - caused by excessive salt and/or water loss from the body by profuse sweating.

3. Heat cramps - caused by loss of salt, and dilution of body fluids.

To control heat-stress exposures, body heat must be dissipated at the same rate it is produced. This is accomplished by one or more of three different ways: convection, radiation, and evaporation.

- Convection - Cool, ambient air in contact with the skin is heated. The heated air is then removed by convection or forced-air currents and replaced with cooler air. Body heat is thus dissipated; however, the body will absorb heat by a reversal of this process if the ambient air is at a higher temperature than the body.

- Radiation - If ambient temperatures are lower than the body, the skin will radiate heat outward. However, at ambient temperatures higher than the body, the skin will absorb almost all the radiant heat directed it.

- Evaporation - The body's main defense against elevated temperatures is perspiration. Cooling is effected by the evaporative process of the perspiration on the body. At ambient temperatures higher than the body, evaporative cooling is especially vital.

The worker's ability to withstand heat-stress exposure can be enhanced by acclimatization. Other areas in heat-stress control are health, fatigue, and nutrition; also, workers with cardiac or circulatory ailments should not be exposed to heat-stress conditions. Water and salt replacement is essential to heat-stress resistance, as body losses of these items can be extensive under extreme heat-stress conditions.

Protective clothing for heat-stress exposure reduction is required when other methods of control, such as environmental conditioning or isolation, are not feasible. In light heat-stress exposures, clothing should be lightweight, porous, and loose fitting to allow good air circulation. In most cases, one-piece coveralls are preferable to two-piece clothing, and as much of the body should be covered as possible to protect against radiant heat. Control of radiant heat exposures can best be attained by reflective aluminized clothing. Control of extreme ambient air temperature and radiant heat can be attained by use of insulated aluminized reflective clothing. Sometimes portable man-cooling units may be needed to eliminate heat retention in these types of suits.

A Hazard Severity matrix was not prepared for Heat-Stress Involvement Operations as the conditions for heat-stress exposure are too generalized, and vary with individual tolerance.

Bendix accident review did not identify any heat-stress involvement operations or injuries; therefore none is displayed.

State accident data was reviewed for industries which are identified with heat stress. Accident rates were averaged for the following industries:

- Flat Glass, SIC 321
- Glass and Glassware, Pressed or Blown SIC 322
- Primary Metal Industries, SIC 33

Florida 1971 accident data analysis, which took into consideration the 40 percent incidence of strain, sprain, or hernia natures, revealed the following:

Industry	Injury Total	Trunk Injury	Torso Protection Clothing Related %
Flat Glass	1	0	0
Glass and Glassware, Pressed or Blown	25	4	9.6
Primary Metal Industries	228	14	3.7

Pennsylvania accident data analysis for April 1973 takes into consideration the 30 percent occurrence of strain, sprain, or hernia incidences. Pennsylvania data shows:

Industry	Injury Total	Trunk Injury	Torso Protection Clothing Related %
Primary Metal Industries	710	137	13.5

Twenty-four companies exhibiting Heat-Stress Involvement Operations were surveyed. The worker population of the industrial sample was 27,254. The Field Survey Representative's observation on current protective clothing practices in Heat-Stress Involvement Operations of the companies surveyed indicated:

- Available and adequate protective clothing was utilized in 15 of the 24 companies.
- Available but inadequate protective clothing was utilized in two of the companies.
- No protective clothing was available for use in seven of the companies.

User acceptance of protective clothing was evident in sixteen of the companies sampled. Protective clothing was noted to cause increased risk and was not acceptable to the workers in one of the companies. The complaints in both instances were by workers in the same company who stated the protective clothing was too hot and too heavy to wear.

The Protective Clothing Needs chart on the following page shows the type of clothing required to protect workers in heat-stress situations. As can be seen, many types of thermal protective clothing are needed to protect workers in differing heat-stress extremes.

Hazard	Degree	Protective Clothing Required	Available from Prot. Clothing Mfgrs.
Thermal		Coverall, Lightweight	yes
		Jacket, Fire-Resistant/aluminized	yes
		Coat, Fire-Resistant/Aluminized	yes
		Pants, Fire-Resistant/Aluminized	yes
		Suit, Fire-Resistant/Aluminized	yes
		Overall, Fire-Resistant/Aluminized	yes
		Coverall, Fire-Resistant/Aluminized	yes
		Vest Assembly, Vortex-Cooled	yes
		Head Cooling Assembly, Vortex-Cooled	yes
		Suit Assembly, Liquid-Cooled, Self-Contained	yes
		Suit Assembly, Liquid-Air-Cooled, Self-Contained	yes
		Head Cooling Assembly, Liquid-Cooled, Self-Contained	yes
		Suit, Insulated, Aluminized, Environmental	yes

Table 26

PROTECTIVE CLOTHING NEEDS

I/O Area Heat-Stress Involvement

SUMMARY

Task A was completed with 130 companies surveyed, representing 93,343 employees within the 27 different Industrial/Occupational areas.

Hazard severities ranged between 1st degree and 4th degree. The hazard severities for each Industrial/Occupational area were averaged using a hazard severity rating above 1; this was used as a variable in the Priority Plan. A list of the 27 Industrial/Occupational areas and their degree of hazard index is presented on the following page.

Protective clothing non-usage as witnessed during the survey was used as a variable in the Priority Plan. The number used was calculated by using a percentage of non-usage and assigning a numerical value to that percentage.

The likelihood variable was derived from using the total number of hazards witnessed in each Industrial/Occupational area and assigning a number to that value.

Figure 39

DEGREE OF HAZARD INDEX

HAZARD INDEX SUMMARY

I/O AREA	HAZARD INDEX
Chemical and Allied Products	3.1290
Oil Refineries	3.1000
Pig Iron and Steel Mills	3.1904
Metal Smelting	3.3125
Beryllium Operations	2.0000
Asbestos Operations	2.5000
Coal Mining	3.6667
Metal Mining	3.0666
Uranium Mining	3.5000
Rubber and Tire Production	2.7500
Vehicle Production	2.6429
Glass Production	3.3333
Construction	3.3333
Bakeries	2.5000
Painting Operations	2.3571
Public Utilities	3.0000
Welding Operations	3.2750
Abrasive and Buffing Operations	3.0263
Operations Generating Silica Dust	3.5000
Pesticide and Insecticide Spraying	3.0000
Machine Tool Production	3.1071
Metal Fabrications	3.1052

Figure 39

DEGREE OF HAZARD INDEX

HAZARD INDEX SUMMARY
(Continued)

I/O AREA	HAZARD INDEX
Lumber and Wood Products	3.0000
X-ray Operations	2.0000
Operations Involving Bacteria	2.0000
*Operations Involving Heat Stress	3.1705

*Average of all heat-stress hazards within the 27 Industrial/Occupational areas.

TASK B - EVALUATING THE PRESENT STATE OF THE ART

INTRODUCTION

Evaluating the present state of the art will be done by the hazards for which the clothing is designed to protect against, rather than the individual Industrial/Occupational area. The evaluations are accomplished in this manner for two reasons.

- Protective clothing is identified by the manufacturer as to the hazard it is designed to protect against. There are some exceptions to this, notably in the identification of items of apparel for welders, sandblasters, and some other occupational areas.

- As protective clothing is manufactured to protect against certain hazards, and some of the same type and degree of hazards exist in differing industries, it is logical to assume that some types of protective clothing utilized in one industry would be the same in another industry. For example, the use of aluminum-coated asbestos suits would be used for radiant heat protection in the steel-making industry as well as in the Chemical and Allied Products industry.

It should be noted that any clothing worn will provide some protective function. The use of long pants, long-sleeved shirts, and nonporous shoes should be mandatory in any manufacturing facility. The wearing of these items will provide a measure of protection against minor forms of injury such as abrasions, cuts, contusions, nonionizing radiation, and burns.

Many forms of clothing also perform multi-roles in protecting against differing hazards. During welding operations, for instance, the welder is exposed to varying mechanical, thermal, and radiological hazards. The wearing of what is referred to in the industry as "hides," or chrome tanned leather items of apparel will adequately protect the welder from most forms of mechanical, thermal, or radiological hazards encountered during welding operations.

MECHANICAL HAZARD PROTECTIVE CLOTHING

Mechanical hazard protection by clothing is for the most part limited to minor- and moderate-exposure hazards. Mechanical hazard protective clothing is not available in as many styles as clothing for chemical and thermal hazards, and the design is not as sophisticated as in other areas. Protective clothing now available cannot protect adequately against most severe mechanical hazards. These hazards are those defined as involving extreme forces, heavy masses, high velocities, or combinations of the three. For example, it can be assumed that a worker caught between the dies of a large power press would incur injuries if he was wearing protective clothing or not. Conversely, a worker exposed to the sudden failure of a grinding wheel could expect reasonable protection from the projectiles thrown off if he was wearing proper torso protection along with head and eye protective devices.

Mechanical hazard protective clothing is for the most part fabricated of the following materials:

- Heavy cotton duck, which may be reinforced with steel staples.
- Various grades of heavy leather, which may be reinforced with steel staples.
- Ballistic nylon.
- Metal mail or mesh.
- Pressed fiberboard

The materials mentioned may be fabricated into various types of protective clothing, which can be reinforced by metal plates, studs, wooden dowels, or pressed fiberboard. The clothing items may be further backed by wool, felt, sponge rubber, or horsehair to provide impact distribution over a wider area of the wearer's body.

THERMAL HAZARD PROTECTIVE CLOTHING

The availability of thermal protective clothing on the market is extensive. There is a wide variety of styles available in the following materials.

- Asbestos
- Fiber glass
- Wools
- Flameproof cottons
- Chrome tanned leathers

All of these materials, if properly selected, provide excellent protection for workers.

At the present time, asbestos provides the best thermal protection against extremes in temperature. Against these conditions, the asbestos is usually backed with an insulating material of wool, felt, or rabbit hair. The asbestos may have a reflective layer of aluminum deposited on the outer surface for radiant-heat exposure protection.

Fiber glass fabrics provide excellent fire resistance. They may have a reflective aluminum layer, and possess good wear and abrasion resistance.

Much work has been done to date on synthetic fire-resistant fabrics. Among these are Nomex and PBI, trade names for polymers developed by the E. I. DuPont DeNemours Co., and Kynol, a trade name of Carborundum Co. These materials provide very good protection against exposed flames. Several manufacturers offer on the market general-work uniforms made of Nomex. PBI and Kynol are second-generation fabric materials, and, at the present time, are rather expensive as compared with Nomex.

Nomex fibers, under normal atmospheric pressures, are self-extinguishing when removed from mild ignition sources. However, the fibers tend to shrink when exposed to flame. For this reason, Nomex fibers are sometimes given treatments to improve their resistance to fire. One such treatment is a direct halogenation process at elevated temperatures. The other is the addition of reactive fire retardants by conventional pad/dry/cure techniques. Fabrics treated in the halogenation approach are sold by the Monsanto Company as the 400 series of Durette fabrics.

Another of the better thermal protective materials is wool. According to the American Wool Council, wool has the following attributes:

- Regulates body temperature in extreme temperature changes.
- Insulates and prevents loss of body heat.
- Utilizes water vapor.
- Repels liquid water.
- Is flame repellant.
- Provides a cushion to prevent injuries.
- Prevents dehydration of body fluids.

Cottons are another natural fiber used for thermal protective clothing. These cottons are usually treated with flame-retardant chemicals. Some of these may be washed out of the fabrics during laundering; for this reason, some cottons have to be reprocessed after a number of washings to retain their nonflammable characteristics. These cottons are usually employed for protection against light-to-moderate thermal exposure hazards.

Chrome leather is a natural material that provides both thermal and mechanical hazard-exposure protection. It is a specially treated, very pliable, side split leather that is exceptionally resistant to abrasion and heat. This leather is sometimes steel-studded or stapled to provide additional mechanical protection. However, this technique is not recommended for items used for thermal protection, as heat transfer through the steel reinforcing could cause burns to the worker.

The present state of the art for thermal protection appears to be very good. There are on the market, fire entry suits that will withstand temperatures up to 1500° F for limited periods of time. Heat-stress exposure is another thermal exposure hazard that warrants consideration.

A problem area in thermal and, in some cases, chemical protective clothing for moderate and severe exposure hazards is that protective clothing for these hazards is usually made of impermeable and very heavy materials that trap the body heat of the workers. This can contribute to heat-stress situations. Many times, this problem can be eliminated by using cooling systems consisting of air-circulation manifolds, or liquid-circulation systems. The liquid-circulation system uses an undergarment especially provided with liquid distribution channels. One such device has been recently introduced on the market and is made of a synthetic material with the channels molded into the undergarment rather than using small plastic tubing. This item was developed under contract to NASA for aerospace application and appears to be much more efficient than other systems in use. It is completely self-contained, using water cooled by ice and circulated by a small battery-driven pump.

Other methods of thermal reduction are the use of liquid air systems or vortex devices. Vortex devices work on a venturi-tube principle that separates hot air from cold air in an air stream. The venturi tube is fed air of approximately 75 to 100 psi. Typical vortex devices can deliver 20 cfm of air at an average temperature of 55° below the temperature of the compressed air supply.

CHEMICAL HAZARD PROTECTIVE CLOTHING

Perhaps the most extensive array of protective clothing varieties is present in the chemical hazard area. A great number of materials are available for the manufacture of protective clothing. Some of the materials used are:

- Natural Rubber - Natural rubber can be supplied in various weights and colors. It offers protection against a variety of chemical liquids, mists, and vapors. It is not recommended where solvents, oils, or grease are encountered.

- Synthetic Rubber - Synthetic rubber can also be supplied in various weights and colors. It offers protection against a greater variety of chemicals than natural rubber as it is recommended for solvents, oils, and grease.

- Rubber-Coated Fabrics - Rubber-coated fabrics can be supplied in various weights and colors. They offer the same resistance to chemicals as the rubber coating material, plus they are more wear- and abrasion-resistant. They also withstand tearing and snagging.

- Polyvinyl Chloride - Polyvinyl chloride is supplied in various weights and colors. It is inexpensive and can be used for the fabrication of disposable units. It offers protection against most acids, alkalies, oils, and greases.

- Polyethylenes and Polypropylenes - Polyethylenes and polypropylenes can be made into protective clothing for use involving certain chemicals, oils, and greases. They can be used for fabrication of lightweight disposable clothing.

- Fiber glass - Fiber glass materials provide flame resistance and offer good protection against harmful liquids. When vinyl coated, it gives excellent resistance to abrasion, and yet is still lightweight and easy to wear. The vinyl coating makes it extremely resistant to acid, alkalies, greases, oils, and many other chemicals.

- Polyvinyl Alcohol - Polyvinyl alcohol plastics offer excellent protection against certain chemicals. Their one disadvantage is that they are water-soluable and should not be used in water-based chemicals, or where large amounts of moisture are present.

Hazard severity and exposures play an important role in protective clothing needs. Protective clothing comes in a wide variety of materials, weights, and designs. Intelligent selection is the keynote in providing adequate worker protection while being economically plausible. Therefore, the use of lightweight or partial-body protection may be indicated for light-chemical-exposure hazards, versus the use of heavy-duty or complete protection for moderate-to-severe chemical exposure hazards.

RADIOLOGICAL HAZARD PROTECTIVE CLOTHING

Protective clothing for radiological hazards varies with the exposure and type of radiation. Nonionizing radiations such as infrared and ultraviolet can be protected against by the same clothing used in thermal protection applications. Protection against "soft" or low-energy ionizing radiation may be accomplished by the use of impermeable clothing such as is used in chemical hazard protection. Some suits especially designed for this type of hazard are made of disposable paper. The use of leaded clothing is demanded for protection against the "harder" forms of ionizing radiations such as gamma- or X-radiation. The use of this type of protective clothing is not proof against the radiation hazard. Leaded protective clothing provides a barrier against some of the radiation encountered, thus increasing the allowable time for exposure to a given level of radiation.

ELECTRICAL HAZARD PROTECTIVE CLOTHING

Electrical hazard protective clothing may be divided into two distinct types:

- Type 1 - That clothing used to provide an electrically nonconductive barrier between the wearer and a high electrical potential. The material commonly used is natural rubber. However, any materials such as plastics, fiber glass, or others with a high dielectric strength may be utilized. An example of the protection provided by the use of electrical hazard protective clothing of this type can be seen in the natural rubber sleeves and gloves fabricated for linemen's use on high-voltage power lines which are proof-tested at voltages up to 20,000 volts for the sleeves, and up to 35,000 volts for some types of gloves that are used in conjunction with the sleeves.

- Type 2 - That clothing used to provide an electrically conductive path to a ground. This type of clothing is usually worn in areas where static electricity discharges are a problem. High voltages are built up quite easily in some situations. Removing the protective polyethylene bag from clothes just returned from the cleaners can generate voltages as high as 50,000 volts. Many sensitive powders or volatile liquids can be triggered into an explosion or fire by static sparks below the threshold of seeing, hearing, or feeling.

BIOLOGICAL HAZARD PROTECTIVE CLOTHING

Biological hazard protective clothing is very similar to that used for chemical or some radiological hazards. In fact, it may in many ways be termed interchangeable. The entrance routes to the body are the same: skin, digestive, or respiratory absorption. It is interesting to note that the use of protective clothing in some biological laboratories is not for protection of the worker, but for protection of the product. In other words, the clothing was worn to prevent contamination of the pure cultures being produced. Materials used to fabricate biological protective clothing are usually impermeable plastics, paper, or rubber. Some of these may be disposable for ease of decontamination.

AVAILABILITY OF PROTECTIVE CLOTHING

The identification of available protective clothing has been accomplished through the compilation of a catalog of Available Protective Clothing which is issued as a supplement to this report. It should not be inferred that all types of protective clothing are identified in the catalog. Most protective clothing manufacturers contacted expressed a willingness and ability to custom-fabricate any type of protective clothing needed for worker needs. The catalog is intended to provide the reader with a quick reference to the types of torso protective clothing currently available on the market.

For ease of use, pertinent information on each item of protective clothing has been listed under seven different column headings. An explanation of the heading titles and their use is as follows:

- Nomenclature - Identifies the item of protective clothing being discussed.
- Category - Identifies the type of torso protective wearing apparel.
- Manufacturer - Identifies the company that manufactures the item of apparel.
- Part Number - Identifies the number the manufacturer uses to identify the particular item of apparel.
- Fabrication Material - Identifies the major materials the manufacturer uses to fabricate the particular item of apparel.
- Hazard Involvement - Identifies the type of hazard and the Hazard Severity Classification.
- Protection Classification - Identifies the hazard level protection classification for which the item of clothing is best suited.

Protective torso wearing classifications are dealt with under the Category heading. The list below identifies each category and gives examples of the types of apparel included in each.

- Category 1 - Head and Torso
  - Hood
  - Snood
  - Parka
  - Helmet Cover

- Category 2 - Upper Torso
  Bib
  Cape Sleeves
  Cape Sleeves with Bib
  Cape
  Shirt
  Jacket
  Vest

- Category 3 - Lower Torso
  Chaps
  Trousers
  Apron, Waist-Type
  Apron, Waist-Type, Split-Leg
  Waders

- Category 4 - Entire Torso
  Coat
  Coverall
  Overall
  Apron, Bib
  Apron, Bib, Split-Leg
  Apron, Sleeve
  Suit
  Suit, Open Back
  Smock

- Category 5 - Specialized Torso
  Suit, Survival Arctic Waters
  Suit, Skin Diving
  Air Conditioner, Suit, Vortec
  Vest, Buoyant, Work
  Suit, Captive or Tunnel
  Suit, Environmental, Self-Contained

The purpose of the Hazard Involvement column is to define the different stages of environmental hazards inherent in the occupation of the worker for which the protective clothing is selected. The reader should know that the ratings given are of a general nature, and those persons actually selecting items of protective clothing should consider the materials being handled, the machines or tools utilized, work position, the possibility of injuries to the worker, and the general hazard environment. The hazards listed are those identified in the original Protective Clothing - Assessment of Need contract. These were established as:

- Thermal
- Chemical
- Mechanical
- Electrical
- Biological
- Radiological

The following definitions apply to the Hazard Involvement classifications:

- 1st Degree - Exposure to safety and health hazards are negligible.

- 2nd Degree - Exposure to minor injuries, such as abrasions, cuts, bruises. Health hazards are negligible.

- 3rd Degree - Exposure to injuries requiring medical attention but without loss of time and without permanent disability. Exposure to occupational health hazards, but of a temporary nature.

- 4th Degree - Exposure to incapacitating injuries and/or occupational health hazards. Such cases would result in loss of time and/or permanent partial disability.

- 5th Degree - Exposure to incapacitating injuries and/or occupational health hazards which may result in extensive lost time and/or major disability or death.

The purpose of the Protection Classification column is to identify the hazard level protection classification of the protective clothing item. Definitions of these classifications are:

- Class A - Ensembles providing complete environmental isolation from serious accident or health hazards where fatal injuries could result.

- Class B - Full-body ensembles providing a less extensive standard of protection in an area where the risk of injury or death is less acute.

- Class C - Partial-body protection to ensure positive protection to specific body parts.

- Class D - Basic standard of body protection required to avoid personal injury in an environment where hazardous conditions may occur due to the nature of job operations, equipment, or materials involved.

It must be understood that protective clothing is not and should not be considered a panacea for all hazardous exposure conditions. Protective clothing is a last resort arrived at when hazard isolation or elimination is beyond the current state of the art, or is economically unfeasible. Protective clothing cannot eliminate the possibility of injury, but it can, with judicious use and intelligent selection, reduce the probability of injury to workers from work hazard exposure.

SUMMARY

While it may appear on the surface that protective clothing for all Industrial/Occupational areas is available, this may in fact not be the case. For example, if a worker is exposed to multiple hazards such as chemical, thermal, and mechanical, the protective clothing designed to protect against the chemical hazard may not protect sufficiently against the thermal and mechanical hazards. Therefore, where multiple hazards are present, an engineering study should be formed and, if necessary, specially designed protective clothing should be provided.

TASK C - DEFINING PROTECTIVE CLOTHING POOR PERFORMANCE OR LACK OF WORKER ACCEPTANCE

TASK APPROACH

An evaluation was performed to determine those areas where protective clothing is presently available but is unsatisfactory because of poor performance or lack of worker acceptance. The following references were reviewed:

- Manufacturers'/Suppliers' specifications
- American National Standards
- Armed Services Specifications
- Civilian Agency Specifications and Standards (NASA, AEC)
- Occupational Safety and Health Standards
- Bureau of Mines Schedules

Unfortunately, specific information needed to evaluate the task was not available from the above sources.

Labor unions, trade associations, and professional societies were also contacted and asked for specific records and experience in the area of unsatisfactory protective clothing because of poor performance or lack of worker acceptance. The labor unions, trade associations, and professional societies stated they did not keep detailed enough records of accidents to tell if the accident was caused by poor performance of protective clothing or lack of acceptance by the worker.

SURVEY DATA

The field surveys however revealed some complaints by the worker. In the 130 companies surveyed, interviews were accomplished with workers as to their acceptance and rating of protective clothing. Twenty-four of the 130 companies surveyed had employees who voiced dissatisfaction with the protective clothing utilized. Eight of these 24 complaints were concerned with added risk involvement produced by the wearing of protective clothing or accessories.

A listing of the eight complaints voiced, identified by Industrial/Occupational area, follows:

Industrial/Occupational Area	Added Risk Complaints
Public Utilities	Boots entrap gases.
Pulp and Paper Manufacturing	Gloves entangle in steam dryer when cleaning jams.

Metal Fabrication	Gloves entangle at rolling machines.
Chemical and Allied	Face shields trap vapors.
	Clothing too bulky, catches in confined areas.
Metal Plating	Face shields and glasses fog, limiting vision.
Petroleum Refining	Airline respirators reduce vision.
Metal Mining	Loose fit of clothing can cause entanglement in machinery.

It can be seen that protective clothing complaints center on the bulkiness and fit of protective clothing. The other complaints on accessories are equally divided between gas and vapor entrapments, entanglement, and vision restriction.

Complaints by workers on acceptability of protective clothing emanated from 16 companies. At 12 of the 16 companies, workers voiced the opinion that the clothing was too hot and heavy to be worn comfortably.

Specific items of apparel pointed out in worker complaints were as follows:

- Raingear too hot - 3 instances
- Coveralls too hot - 1 instance
- Welding protective clothing too hot - 1 instance
- Aluminized jackets too hot - 1 instance
- Welding protective clothing too heavy - 1 instance
- Flame-resistant clothing too bulky - 1 instance
- Flame-retardant cotton work suits wearing out too fast - 1 instance

From the preceding data, the following inferences can be drawn:

- The major areas of complaint are against chemical and thermal protective clothing.
- Fifty percent of the complaints by workers were directed at protective clothing too hot and heavy to be worn comfortably.
- Only two complaints involved torso protective clothing that incurred added risk. These complaints were against entanglement hazards of

loose-fitting, bulky clothing. Six complaints were directed against protective clothing accessories.

Analysis of data available for New York, 1969; Florida, 1971; and California, 1971, while not specific enough to determine accidents caused by poor performance of protective clothing or lack of worker acceptance, does indicate accidents that are occurring by hazard involvement to employees in industry. This provides an indicator of the types of protective clothing by hazard that should be considered in the priority rating plan.

The following chart portrays the nature of injury to hazard involvement for the State of New York, 1969:

Nature of Injury	Hazard	Number of Cases	Percentage of Total
All injuries and diseases	-	117,100	100
Strains, sprains, other than hernias	Mechanical	32,720	27.94
Fractures	Mechanical	26,501	22.63
Cuts, punctures, lacerations, and abrasions	Mechanical	24,476	20.90
Bruises and contusions	Mechanical	12,251	10.46
Hernias	Mechanical	6,656	5.68
Burns and scalds	Thermal	3,925	3.35
Concussions	Mechanical	1,232	1.05
Traumatic amputations	Mechanical	1,264	1.08
Dislocations	Mechanical	907	0.77
Exposure to injurious substances, poisons, etc.	Chemical	512	0.44
Foreign bodies in eyes	Mechanical	115	0.10
Surgical amputations	Mechanical	200	0.17
Electric shocks	Electrical	62	0.05
Asphyxiations, including inhalation of fumes, gases, etc.	Chemical	26	0.02
Drownings	Chemical	5	0.0043
Other	-	4,638	3.96
Occupational diseases	-	1,610	1.37

Protective clothing-related injuries, i.e., those injuries not including strains, sprains, or hernias accounted for 66.38 percent of the total. Of the remaining injuries, 57.16 percent were classifiable as mechanical hazard involvements, 3.35 percent as thermal hazard involvements, and 0.45 percent as chemical involvements. Radiological involvements were not identifiable. Electrical involvements were noted in 0.05 percent of the total. Biological involvements may be found in occupational disease natures, but are not identifiable, as not all occupational diseases are of a biological involvement.

Florida 1971 data showed the following injury nature and hazard involvement:

Nature of Injury	Hazard	Number of Cases	Percentage of Total
All injuries and diseases	-	86,250	100
Amputations, loss of, loss of use of	Mechanical	908	1.05
Fractures	Mechanical	9,102	10.55
Poisoning	Chemical	357	.41
Occupational diseases	-	1,278	1.48
Crushing injuries	Mechanical	930	1.08
Cuts, lacerations, punctures, abrasions	Mechanical	18,042	20.92
Strains, sprains, dislocations, hernias	Mechanical	34,041	39.47
Bruises, contusions	Mechanical	9,926	11.51
Chemical burns	Chemical	933	1.08
Welding flash, conjunctivitis electric flash	Radiological	259	.30
X-ray, radiation burn	Radiological	4	.0046
Other burns and scalds	Thermal	2,412	2.80
Drowning, asphyxiation	Chemical	30	.035
Electrocution, electric shock	Electrical	282	.33
Heat exhaustion, sun stroke	Thermal	102	.12
Other	-	3,073	3.56
Unknown	-	4,571	5.30

Injuries that were classified as protective clothing-related were noted as 60.53 percent of the total. This figure is defined as those injuries not including strains, sprains, or hernias. Mechanical hazard involvement injuries accounted for 45.11 percent of the remaining injuries. Thermal hazard involvement injuries were noted in 2.92 percent of the injuries. Chemical hazard involvement injuries were apparent in 1.53 percent, and radiological hazard involvement in .3046 percent. Injuries caused by electrical hazards were noted in .33 percent of the total. Biological hazard involvements were not identifiable from available Florida data. California data for the year 1971 was analyzed for pertinent information on hazard involvements. The following data was observed:

Nature of Injury	Hazard	Number of Cases	Percentage of Total
All injuries and diseases	-	210,328	100
Amputations, loss, loss of use of	Mechanical	1,330	0.63
Burns and scalds	Thermal	6,853	3.26
Cuts, lacerations, punctures	Mechanical	34,231	16.28
Strains, sprains, dislocations, hernias	Mechanical	82,034	39.00
Crushing injuries	Mechanical	3,078	1.46
Fractures	Mechanical	17,397	8.27
Occupational diseases	-	7,069	3.36
Bruises and contusions	Mechanical	20,942	9.96
Eye injuries	-	8,794	4.18
Other	-	3,553	1.69
Nature not stated	-	25,047	11.91

Protective clothing-related injuries, not including strains, sprains, and hernias, were evident in 61 percent of the total injuries. Mechanical hazard involvement injuries were noted in 36.6 percent of the cases, and thermal in 3.26 percent. Chemical, radiological, electrical, and biological involvements were not identifiable in the California data.

Combining of the data from the various states gives the following trends:

- Mechanical hazard involvements accounted for 46.29 percent.
- Thermal hazard involvements were seen in 3.18 percent.
- Chemical hazard involvements were shown to be .66 percent.

- Radiological hazard involvements accounted for .3046 percent of the injuries.

- Electrical hazard involvements were noted in .19 percent.

- An averaged value of the occupational disease nature was used for the biological percentage ranking. This was considered a valid index, as even if not all occupational diseases are biological involvements, biological involvements may be found in this nature. Biological involvements accounted for 2.07 percent.

From this information, it is evident that the first consideration of the priority plan should be for mechanical hazard protective clothing; second consideration, thermal hazard protective clothing; third, biological protective clothing; and chemical, radiological, and electrical protective clothing in descending order.

SUMMARY

Because of lack of information available in industry and government, it was difficult to evaluate those areas where protective clothing is presently available but unsatisfactory because of poor performance or lack of worker acceptance. However, indications from the field survey do indicate protective clothing to be hot and bulky in some instances. Future work on criteria and standards development should focus on this subject in more detail.

TASK D - PRIORITY-RANKING INDUSTRIAL/OCCUPATIONAL AREAS OR OPERATIONS

The fourth task in this study effort was to devise a plan for priority-ranking the need for various types of protective clothing in the 27 identified Industrial/Occupational areas or operations. Table 27, shown on page 180, illustrates the final priority rank for protective clothing needs in each area or operation, and those variables used for rank development. The areas are listed in order of highest priority first. The following discussion explains the variables used and the rationale for their selection.

- Frequency (f) rates were used for the first variable because of the universal acceptability for hazard level identification. The injury frequency rate is the number of disabling work injuries for each million employee hours worked. The figures were taken, as published, from the Handbook of Labor Statistics, 1972. Figures for those areas not specifically identified by the Bureau of Labor Statistics were determined as described in the table notes. These rates were also used because of the capability of being able to revise the priority plan as new figures are published.

- Severity (s) rates were used for the second variable because of their universal acceptability for hazard level identification. The injury severity rate is the number of days of disability resulting from disabling work injuries for each million employee hours worked. The figures were taken, as published, from the Handbook of Labor Statistics, 1972. Figures for those areas not specifically identified by the Bureau of Labor Statistics were determined as described in the table notes. These rates were also used because of the capability of being able to revise the priority as new figures are published.

- The Disabling Injury Index (I) was then computed by using the following formula:

  $$I = \frac{f \times s^*}{100}$$

  Where: f = frequency
  s = severity
  I = index

  *Defined in ANSI Standard Z-16.1-1967, paragraph A4.4.1(b).

  This index was used because of its suitability to this effort and because of its considerable use in industry by the American Standards Institute. At this point, the relative hazard level for all Industrial/Occupational areas with regard to all disabling injuries was established.

- Next, a variable was introduced that would base the hazard levels on only those injuries that might be eliminated or reduced by the proper use of protective clothing. This was achieved by first determining the number of injuries that occur to the trunk and then adjusting these figures to reflect only those trunk injuries that may be related to protective clothing. The number of trunk injuries was obtained by extracting them from accident statistics from the states of New York, 1966 through 1970; Florida, 1971; and Pennsylvania, 1971.

These figures, along with additional statistics from California and Ohio, were then used to determine what percentage of accidents occurred to the trunk that could be directly related to protective clothing. Strains, sprains, and hernias were not included as they are not related to protective clothing. There was no means of identifying accidents to specific protective clothing; however, trunk injuries that may be related to protective clothing served as an acceptable indication of areas where better protection is needed, whether because of the non-use or inadequacy of the protective clothing. The averaged state accident data for torso protective clothing related accidents is contained in Appendix II.

For the purpose of further clarification, it was determined that approximately 35 percent of all trunk injuries are related to strains, sprains, or hernias. This percentage was developed using State and Bendix accident data.

The percent of total injuries occurring to the trunk related to protective clothing protection excluding strains, sprains, and hernias was then entered in the priority plan as a decimal figure, (T).

- The next variable used was the percentage of the companies surveyed that did not use protective clothing where it was required, or where clothing was made available but was inadequate for worker protection. For computational purposes and to reduce the relative importance of the factors, the following index values were assigned protective clothing non-usage:

% Non-usage and Inadequacy	Assigned Value
0.20	1.0
21-40	2.0
41-60	3.0
61-80	4.0
81-100	5.0

  This variable is based on the rationale that if protective clothing is not used and is required, the relative hazard level would increase.

- The next variable introduced was that of Likelihood (L). This was established to provide a factor of the likelihood that research in one Industrial/Occupational area would benefit other areas. The factor was arrived at by inspecting the hazard matrixes for each Industrial/Occupational area, and determining the number of hazard headings which exhibited hazard degree ratings greater than 1st degree. The hazard headings are: mechanical, chemical, thermal, radiological, electrical, and biological. The values used were:

No. of Hazards	Assigned Value
One hazard	.1
Two hazards	.2
Three hazards	.3
Four hazards	.4
Five hazards	.5
Six hazards	.6

- A Degree of Hazard (D) was the final variable used in the priority plan. The values used were an average of all degree of hazard numbers greater than one which appeared in each Industry/Occupation's Hazard Severity matrix. The 1st-degree figures were not averaged as it would tend to add priority to the industries with more hazards.

The data for determining the values for the Degree of Hazard Index is shown on page 160 of this report.

The priority was computed by multiplying each of the variables. The product of the multiplications was the final priority index value. The priority plan is shown on the following page.

It was noted during the priority ranking plan development that the trend was for the more mechanically hazardous industries to be higher in their rankings. This can be explained when one is familiar with the nature of injuries that occur in the various industries. There is little argument from the analysis of the state data that the mechanical natures of accidents are by far the most numerous, averaging 48.17 percent of the total; the other hazards accounted for less than 10 percent of the total with accidents not related to protective clothing making up the balance. Review of the Bendix accident data presented earlier in the report and in comparison with the ranking of the priority plan shows the following:

- Abrasive and Buffing Operations, which was the ninth ranked on the priority plan, indicated from Bendix data a 65.1 percent mechanical hazard injury involvement. Approximately 33 percent of the natures of injury were unknown, and it is suspected a high percentage of these were also mechanical.

- Construction was ranked fourth. Bendix data displayed a 96.9 percent mechanical hazard injury involvement.

- Painting Operations was ranked thirteenth. Bendix data was not adequate to make a comparison, as only three injuries were identified, all chemical involvements to the eyes.

- Welding Operations were ranked seventh and as such displayed a mechanical hazard injury involvement of 72.8 percent, according to Bendix data.

Priority Number	Industrial/Occupational Area*	Frequency Rate (f)	Severity Rate (s)	Disabling Injury Index (I)	Trunk Total Injury (T)	Protective Clothing Non-use (P)	Likelihood Index (L)	Degree of Hazard Index (D)	Final Priority Index
1	Coal Mining	41.6	7792	3241.0	.194	1	.3	3.6667	691.64
2	Uranium Mining	21.4	5014	1073.0	.171	2	.4	3.5000	513.75
3	Metal Mining	23.7	3238	767.4	.171	4	.3	3.0666	482.90
4	Construction	29.7	2716	806.7	.116	5	.3	3.3333	467.88
5	Lumber & Wood Products	33.9	2118	718.0	.117	5	.3	3.0000	378.03
6	Pig Iron Production	32.9	1403	461.6	.118	5	.4	3.1904	347.55
7	Welding Operations[3]	31.4	2111	662.8	.102	3	.5	3.2750	332.08
8	Silica Dust Generating Operations[4]	19.5	2421	472.1	.124	3	.3	3.5000	184.38
9	Abrasive & Buffing Operations[1]	35.9	1077	386.6	.102	5	.3	3.0263	179.02
10	Metal Fabrications	22.4	1003	224.7	.103	4	.5	3.1052	143.70
11	Public Utilities	23.6	1213	286.2	.166	5	.2	3.0000	142.50
12	Steel Mills	17.3	1040	179.9	.118	5	.4	3.1904	135.40
13	Painting Operations[2]	18.3	2291	419.3	.118	3	.3	2.3571	104.96
14	Machine Tool Production	15.6	715	111.5	.078	5	.4	3.1071	54.00
15	Glass Production	12.7	542	68.8	.133	3	.3	3.3333	27.43
16	Chemical & Allied Products	8.5	562	47.8	.137	3	.3	3.1290	18.39
17	Oil Refining	6.3	1034	65.1	.154	1	.4	3.1000	12.43
18	Rubber and Tire Production	16.2	720	116.6	.128	1	.3	2.7500	12.29
19	Heat-Stress Involvement[5]	21.5	848	182.3	.103	2	.1	3.1705	11.91
20	Vehicle Production	7.8	1085	84.6	.106	1	.5	2.6429	11.84
21	Pesticide & Insecticide Spraying[6]	11.9	1777	211.5	.084	1	.2	3.0000	10.66
22	Metal Smelting	7.3	1258	91.8	.075	1	.4	3.3125	9.10
23	Beryllium Operations[7]	21.9	835	182.8	.118	1	.2	2.0000	8.62
24	Asbestos Operations	15.9	922	146.6	.044	5	.1	2.5000	8.06
25	X-ray Operations[8]	10.0	262	26.2	.202	3	.2	2.0000	6.34
26	Bacterial Operations	14.6	417	60.9	.209	1	.2	2.0000	5.09
27	Bakeries	6.5	246	16.0	.109	5	.2	2.5000	4.35

*See Notes section, on following page.

Example: Coal Mining

Formula: $I = \frac{(f)x(s)}{100} = \frac{(41.6)x(7792)}{100} = 3241.472$

Final Priority Index = (I)x(T)x(P)x(L)x(D) = (3241)x(0.194)x(0.3)x(3.6667) = 691.64

TABLE 27

THE PRIORITY RANKING OF INDUSTRIAL/OCCUPATIONAL AREAS OR OPERATIONS

Table 27 (Continued)

INDUSTRIAL/OCCUPATIONAL AREA PRIORITY RANKING

Notes

1.. The frequency and severity rates for abrasive and buffing operations were not specifically identified. Average rates based on the following areas were used:

Abrasive Products, SIC 3291
Iron and Steel Foundries, SIC 332
Glass and Glassware, Pressed or Blown, SIC 302
Nonferrous Primary Smelting and Refining, SIC 333

2. The frequency and severity rates for Painting Operations were those published under SIC 172, Painting, Paper Hanging, and Decorating.

3. The frequency and severity rates for Welding Operations were not published. The rates used are for the Forging Industry, SIC 3391. This was done because study in the area of machinery-related injuries shows a close similarity between welding and forging operations.

4. The frequency and severity rates for Silica Dust Generating Operations are averages of the rates for the following industries:

Abrasive Products, SIC 3291
Nonferrous Primary Smelting and Refining, SIC 333
Iron and Steel Foundries, SIC 332
Stone, Clay, and Glass Products, SIC 32

5. The frequency and severity rates for Heat-Stress Involvement are average rates for the following industries:

Flat Glass, SIC 321
Glass and Glassware, Pressed or Blown, SIC 322
Primary Metal Industries, SIC 33

6. The frequency and severity rates for Insecticides and Pesticides are those published for all agricultural chemical operations, SIC 287. It is assumed that insecticides and pesticides would comprise the major portion of agricultural chemicals.

7. Frequency and severity rates for Beryllium Operations were not identified; therefore, the rates for Miscellaneous Fabricated Metal Products, SIC 349, were used. This is based on the assumption that since beryllium is a metal, the involved operations would be similar to other metal operations.

8. Frequency and severity rates for X-ray Operations were not available. Those rates used are for Hospitals, SIC 806.

- Lumber and Wood Products was ranked fifth. This Industrial/ Occupational area also displayed a lower mechanical hazard injury involvement of only 62.3 percent.

- Asbestos Operations was ranked rather far down the priority listing at twenty-four. Its mechanical hazard injury involvement percentage, according to Bendix accident data, was only 41.8.

SIGNIFICANT FINDINGS

INTRODUCTION

This section discusses findings not used in the priority plan development but considered significant in the evaluation of the priority plan and considerations for future research projects.

BENDIX CORPORATION PRIORITY PLAN DEVELOPMENT

For comparison purposes, a priority plan was developed for the Industrial/Occupational areas for which Bendix data was available. The same procedure as for the original priority plan was used for computation.

- Frequency (f) rates were used for the first variable because of the universal acceptability for hazard level identification. The injury frequency rate is the number of disabling work injuries for each million employee hours worked. The figures were taken, as published, from the Bendix Corporation Safety Performance, Third Quarter FY/74, North American Operations.

- Severity (s) rates were used for the second variable because of their universal acceptability for hazard level identification. The injury severity rate is the number of days of disability resulting from disabling work injuries for each million employee hours worked. The figures were taken, as published, from the Bendix Corporation Safety Performance, Third Quarter, FY/74, North American Operations.

- The Disabling Injury Index (I) was then computed by using the following formula:

  $$I = \frac{f x s^*}{100}$$

  Where: f = frequency
  s = severity
  I = index

  *Defined in ANSI Standard Z-16.1-1967, paragraph A4.4.1(b).

  This index was used because of its suitability to this effort and because of its considerable use in industry by the American Standards Institute. At this point, the relative hazard level for all Industrial/Occupational areas with regard to all disabling injuries was established.

- Variables (T), (P), (L), and (D) were not used because of lack of specific information in these areas.

Table 28

BENDIX CORPORATION ACCIDENT DATA
FOR PRIORITY PLAN BACKUP

Industrial/Occupational Area	Frequency Rate (f)	Severity Rate (s)	Disabling Injury Index (I)	Final Priority Bendix Corp.	Final Priority Adjusted Ranking (Contract)
Construction[2]	65.11	695.31	452.72	1	1
Abrasive & Buffing[1]	55.24	685.19	378.50	2	4
Lumber & Wood Products[5]	24.33	1458.50	354.85	3	2
Painting Operations[3]	44.46	677.24	301.10	4	5
Welding Operations[4]	30.75	858.56	264.01	5	3
Asbestos Operations[6]	26.80	507.27	135.95	6	8
Vehicle Production[7]	21.17	435.65	92.23	7	7
Chemical & Allied Products[8]	1.97	11.85	0.23	8	6

[1]Average of: Brake and Steering; Friction Materials; Abrasives
[2]Bendix Home Systems
[3]Average of: Bendix Home Systems; Friction Materials
[4]Average of: Bendix Home Systems; Filter; American Forest Products
[5]American Forest Products
[6]Average of: Brake and Steering; Friction Materials
[7]Average of: Brake and Steering; Friction Materials; Filter; Hydraulics
[8]Launch Support Division

The Final Priority Adjusted Ranking (Contract) is the relative ranking of the Industrial/Occupational area priority plan excluding the Industrial/Occupational areas not found within the Bendix Corporation. This gives a priority list as follows:

Priority Number	
1	Construction
2	Lumber and Wood Products
3	Welding Operations
4	Abrasive and Buffing
5	Painting Operations
6	Chemical and Allied Products
7	Vehicle Production
8	Asbestos Operations

A comparison of the Bendix priority ranking and the adjusted ranking shows that construction is ranked #1 in each table:

- Abrasive and Buffing is ranked #2 in the Bendix priority ranking and #4 in the adjusted ranking. This difference is caused by the higher frequency of accidents in the Bendix Corporation.

- Lumber and Wood Products is ranked #3 in the Bendix priority ranking and #2 in the adjusted ranking. This shift is caused by the low frequency and severity rates for the one related Bendix Division.

- Painting Operations is ranked #4 in the Bendix priority ranking and #5 in the adjusted ranking. This difference is caused by the higher accident frequency rate, possibly caused by the fact that painting operations is only a secondary operation within the Corporation and possibly not as much safety surveillance is accomplished, therefore leading to more accidents.

- Welding Operations is #5 in the Bendix priority ranking and #3 in the adjusted ranking. This difference is due to the lower frequency rate which is the result of having a strong welding safety program.

- Asbestos Operations is #6 in the Bendix priority ranking and #8 in the adjusted ranking. This difference is caused by the fact that Bendix Corporation is a large producer of automotive parts, many of which contain asbestos; therefore, asbestos would tend to be of higher priority within the Corporation due to the higher-than-average employee exposure.

- Vehicle Production is #7 in both tables.

- Chemical and Allied Products is #8 in the Bendix priority ranking and #6 in the adjusted ranking. This difference is explained by the fact that the Bendix Division used has very low frequency and severity rates because of an excellent 10-year safety record.

The first five priorities, even though they differ somewhat in order, represent the same I/O areas. In examining whether or not there is a correlation between the two lists, Spearman's Rank Correlation Coefficient was calculated which gave a correlation coefficient between the two lists of 78.6. This shows a positive agreement in increasing order and results in a confidence level of 95 percent which shows that the two lists are not independent and that the data for both lists were drawn from the same population. This demonstrates that the Bendix data is representative of industry and, therefore, the Industrial/Occupational area priority ranking is valid for industry.

Examination of the Final Priority Index, Table 27, shows that the Industrial/Occupational areas are grouped into three distinct groups:

1-7
8-13
14-27

This grouping seems to suggest that future criteria and standards research could be grouped into three separate efforts starting with the first group.

PRIORITY PLAN DISCUSSION

Although Coal Mining, Uranium Mining, and Metal Mining are ranked in the top three on the Priority Plan, these areas were influenced by their high frequency and severity rates. Providing torso protective clothing for miners designed to protect against mine shaft cave-in or heavy rock falling is not feasible; therefore, it is suggested that Construction, Lumber and Wood Products, and Pig Iron Production become the top three priority items for future criteria and standard development within NIOSH.

CONCLUSIONS

From analysis of all the data collected for study in the contract, the following conclusions are drawn:

- Mechanical hazards account for the most injuries in each of the 27 Industrial/Occupational areas. Thermal hazards account for the next highest incidence of injuries, and, in descending order, are: chemical, radiological, electrical, and biological. Accident data places biological injuries as third; however, survey data failed to corroborate this.

- There is a general lack of knowledge on the part of management and employees of the need for protective clothing. Additionally, a large percentage of management and employees who are aware of the need, lack the knowledge to properly select and use protective clothing.

- Even when management acknowledges a need for protective clothing, it does not always attach a high degree of importance to that need. Worker requirements for protective clothing were reviewed periodically by management in only 38 percent of the companies surveyed.

- Some protective clothing used for chemical and thermal protection can contribute to heat-stress situations by trapping the body heat of workers.

- Some types of protective clothing, especially high-temperature-exposure clothing is bulky to wear and interferes with worker mobility. The present state of the art is not advanced enough to provide insulating qualities efficient enough to reduce the bulk now required for worker protection.

- A large percentage of industry does not supply protective clothing as defined in this study to their workers. From survey data, it was determined that only 59 percent of the companies surveyed supplied protective clothing to their workers.

- Protective clothing usage is not stressed in industry, as only 35 percent of the companies surveyed had policies which dictated mandatory protective clothing usage.

- No standardized reporting system for accident data is utilized by the various states. This was determined from the states' Workmen's Compensation data analysis.

RECOMMENDATIONS

Recommendations as a result of the research effort and conclusions are:

- That development of criteria and standards be initiated in the following Industrial/Occupational areas:

  Construction
  Lumber and Wood Products
  Pig Iron Production
  Welding Operations

- That research be initiated to study the development of lighter, less restrictive, mechanical-type protective clothing to provide improved protection parameters against impact, puncture, and laceration-type injuries.

- That research be instituted into the study of development of lighter chemical-resistant and extreme-heat-resistant materials to provide more comfortable protective clothing with the ability to dissipate the body heat of the wearer.

- That studies be initiated toward the goal of establishing a protective clothing certification program.

APPENDIX I

HAZARD INDEX TABLE

I. Mechanical Hazards

A. Physical Classifications

1. Struck against, rubbed, or abraided
2. Struck by
3. Caught in, under, or between
4. Fall to same level
5. Fall to different level
6. Overexertion or bodily reaction

B. Mechanical Classification

1. Stationary object
2. Moving object
3. Objects being handled
4. Falling object
5. Flying object
   (a) Chips
   (b) Particles
   (c) Debris
6. Wielded object
7. Explosion (overpressure)
8. Running or meshing object
9. Moving and stationary object
10. Two or more moving objects
11. Turning objects

C. Physiological Classification

1. Amputation, loss, loss of use
2. Fracture
3. Crushing
4. Cut, laceration
5. Puncture
6. Abrasion, contusion
7. Strain, sprain
8. Dislocation
9. Hernia

II. Electrical Hazards

A. Physical Classification

1. Alternating current
2. Direct current
3. Static

B. Electrical Classifications

1. Safety low voltage (0-24 volts)
2. Low voltage (25-600 volts)
3. High voltage (601 and up volts)

C. Physiological Classifications

1. Shock

(a) Light muscular contraction

(b) Light-to-moderate muscular contraction, possible cardiac arrest

(c) Severe muscular contraction, cardiac arrest highly likely

2. Flash burns

3. Destruction of nerves, tissues, and muscles (high amperage)

III. Thermal Hazards

A. Physical Classification

1. Convected

2. Radiated

3. Conducted

B. Thermal Classification

1. General heat, atmospheric or environmental

2. General cold, atmospheric or environmental

3. Hot objects or substances

4. Cold objects or substances

C. Physiological Classification

1. Burns, scalds

2. Conjunctivitis

3. Heat stress

(a) Heat exhaustion

(b) Heat stroke

(c) Heat cramps

4. Sun poisoning

5. Frostbite (tissue freezing)

IV. Chemical Hazards

A. Physical Classification

1. Gases and vapors

2. Particulate matter

   (a) Aerosol

   (b) Dust

   (c) Fog

   (d) Fume

   (e) Mist

   (f) Smog

   (g) Smoke

3. Liquids

4. Solids

B. Chemical Classifications

1. Halogens

2. Alkaline materials

3. Arsenic, Phosphorous, selenium, sulfur, and tellurium

4. Inorganic compounds of oxygen, nitrogen, and carbon

5. Metals

6. Hydrocarbons

7. Glycols

8. Epoxy compounds

9. Ethers

10. Ketones

11. Esters

12. Aldehydes and acetols

13. Nitrogen, nitro, cyanide, amine compounds

C. Physiological Classifications

1. Irritants

2. Asphyxiants

   (a) Simple

   (b) Chemical

3. Anesthetics and narcotics

4. Systemic poisons

5. Particulate matter - other than systemic poisons

6. Occupational Diseases

   (a) Skin and subcutaneous tissue

   (b) Bones or organs of movement

   (c) Respiratory system

   (d) Circulatory system

V. Radiation Hazard

A. Physical Classification

1. Ionizing radiation

2. Non-ionizing radiation

B. Radiation Classification

1. X-radiation

2. Gamma radiation

3. Beta radiation

4. Alpha radiation

5. Ultraviolet

6. Infrared

7. Radio frequency
8. Ultrasonic
9. Audible noise
10. Subsonic

C. Physiological Classification

1. Skin reddening
2. Cancer
3. Tissue breakdown
4. Life shortening
5. Dermatitis
6. Hair loss
7. Bone damage
8. Hearing loss
9. Gene damage or mutation
10. Eye damage (cataracts, retina burns)

VI. Biological Hazards

A. Physical Classification

1. Skin contact
2. Ingestion
3. Inhalation

B. Biological Classification

1. Virus
2. Bacteria
3. Fungi
4. Parasites

C. Physiological Classification

1. Dermatitis

2. General infection

3. Infectious diseases

Appendix II

AVERAGED STATE ACCIDENT DATA FOR TORSO PROTECTIVE CLOTHING RELATED ACCIDENTS

Abrasive and Buffing Operations

State	Torso Protective Clothing Related %
California	19.90
Florida	4.65
New York	6.05
Average	10.20

Metal Mining and Uranium Mining

State	Torso Protective Clothing Related %
California	16.5
Pennsylvania	14.8
Florida	20.0
Average	17.10

Steel Mills and Pig Iron Production

State	Torso Protective Clothing Related %
California	16.8
Florida	12.9
New York	5.8
Average	11.83

Construction

State	Torso Protective Clothing Related %
California	19.20
Pennsylvania	12.87
Florida	5.00
New York	9.52
Average	11.65

AVERAGED STATE ACCIDENT DATA FOR TORSO PROTECTIVE CLOTHING RELATED ACCIDENTS (Continued)

Painting Operations

State	Torso Protective Clothing Related %
California	19.30
Florida	5.60
New York	10.40
Average	11.77

Welding Operations

State	Torso Protective Clothing Related %
Ohio	10.15

Silica Dust Generating Operations

State	Torso Protective Clothing Related %
California	18.72
Pennsylvania	20.10
Florida	3.55
New York	7.32
Average	12.42

Lumber and Wood Products

State	Torso Protective Clothing Related %
California	16.7
Pennsylvania	13.4
Florida	5.1
Average	11.73

AVERAGED STATE ACCIDENT DATA FOR TORSO PROTECTIVE CLOTHING RELATED ACCIDENTS (Continued)

Metal Fabrications

State	Torso Protective Clothing Related %
California	15.9
Pennsylvania	15.7
Florida	5.3
New York	4.25
Average	10.29

Public Utilities

State	Torso Protective Clothing Related %
California	22.9
Pennsylvania	29.3
Florida	5.7
New York	8.5
Average	16.60

Glass Production

State	Torso Protective Clothing Related %
California	17.0
Florida	9.6
Average	13.30

Machine Tool Production

State	Torso Protective Clothing Related %
California	15.7
Florida	4.8
New York	3.0
Average	7.83

AVERAGED STATE ACCIDENT DATA FOR TORSO
PROTECTIVE CLOTHING RELATED ACCIDENTS
(Continued)

Chemical and Allied Products

State	Torso Protective Clothing Related %
California	19.8
Pennsylvania	23.5
Florida	5.2
New York	6.45
Average	13.73

Oil Refining

State	Torso Protective Clothing Related %
California	21.9
Pennsylvania	20.4
Florida	4.0
Average	15.43

Vehicle Production

State	Torso Protective Clothing Related %
California	19.2
Pennsylvania	17.2
Florida	2.26
New York	3.9
Average	10.64

Insecticide and Pesticide Spraying Operations

State	Torso Protective Clothing Related %
California	12.4
Florida	4.85
New York	7.8
Average	8.35

AVERAGED STATE ACCIDENT DATA FOR TORSO
PROTECTIVE CLOTHING RELATED ACCIDENTS
(Continued)

Heat-Stress Involvement Operations

State	Torso Protective Clothing Related %
California	17.2
Pennsylvania	13.5
Florida	4.43
New York	5.97
Average	10.28

Asbestos Operations

State	Torso Protective Clothing Related %
Florida	2.6
New York	6.1
Average	4.35

Rubber and Tire Production

State	Torso Protective Clothing Related %
California	19.9
Florida	5.7
Average	12.80

Coal Mining

State	Torso Protective Clothing Related %
Pennsylvania	19.4

Bakeries

State	Torso Protective Clothing Related %
California	18.9
Florida	6.6
New York	7.1

AVERAGED STATE ACCIDENT DATA FOR TORSO
PROTECTIVE CLOTHING RELATED ACCIDENTS
(Continued)

Bakeries (Continued)

	Torso Protective Clothing Related %
Average	10.86

Bacterial Involvement

State	Torso Protective Clothing Related %
California	27.4
Florida	28.1
New York	7.4
Average	20.93

Beryllium Operations

State	Torso Protective Clothing Related %
California	15.5
Florida	15.7
New York	4.2
Average	11.80

X-ray Operations

State	Torso Protective Clothing Related %
California	27.4
Florida	24.1
New York	9.1
Average	20.20

Metal Smelting

State	Torso Protective Clothing Related %
Florida	7.5

REFERENCES

References contained herein fall into four categories (books and manuals, pamphlets, Government specifications and standards, and State accident publications), and are listed in alphabetical or alpha-numerical order under these subheads.

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PAMPHLETS

Everett, Lewis B. What Executives Need to Know About Protective Clothing. E. I. duPont de Nemours & Co., Inc., 12 pp.

GOVERNMENT SPECIFICATIONS AND STANDARDS

American National Standard Institute (ANSI standards)

J6.5-1971,	Rubber Insulating Sleeves.
Z41.1-1967,	Men's Safety-Toe Footwear.
Z87.1-1968,	Practice for Occupational and Educational Eye and Face Protection.
Z88.1-1969,	Safety Guide for Respiratory Protection Against Radon Daughters.
Z89.1-1969,	Safety Requirements for Industrial Head Protection.
Z89.2-1971,	Safety Requirements for Industrial Protective Helmets for Electrical Workers, Class B.

Federal Specifications

DDD-A-1466A,	Apron, Construction Worker's.
HH-G-450D,	Gloves, Cloth (Asbestos).
JJ-G-001396(GSA-FSS),	Gloves, Flannel, Cotton, Work.
JJ-G-451F,	Gloves, Cloth, Leather Palm.
KK-C-450D,	Clothing, Leather (Aprons, Sleeves, and Jackets).
KK-G-476D,	Gloves, Leather, Gauntlet, Linemen's.
KK-G-486C,	Gloves, Leather, Welder's Gauntlet.
ZZ-A-605b,	Apron, Laboratory.
ZZ-G-381B,	Gloves, Rubber, Industrial.
ZZ-G-401B,	Gloves, Rubber (for) Electrical Workers. (For Use in Connection with Apparatus or Circuits Not Exceeding 5,000 Volts to Ground)

Military Specifications

MIL-A-2334E,	Apron, Toxicological Agents Protective, M2.
MIL-A-40032D,	Apron, Meat Cutter's.
MIL-A-41801A,	Apron Laboratory, Plastic.
MIL-A-41829A,	Apron, Impermeable, Rubber-Coated Fabric (General Purpose).
MIL-C-14610D,	Coveralls, Explosive Handlers.
MIL-G-1008F,	Gloves, Cloth, Cotton, Work, Men's and Women's.
MIL-G-1057E,	Gloves, Cloth, Cotton, Special, OG 109.
MIL-G-10849E,	Glove Shells, Leather, Protector.
MIL-G-10902E,	Gloves, Cloth, Anti-Contact.
MIL-G-12223E,	Gloves, Toxicological Agents Protective.
MIL-G-19465D(SA),	Glove, Leather, Gauntlet, Chipper.
MIL-G-20587E,	Gloves, Wire Mesh, Entire Hand.
MIL-G-21854(S&A),	Gloves, Protective, Fuel and Oxidizer Resistant (Resin Modified Butyl).

MIL-G-2366E,	Gloves, Leather, Heavy, M-1950.
MIL-G-26236(USAF),	Gloves, Flying, Pressurized, High Altitude, Type MG-1.
MIL-G-27650A(USAF),	Gloves, High Altitude HAK-3/P22S-2.
MIL-G-2874B(SA),	Gloves, Cloth, Anti-Flash.
MIL-G-36479a,	Gloves, X-ray, Protective.
MIL-G-38324B(USAF),	Gloves, Rocket Fuel Handlers.
MIL-G-3866D,	Gloves, Cloth, Cotton, Knitted, Lightweight.
MIL-G-43196A,	Gloves, Rocket Fuel Handlers.
MIL-G-43411B,	Gloves, Leather; Barbed Tape-Wire Handlers.
MIL-G-43509(GL),	Gloves, Rubber, Non-Slip.
MIL-G-43580(GL),	Gloves, Cloth, Cotton, Vinyl-Coated.
MIL-G-822G,	Glove Shells, Leather.
MIL-G-82241B,	Glove, Inserts, Radioactive Contaminants.
MIL-G-82242B,	Gloves, Radioactive Contaminants, Protective.
MIL-G-82248B(SA),	Gloves, Cotton, Terry Knit, Flame Resistant.
MIL-G-82253B,	Gloves, Cloth, Vinyl Dipped, General Purpose (Water, Aviation Fuel, Hydrogen Peroxide, Oils).
MIL-G-82405(CG),	Glove, Cloth, Jersey, Work, Polyvinyl Impregnated.
MIL-S-21894D,	Shoes, Service and Shoes, Safety.
MIL-S-3794C,	Shoes, Conductive, Safety.
MIL-S-41821D,	Shoes, Nonsparking, Safety, Traction Tread Sole and Heel, Mildew Resistant.
MIL-S-82245A,	Shoe, Molders, Safety.