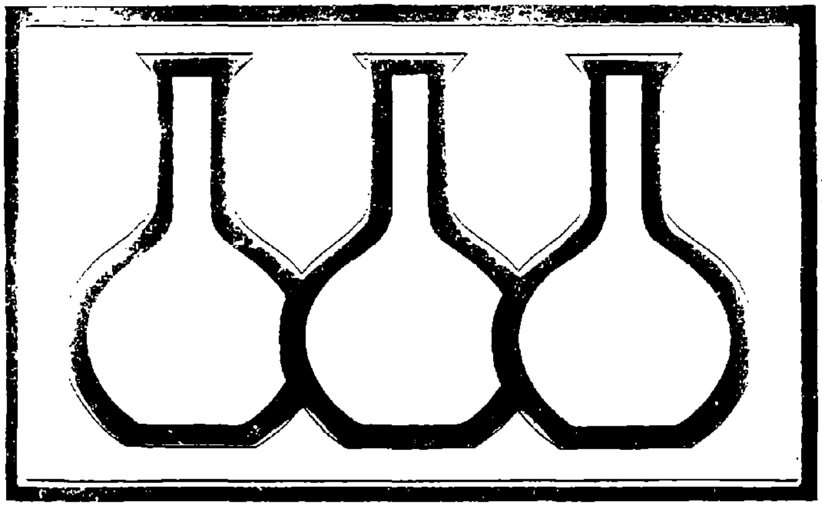

Behavioral Analysis of Workers and Job Hazards in the Roofing Industry

NIOSH Research Report

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2. NA	3. Recipient's Accession No. PB83 176529

4. Title and Subtitle
Behavioral Analysis of Workers and Job Hazards in the Roofing Industry

5. Report Date
June 1975

6.
NA

7. Author(s)
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8. Performing Organization Rept. No.
76-176

9. Performing Organization Name and Address
Theodore Barry and Associates
Los Angeles, CA.
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10. Project/Task/Work Unit No.
NA

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
NIOSH
4676 Columbia Parkway
Cincinnati, Ohio 45226

13. Type of Report & Period Covered
NIOSH Pub.

14.
NA

15. Supplementary Notes

16. Abstract (Limit: 200 words)

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17. Document Analysis a. Descriptors
roofing, accident-statistics, safety, construction

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement:	19. Security Class (This Report)	21. No. of Pages
AVAILABLE TO THE PUBLIC	UNCLASSIFIED	169
	20. Security Class (This Page)	22. Price
	UNCLASSIFIED	

BEHAVIORAL ANALYSIS OF WORKERS AND JOB HAZARDS IN THE ROOFING INDUSTRY

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June 1975

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the National Institute for Occupational Safety and Health.

HEW Publication No. (NIOSH) 75–176

FOREWORD

The research described in this report represents a first effort at defining hazards in an acknowledged high risk occupation, roofing. It elaborates on worker attributes, equipment, training and other factors which may contribute to the occurrence of accidents in such work. The results suggest a number of needs for improved safety including redesign of basic roofing implements and development of personal protective equipment especially tailored to cope with the environmental and materials handling burdens in roofing routines. Also recommended is an upgrading of apprenticeship training. The roofing foreman is seen as the key person influencing the safety level of the work crew. This has prompted a follow-up study,now in progress, seeking to characterize those supervisory-practices that can reduce accident risks in roofing.

The research data collected in this and subsequent investigations is intended to become the basis for the formulation of guidelines, work practices, and equipment standards for enhancing safety in roofing work.

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ACKNOWLEDGEMENT

We wish to acknowledge the cooperation and support of all who helped make this study possible. The NIOSH contracting officers and technical project officers have been very patient and helpful to us in completing this project. The technical project officers from NIOSH were Dr. William Kroes, Dr. Alex Cohen, and Dr. Charles Xintaras.

Equally important to the successful completion of this project was the cooperation of 123 roofer volunteers who participated in the test batteries. The volunteers were primarily from the Los Angeles County, Orange County, and Bay Area (San Francisco, Oakland, San Jose) union locals of the United Slate, Tile, and Composition Roofers, Damp and Waterproof Workers Association. The Southern California and Bay Area Roofing Contractors Associations, along with many individual roofing contractors cooperated with us in recruiting volunteers, and let us visit various roofing jobs. Finally, the Tri-County Roofers Joint Apprenticeship Committee in Southern California was especially helpful and generous in assisting us in obtaining good data on roofing operations and film footage of roofing work practices.

ABSTRACT

Behavioral Analysis of Workers and Job Hazards in the Roofing Industry

Contract No. HSM-99-72-121

This study, sponsored by NIOSH, investigated safety hazards in the roofing construction industry, and examined behavioral and psychological variables potentially related to high accident occurrence. In particular, 123 volunteer roofers (60 with low and 63 with high accident records) were interviewed and tested for variables that might account for differences in their individual accident histories. Roofers were selected because of their high lost time accident frequency rate. This rate is approximately 70 accidents per million man-hours, excluding industry occupations such as sheet metal workers, truck drivers, carpenters, etc. Roofing has one of the highest lost time frequency rates of any large occupational group in the United States, including coal miners.

This interdisciplinary study involved the following types of investigations and analyses:

- An industrial engineering oriented analysis of roofing work and available accident data directed toward identification of work practices and procedures associated with high accident experience. This analysis included the layout of the job and work conditions that may increase the hazards or otherwise be associated with high accident incidence. This analysis involved personal and filmed observation of the behavior patterns of construction workers under real work conditions, with the purpose being to identify any behavioral patterns of the workers themselves that may be associated with high accident experience.

- A psychological evaluation of characteristics of personality, attitude and adjustment of roofing workers identified as having significantly high or low accident experience to ascertain whether these factors could influence safe job performance. In part, the issue is the existence or nonexistence of "the accident prone worker."

- The measurement and analysis of certain behavioral or functional performance capacities that may differentiate between roofing workers with high and low accident histories. Such behavioral capacities as vision, reaction time and aspects of decision making were to be considered, again in the context of their influencing one's accident potential in this high risk job.

The Investigators found almost no significant differences between roofers with high and low accident records. However, certain findings of the study are of great importance to future roofing safety research efforts such as the following:

1. Roofers believe strongly that the foreman is the key to roofing crew safety.

2. New workers and young workers incur an accident rate much higher than experienced roofers.

3. Roofers rank safety training as one of the biggest safety needs of the industry.

4. There is a strong need for better and more detailed accident data. Such data will help resolve strong controversies, in the industry and in regulatory agencies, about how roofing accidents occur and how they can best be prevented.

5. There is a strong need for safety research and development work for roofing equipment, protective clothing and safe roofing work practices.

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CHAPTER 1

INTRODUCTION

Research Sponsors

This project entitled "Behavioral Analysis of Workers and Job Hazards in the High-Risk Construction Occupation of Roofing," Contract HSM 99-72-121, was sponsored by the Behavioral and Motivational Factors Branch of The National Institute for Occupational Safety and Health (NIOSH). NIOSH, a research institute of the U. S. Department of Health Education and Welfare, was created by the Occupational Safety and Health-Act of 1970. As mandated by this act, NIOSH performs research and develops occupational environmental standards applicable to the problems of occupational safety and health.

Overview of the Study and Report

This study was an initial investigation by NIOSH of safety hazards in the roofing industry and an examination of behavioral and psychological factors in roofing workers which could relate to their accident experience. The approach involved the following:

- An industrial engineering oriented analysis of roofing work and available accident data directed toward identification of work practices and procedures associated with high accident experience. This analysis included the layout of the job and work conditions that may increase the hazards or otherwise be associated with high accident incidence. This analysis involved personal and filmed observation of the behavior patterns of construction workers under real work conditions, with the purpose being to identify any behavioral patterns of the workers themselves that may be associated with high accident experience.

- A psychological evaluation of characteristics of personality, attitude and adjustment of roofing workers identified as having significantly high or low accident experience to ascertain whether these factors could influence safe job performance. In part, the issue is the existence or nonexistence of "the accident prone worker."

- The measurement and analysis of certain behavioral or functional performance capacities that may differentiate between roofing workers with high and low accident histories. Such behavioral capacities as vision, reaction time and aspects of decision making were to be considered, again in the context of their influencing one's accident potential in this high risk job.

The investigation involved the following five key steps:

Task 1. Determination of suitable high risk jobs in construction work.

Task 2. Job safety analysis of the accident data and the jobs at the work site with observation of behavioral patterns of the workers under real work conditions.

Task 3. Selection of workers.

Task 4. Development and administration of the psychological and performance capacity test batteries.

Task 5. Analysis of differences between workers in the high and low accident groups in terms of measured psychological characteristics, performance capacities, and behavioral patterns on the job.

This report basically follows the order of the above tasks. The remainder of Chapter 1 will discuss the need and implications of behavioral research in occupational safety problems.

Need for Behavioral Research in Occupational Safety Problems

Most safety regulations and their enforcement, via inspection, traditionally deal with working conditions versus defining safe worker behavior. In the long run, working conditions can be viewed as a component of job behavior. However, in the short run, an accident can be viewed as the interaction of both an unsafe human act and unsafe environmental conditions.

There are a number of approaches for dealing with workplace hazards. The most effective approach involves the redesign of the work environment to improve worker performance capabilities, utilizing engineering approaches to remove the hazard from the work environment. Many times it is difficult and expensive to eliminate physical work hazards utilizing engineering approaches, thus developing appropriate work behaviors utilizing training and motivational techniques is necessary and can be very effective in controlling and coping with such hazards.

The relative importance of worker behavior versus unsafe work conditions in accidents was described in a federally sponsored study conducted by a research team working with the Industrial Safety and Building Statistical Divisions of the Wisconsin Department of Industry Labor and Human Relations in 1971. The study, entitled "Inspection Effectiveness Report," observed the following:

"Approximately forty-five percent of the accidents . . . . . were due to behavioral problems. These problems could be controlled by performance codes which would deal with specific behavioral acts. However, they also seldom occur when an inspector is present, and 'in-house' inspection and detection of unsafe acts would be needed to produce positive effects."

". . . . this approach could be a systems design that would integrate physical hazard control and performance codes, with training and education of the workers and the management, and the development of 'in-house' inspection, detection and correction procedures."

The results of this recent study dramatically illustrate important limitations of current legislation and enforcement of safety rules that focus only on work conditions and thus only a portion of the total safety problem on the job. Typically, employers rely on exhortation through safety meetings or films to "work safe" and thus attempt to decrease the amount of "unsafe" worker behavior on a job. More enlightened employers devote more resources into training and supervision of the employees to improve work performance and safety performance.

Unfortunately, some unsafe worker behavior is not inadvertent, but deliberate acts despite worker knowledge of safety regulations. The occurrence of unsafe worker acts in high risk job situations poses a major research challenge to the behavioral scientist, not only to understand this behavior, but to develop ways to effectively cope with it. This vital part of the occupational safety problem has not received as much safety research attention as it deserves. Subsequent discussions in this report will describe and document a general and serious behavioral and motivational problem that seems especially widespread in the roofing industry.

The "Accident Proneness" Issue of Individual Factors in Accidents

Another NIOSH research goal in this study was to conduct a methodologically sound inquiry into characteristics that might distinguish workers with high versus low accident records. This is sometimes described as research into "accident proneness." Interest in this type of safety research has decreased since World War II for a number of reasons. Statisticians have observed that the frequency differences between the empirically observed number of repeat accidents by accident repeaters are relatively small in comparison to the number of repeat accidents that one would expect from the laws of chance. Hence, dramatic sounding, but true statements like "15 percent of the workers incurred 50 percent of the accidents" no longer delude safety professionals into assumptions of accident proneness without more careful examination of the statistical facts of the situation.

Hundreds of research studies with small research populations, typically psychoanalytic or psychiatric case studies which purported to have identified accident prone factors in accident repeaters, have been discredited by critics on statistical grounds (Jean Surry 1969, Hale and Hale 1972). * In addition, safety professionals often find it impractical to select workers for jobs where investigators have discovered characteristics between high and low accident record worker populations. To successfully screen out the characteristics found in the high accident groups, typically requires a rejection of large numbers of workers.

Despite the problems and controversy of this type of research, a number of investigators, in the last 10 to 15 years, have continued to identify characteristics in reputable studies that appear to distinguish worker populations with high versus low accident records (Hale and Hale 1972). Generally these characteristics have tended to be job specific.

Investigators have also identified a few potentially universal variables associated with high accident record workers such as worker attitudes toward accident risk and worker perceptions of accident consequences (Hale and Hale 1972). Confirmation and development of such findings are potentially very important in high risk occupations, such as construction, where reducing accident risks by changing the physical environment is expensive and difficult. Whether valid or not, construction workers and contractors alike tend to believe that accident prone workers exist. Many construction companies either routinely dismiss, or more often, avoid rehiring men who have incurred several accidents during their employment. Construction workers thus feel compelled to deny having incurred an accident when applying for a job. These beliefs and practices are especially true of roofing. Potentially, the high accident rate in roofing might reveal differences that would otherwise be obscured in lower accident rate industries.

If this research project were to successfully identify behavioral or psychological factors between high versus low accident workers then these factors could potentially be useful in selection or remedial training efforts by the roofing industry. On the other hand if no distinguishing factors of this type between the two groups were found, or if such factorial differences were very small, then this study would help eliminate an important industry myth that has hindered action to solve the safety problem in roofing.

*Note: A bibliography of references (in alphabetical order) is found at the end of this report. These two references are excellent general safety literature reviews. The literature review section of Chapter 3 discusses more specifically accident proneness research studies and references.

CHAPTER 2

SELECTION OF THE ROOFING INDUSTRY AND THE JOB SAFETY ANALYSIS OF HOT COMPOSITION ROOFING JOBS

Roofing Industry Selection

The analysis of high risk construction jobs involved contacting two State of California safety agencies, the accident statistics division and the construction safety inspection force. Also visited were the OSHA inspection force in California, various insurance companies, and a number of California construction unions. The recommendations of knowledgeable safety men in these organizations, plus the accident data, and the insurance cost data suggested several industries had relatively high employment and high accident rates: roofing, sewer and pipeline construction, steel bridge construction, steel erection for high rise buildings, and concrete bridge construction.

Consequently the investigation was narrowed to an investigation of the problems of these construction industries and the potential selection of companies and workers.

The researchers quickly found the identification and selection of high versus low workers within construction companies to be a formidable task. The classical studies of workers with high versus low accident records in the literature, usually involved relatively stable work forces in transportation or manufacturing companies where good accident records were available for many previous years prior to the study.

The project director visited a number of construction companies in the industries of interest. He found that high turnover of workers, high geographical dispersion of temporary work sites and lack of company records almost precluded making a valid statistical selection of workers from company records except in a very few large companies. Construction company personnel officers or supervisors who hired men openly discussed their attempts to dismiss workers or to avoid hiring, if possible, workers known to have incurred repeated accidents or who were suspected to be "accident prone." Hence, few accident repeaters appeared in company records. Undoubtedly, construction workers knowing this, avoid volunteering data on previous accidents on application forms to improve their chances of being hired.

At first we looked for the industry with the largest construction companies, but we found these industries also had lower accident rates. Steel erection and steel bridge construction companies tended to be larger than roofing or sewer pipeline construction companies, but their job accident frequencies also tended to be lower. High job accident frequencies were desired for the study because the test batteries could potentially better highlight differences in workers with high versus low accident records.

It was also difficult for the project team to observe workers on the job in steel erection jobs. Steel erection work sites as well as workers tended to have a high geographical dispersion. The workers appeared more nomadic, and the work force was much smaller than in other industries. Hence steel erection was judged to be less than ideal for this study.

Concrete bridge construction was also eliminated from consideration after a concrete bridge under construction in Pasadena collapsed just after we started the study. This accident killed about a dozen men and seriously injured a number of others. A highly publicized investigation, with televised public hearings, was subsequently conducted by the State Legislature. The legislature had previously mandated new strict safety rules on all state contracts after a previous series of bridge construction disasters and investigations.

Thus the emotionally charged atmosphere made it impossible to even get an interview with these construction companies or their insurance carriers to discuss problems in this industry. We reluctantly abandoned concrete bridge construction industry from further consideration for this study after reviewing these factors.

Of the remaining industry categories, sewer and/or pipeline construction companies had recently become subject to new bidding rules in which mandatory shoring was part of the bidding specifications in several Southern California Counties. These measures were considered to likely have a major impact on accident rates, making historical comparisons somewhat less meaningful.

Each high accident construction industry except roofing, seemed to have major drawbacks. Roofing was also one of the construction industries most in need of attention, based on its high accident frequency and size of employment. It had just been selected as an OSHA target industry. Therefore the research team and the NIOSH technical monitors selected roofing jobs for this study despite the small company size and the related potential problems of identifying, selecting, and recruiting volunteer participants.

Within the roofing and sheet metal industry, the project team elected to study hot composition roofing workers. These workers represent the largest group of workers within the industry and the accident and insurance data suggested this group incurs a reported lost time accident rate significantly higher than roofers who apply shingles or sheet metal materials.

Acute Need for Safety Improvement in Roofing Industry

The roofing and sheet metal construction industry has one of the highest lost time injury accident rate in the United States. In 1970, there were 43 injuries per million man-hours and there are over 100,00 men in this industry (Bureau of Labor Statistics Report No. 406, 1972). The roofing accident rate even exceeded the accident rate for coal mining and preparation work which the same BLS report shows as 41.6 lost time injury accidents per million man-hours in 1970. In 1970, the roofing industry accident rate was 50 percent greater than the contract construction industries injury accident rate of 28 per million man-hours and nearly triple the all-manufacturing-industries rate of 15.2 injuries per million man-hours.

The coal mining and preparation work industry has long been regarded as one of the most hazardous industries in the United States. The well deserved, poor safety record image for coal mining is based, to a large extent, on the large number of fatal accidents and well-publicized mining disasters. Although the roofing industry has fewer serious injuries than coal mining, the workman's compensation insurance rates for hot composition roofing is not much different in magnitude from underground coal mining. In California, the normal rate was over $14 per $100 of payroll earnings when the study was started. Moreover, the employment in roofing and sheet metal work is over 110,000 workers and is not much less than the entire coal mining industry which in 1970 employed about 130,000 men.

Enormous Federal and industry sums have been spent on coal mining safety since 1969, and the accident rates are declining. By comparison, roofing has received almost no Federal safety research and enforcement attention. The accident rate in roofing remains extremely high and appears to be in the highest accident rate for any of the construction industry segments that employ large numbers of men. Hence, roofing was selected as one of the first five target industries by OSHA in its safety enforcement efforts.

Selecting hot composition roofing jobs for a research study focusing on behavioral issues is particularly appropriate because composition roofing materials are applied with a high degree of manual labor. Except for large flat roofs, it is necessary to manually carry the roofing materials to the point of application on the roof. Even on large roofs the final roofing material layer on hot composition built-up roofing is typically applied by hand. If the top layer is "rock" (usually a gravel of white appearance), the men often shovel it on by hand. Cap sheet used as a top layer resembles the conventional asphalt shingle without slits used on residential dwellings. The material is manually unrolled, cut, mopped, and set in position.

The current asphalt or hot coal-tar-pitch technology does not utilize much equipment and hence, limits the options for engineering safety solutions on the equipment. The felt machine used to simultaneously apply hot asphalt to the roof and unroll the roofing felt material onto larger roofs, resembles a common yard or garden fertilizer spreader in appearance and operation. There are some important human factors safety issues regarding its size and design for ease of pulling or pushing the machine, but the major unresolved safety issue is whether the machine should be pulled or pushed. The lack of detailed accident data precludes any easy resolution of this and many other safety issues.

This example illustrates the strong need to collect detailed accident data and apply engineering principles to lessen roofing occupational hazards. Nevertheless the high manual labor task content in the occupation makes the investigation of current worker behavioral patterns more important to devising effective accident reduction measures in the immediate future.

Whatever safety improvement program one devises for roofing, the implementation problem will be difficult. Worker job turnover is high, especially in some non-union shops, and the roofing company size is typically small. Most roofing contracting firms are small family owned businesses.

Over 8,000 of the 12,000 roofing contractors in the United States have seven or fewer employees. * The distribution of employees per employer is as follows:

TABLE 2-1

Contractors	Number of Employees	Average	Workers
5531	1-3	2.0	11,062
2682	4-7	5.5	14,751
2423	8-19	13.5	32,710
1052	20-49	30.0	31,560
248	50-99	75.0	18,600
65	100+	120.0	7,800
12,001		9.7	116,483

From the above figures, one realizes the tremendous inspection and enforcement effort required to create an impact on the roofing industry safety record. Most roofing jobs involve only a few days at a given site and many work crews are composed of only two or three men.

*SIC Data from Social Security Records, U.S. Department of Labor, 1971.

Such problems as the large number of employers and temporary job sites pose a tremendous job site inspection cost. Programs that are more likely to directly affect worker behavior such as mandatory job training and/or certification of job competence (especially in regard to safety issues) might be very cost effective in reducing accidents. First, however, one must be able to describe what are safe and unsafe worker behaviors and job conditions. In regard to unsafe behaviors, economically practical safe behavior alternatives must be available or developed to reduce resistance to safety improvement in the industry.

Overview of Job Analysis

The roofing job safety analysis was almost completely performed prior to the development of the test battery. The first phase of this task was a gathering of accident data. One plus-factor in selecting the roofing industry for study was a newly published study (early 1972) by the State of California analyzing roofing accidents in 1970. The investigators gathered additional data from the State of California and also from the Union and Roofing Apprenticeship Program. The analysis and interpretation of that accident data is presented in a later section of this chapter.

After reviewing this data the investigation team visited a number of roofing sites. Where permitted, the team took pictures and informally interviewed the foreman and workers on the job. The workers were usually friendly and they explained and illustrated a number of hazards. These observations are formalized in the form of two work flow charts which represent two typical types of hot composition roofing: one roof job type topped with cap sheet and the other roof job type topped with gravel or "rock." These flow charts are presented after the accident data in the next section with written explanations of each job step and a description of the typical accidents that occur at each job step.

In addition to the accident analysis and flow charts the investigators commissioned a 30 minute super 8 movie with a cassette tape recording narrative, depicting unrehearsed, unsafe work practices filmed on actual roofing jobs.* The film shows many of the unsafe work sequences found on the roofs in Southern California which, unfortunately, cannot be described as vividly in this report as they are captured on the film, but a description of some of the scenes are included at the end of this chapter.

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*The camera man was a roofing apprenticeship instructor and the film was produced with the generous cooperation of the Tri-County Roofing Apprenticeship Program in Southern California.

The information in this chapter will be helpful to the reader to better understand the nature of hot composition roofing work and the related accident problems. Its main purpose was to provide insight for the test battery development, but the research team believes they have also extended the published knowledge of how roofing accidents occur and documented most of the major roofing safety issues.

The Roofing Industry Unions and Contractors

Roofing Industry Unions - The roofing and sheet metal industry employers who report their employment and accident data to the Bureau of Labor Labor Statistics include three or more union groups and several contracting specialties. The main union group in the industry, referred to as the "Roofers' Union," officially is known as United Slate, Tile, and Composition Roofers, Damp and Waterproof Workers Association. The other two main union groups include the Sheet Metal Workers International Association and a sub-group of the Carpenters Union called the 'Shingling Carpenters'.

Roofing Contractors - Roofing contractors sometimes employ workers in one or more of the unions, and if so, their business tends to be split along the union trade lines. In other words, hot composition roofing crews work separately from shingling carpenters who specialize in nailing on wood or asphalt shingle roofs.

Hot composition roofing contractors tend to be specialized by type of work and the way the business is developed. Larger contractors tend to specialize in new commercial or industrial construction, which is acquired by competitive bidding to specifications. In this market, some contractors tend to further specialize in one or more specialties such as high-rise buildings, large housing and apartment tracts, low-rise commercial buildings, and/or industrial buildings such as warehouses and factories.

Smaller contractors tend to specialize in roofing individual residential dwellings or apartments. Some small contractors seem to specialize in in recover work in which the old roofing material is often removed ("tear-off work") and replaced. The smaller contractors are more likely to be non-union and to hire "men off the street" during the busy summer season.

Roofing work is not a capital intensive type of industry. Hence, the proliferation of small roofing contractors in the industry, as illustrated in the Table 2-1, is made possible by extension of credit from suppliers to enterprising roofers, usually foremen, who set up their own businesses. The turnover of these new contractors, in this category, is very high. A serious employee accident will often put a small contractor out of business because he can no longer compete on labor rates with the resulting high insurance premiums.

The roofing and sheet metal industry undoubtedly captures most of the commercial roofing work performed, but employers of roofers whose business is less than 50 percent roofing work, would have their employment and accident data collected under other classifications. For example, roofing, if performed by government maintenance groups or by general contractors who employ shingling carpenters, would not be included in the roofing industry classification. Hence, the classification of roofing and sheet metal work is not completely inclusive of roofing work performed and the roofing work force.

There is some evidence to suggest that including sheet metal work and asphalt or wood shingling operations with hot composition roofing work tend to disguise a much higher accident rate incurred by hot composition roofing workers. Insurance companies set different rates for each group of workers. The insurance rate for hot composition roofers is considerably higher than for the other two trade classifications in each state whose rates we have seen.

Roofing Accidents Data Discussion

The investigators extracted the data in the following exhibits from the special report entitled Work Injuries in Roofing and Sheet Metal Work - 1970, which was published soon after this project started.* This California report is one of the most complete on roofing accidents that we have found, and it applies directly to the roofing worker population used in this study. We have attempted to extend and restate the analysis made by the California report to suggest certain conclusions. However, to make our report more self-contained, we felt it important to duplicate many of the highlights of that report in this report. We will refer to this special roofing accident study analysis as the California Roofing Accident Report in the following discussion of the Exhibits which are grouped together at the end of this section.

Roofing Industry Accident Rates - As can be seen in Exhibit 2-1 entitled "Accident Rate Comparisons," roofing and sheet metal work had an accident frequency rate that exceeded that of coal mining and preparation work as classified by the Bureau of Labor Statistics for the year 1970. In the same chart, if one looks at the accident rate in California for roofing and construction work, one observes that both are considerably higher than that compiled by the BLS.

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*The research team is deeply indebted and grateful to the personnel of the Division of Labor Statistics and Research, State of California Department of Industrial Relations, for their assistance in supplying us unpublished data on California roofing accidents. Their data is used extensively in the accident analysis of this report.

ACCIDENT RATE COMPARISONS

A. 1970 U.S. Accident Rate Comparisons [1]	Injuries per Million Man-Hours
All manufacturing Industries (three of every 100 workers injured)	15.2
All Contract Construction	28.0
Coal Mining and Preparation	41.6
Roofing and Sheet Metal Work	43.0

B. 1970 California Lost-Time Injuries [2]	Average Injury Frequency per 1,000 Employees	Estimated Injuries [3] per Million Man-Hours
Construction	72.4	36.2
Roofing	116.5	58.2

(1) BLS Report 406, Injury Rates by Industry 1970 published in 1972. Rates are calculated on ANSI Z16.1 and not under 1970 Occupational Safety and Health Act rules.

(2) Correspondence in August 1972 from State of California Industrial Relations Department, Division of Labor Statistics and Research Reporting Standards very similar to ANSI Z16.1.

(3) Assume 2,000 work hours per year per employed worker. (Accident per 1,000 is based on averaging monthly employment reports.)

This may be because roofing workers in California do not work an average of 2,000 hours per year per worker. On the other hand, roofing employment in California is less seasonal than most northern states with cold, snowy winters, potentially providing more employable hours per year per roofing worker. Also, the roofing industry in California has very little sheet metal work compared with most Eastern states, thus the higher accident rate may tend to substantiate the insurance industry rates which suggest that hot composition roofing is a far more dangerous occupation, in terms of accident frequency and severity, than suggested by the official accident rate of the roofing and sheet metal industry classification. Accident data is collected from employers classified by their predominant type of business.

The roofing industry employs over 110,000 workers, of which the majority are likely hot composition roofing workers. Thus, size and the high accident frequency rate, compounded by the large number and high turnover of small, marginally financed employers, pose a large and difficult safety problem.

Job Classification - There are several job classifications that were tallied in the California Roofing Accident Report. As seen in Exhibit 2-2, one can observe the relative frequency of accidents incurred by journeymen, roofers, foremen, roofing support workers, sheet metal workers, carpenters, etc. About 80 percent of the accidents were incurred by workers at the roofing job site. Significantly, apprentice roofers incurred an accident rate that was double the combined accident rate for all the other occupations: 221 apprentice accidents per 1,000 workers versus 110 accidents per 1,000 workers for all the other occupations except the apprentices. Although the authors did not really have a basis on which to determine the number of employed roofing workers versus sheet metal or carpenters, it was estimated that the hot composition roofing workers have a much higher accident rate than did the sheet metal and carpenter workers.

Job Experience - It has been observed in a number of safety studies that the lack of job experience can be the most predictive variable of high accident rates (Jean Surrey, 1972). In other words, new workers are more likely to incur an accident on the job than experienced workers. This phenomenon is especially true for relatively high accident rate industries, but has also been observed in relatively low accident frequency work such as factory work (Jean Surrey, 1972). Job experience has been observed as a very critical safety problem to high accident rate industries, such as underground coal mining, construction, and logging industries.*

*Accident Prediction Study Report 1972, U.S. Bureau of Mines Contract No. SO122023, Theodore Barry and Associates.

OCCUPATION ACCIDENT RATES
1970 California Roofing Industry Accidents

Roofing Industry Occupations [1]	Reported [1] 1970 Accidents	Estimated Employment	Accidents per 1000 per Year
Journeymen, Roofers, Shinglers	689		
Roofing Foremen	89		
Kettlemen	+ 11		
	789		
Roofing Helper	+ 65		
	854		
Roofing Support Workers Laborers, Loader, Yardmen, Truck Driver, Estimators, Etc.	+ 87		
	941	8200[4]	115[4]
Roofer Apprentice	+ 89	403[2]	221
	1030		
Sheet Metal Workers	38	1200[4]	85[4]
Carpenters	28		
Other Occupations Employees	17		
Occupation (not stated)	19		
Industry Total	1132	9800[3] Average	116[3]
All Roofing Industry Occupations Except Apprentices	1043	9400	110

Sources: State of California - Department of Industrial Relations

(1) Division of Labor Statistics and Research Special Report, Work Injuries in Roofing and Sheet Metal Work 1970, July 1972.

(2) Division of Apprentice Standards, Registered Roofing Apprentices, June 1970.

(3) Division of Labor Statistics and Research Special Correspondence, August 1972.

(4) Arbritrary Estimates of Occupation Split.

The authors believe that the same problem occurs in roofing for many of the same reasons, i.e. high job turnover, hiring inexperienced men, relatively high accident risk work, work pace pressure, especially on new workers, constantly changing work place, physically demanding work, etc. Exhibit 2-3 was developed from apprenticeship accident rates with a three-year apprenticeship requirement versus estimated journeyman accident rates and experience. Two points do not empirically prove the existence of an exponentially declining curve of accident rates versus job experience. However, the authors are completely convinced that more detailed data will prove the existence of such a curve, whose sharp decline might actually be steeper than drawn.

In other words, the accident rate for roofing apprentices in the first three months on the job could easily exceed the average accident rate for journeymen workers with more than five years of experience by a factor of 10 or more. Support for this is found in underground coal mining accident data (referenced on previous page).

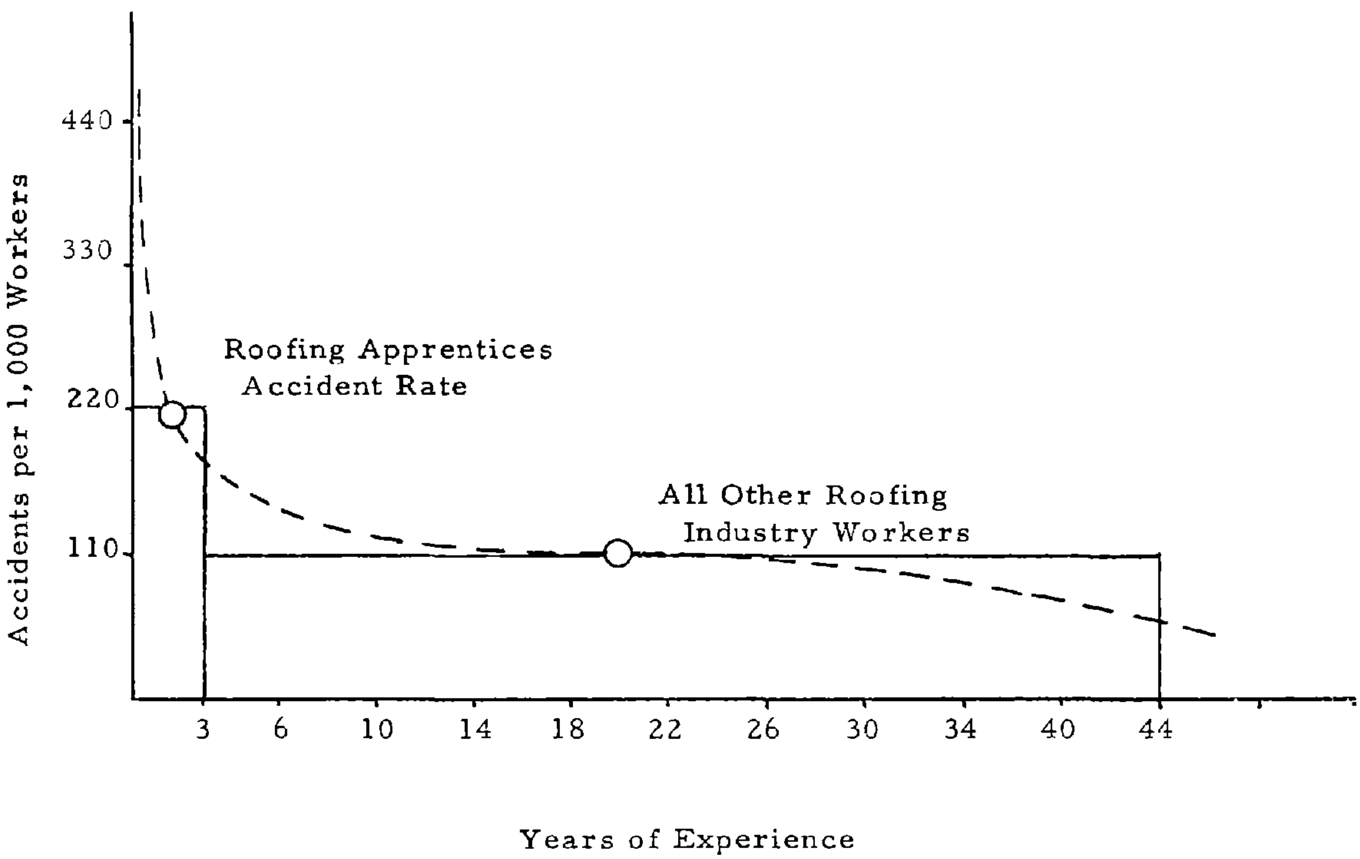
Significantly, training has been found to be a very effective means of reducing accident occurrence associated with job inexperience. Many safety experts have demonstrated that the high accident rate associated with job inexperience is the easiest and most cost effective accident category to eradicate (Jean Surrey, 1972). An accident incurred by a worker with 10 years of accident-free experience, who, in a "mental lapse," steps off a roof, is a much more difficult kind of accident occurrence to prevent than the fall by an exhausted apprentice who did not know the proper and safe way to perform a task.

Both the British and German coal industry found that required job certification had an effect in reducing accidents similar to the effect of required driver license exams on automobile accidents. The training and certification reduced the accidents associated with inexperienced workers. Moreover, close supervision programs for new workers further reduced the accident rates of inexperienced workers. It should be emphasized that the job inexperience factor is task specific and general job experience is not always evidence that the worker has performed a particular task before. Thus an experienced worker would be on almost the same learning curve as a completely inexperienced worker.

Training and certification for new workers is nearly always accompanied by a savings in accident insurance cost and a big bonus in improved productivity of the new worker. Thus, these programs potentially earn a profit rather than become another cost of doing business.

Other pieces of empirical accident data also support the hypothesis that a very strong accident avoidance learning curve is present in the roofing

ACCIDENT AVOIDANCE LEARNING CURVE



industry. Both age and seasonal employment data tend to support the job inexperience hypothesis for roofing accidents.

Roofing Victim Age Data - As can be seen in Exhibits 2-4 and 2-5, approximately 25 percent of Southern California roofing union members are under 30 years of age, either as apprentices or journeymen. However, 46 percent of all the roofing accidents in California occurred to men who were under 30 years of age. Conceivably, non-union roofers represent a much younger population and thus would account for this startling statistic. However, most of the roofing occurs in metropolitan areas such as Los Angeles and Orange County, or the San Francisco/Alameda Counties in Northern California. In these metropolitan areas, a majority of the roofers seem to be union roofers. Even if a substantial number of non-union roofers are under 30, the authors believe the age curves suggest a reinforcement of the job inexperience hypothesis mentioned previously.

Seasonality of Employment: The Marginal or the New Worker Phenomena? One can observe, in the graphs of Exhibits 2-6, 2-7, 2-8, 2-9, and 2-10, that the California roofing industry accident rate tends to correlate with the employment level in each of the five years plotted from 1967 to 1971.

The seasonal employment level in California tended to swing from 8,000 or 8,500 to 10,500 each of the five years. The peak employment months tended to be September or October, along with the highest accident rates per 1,000 workers. The low employment and sometimes low accident rate months tended to be either January-February or April-May, which likely corresponds to heavy seasonal rains.

The accident rate also seems to coincide with other seasonal patterns in the data such as:

- A significant drop from a peak of accident rates the month after peak employment is reached or nearly reached. The strong drop occurs usually over a two-month period, even if employment edges up slightly. This happened each period from September to December for all five years.

- January accident rates were always higher than December, often with a large drop in employment.

- Accident rates tended to increase below the 9,000 man employment level, possibly associated with sharp drops in employment or weather, or just coincidental variations.

EXHIBIT 2-4

AGE COMPARISONS

1,960 Accidents in California Roofing Industry for 1970 plus parts of 1969 and 1971
812 Members of Union Health and Welfare Fund - Three Union Locals in
Los Angeles and Orange Counties as of August 9, 1973

Age	Number Union Fund	%* Union Fund	Cum %* Union Fund	Number Injured	%* Injured	Cum %* Injured	% Difference Union Accidents	Cum %* Difference
15-20	14	1.7%	1.7%	171	8.7%	8.7%	-7.0	-7.0
21-25	92	11.3	13.0	375	19.1	27.8	-7.8	-14.8
26-30	101	12.4	25.4	349	17.8	45.6	-5.4	-20.2
31-35	113	13.9	39.3	260	13.3	58.9	+0.6	-19.6
36-40	113	13.9	53.2	229	11.7	70.6	2.2	-17.4
41-45	118	14.5	67.7	198	10.1	80.7	4.4	-13.0
46-50	104	12.8	80.5	170	8.7	89.4	4.1	-8.9
51-55	78	9.6	90.1	107	5.5	94.9	4.1	-4.8
56-60	54	6.7	96.8	61	3.1	98.0	3.6	-1.2
61-65	18	2.2	99.0	35	1.8	99.8	.4	-.8
66+	7	.9	99.9	5	.3	100.1	.6	-.2*
	812	99.9%	99.9%	1960	100.1%	100.1%		

*Rounding errors

AGE COMPARISON OF ROOFERS INJURED vs ROOFERS WELFARE FUND MEMBERSHIP

□ Cumulative percent of age frequency of injured roofers, California 1970, parts of 1969, 1971

o Cumulative percent of age frequency of Roofers Union Welfare Fund, August 1973

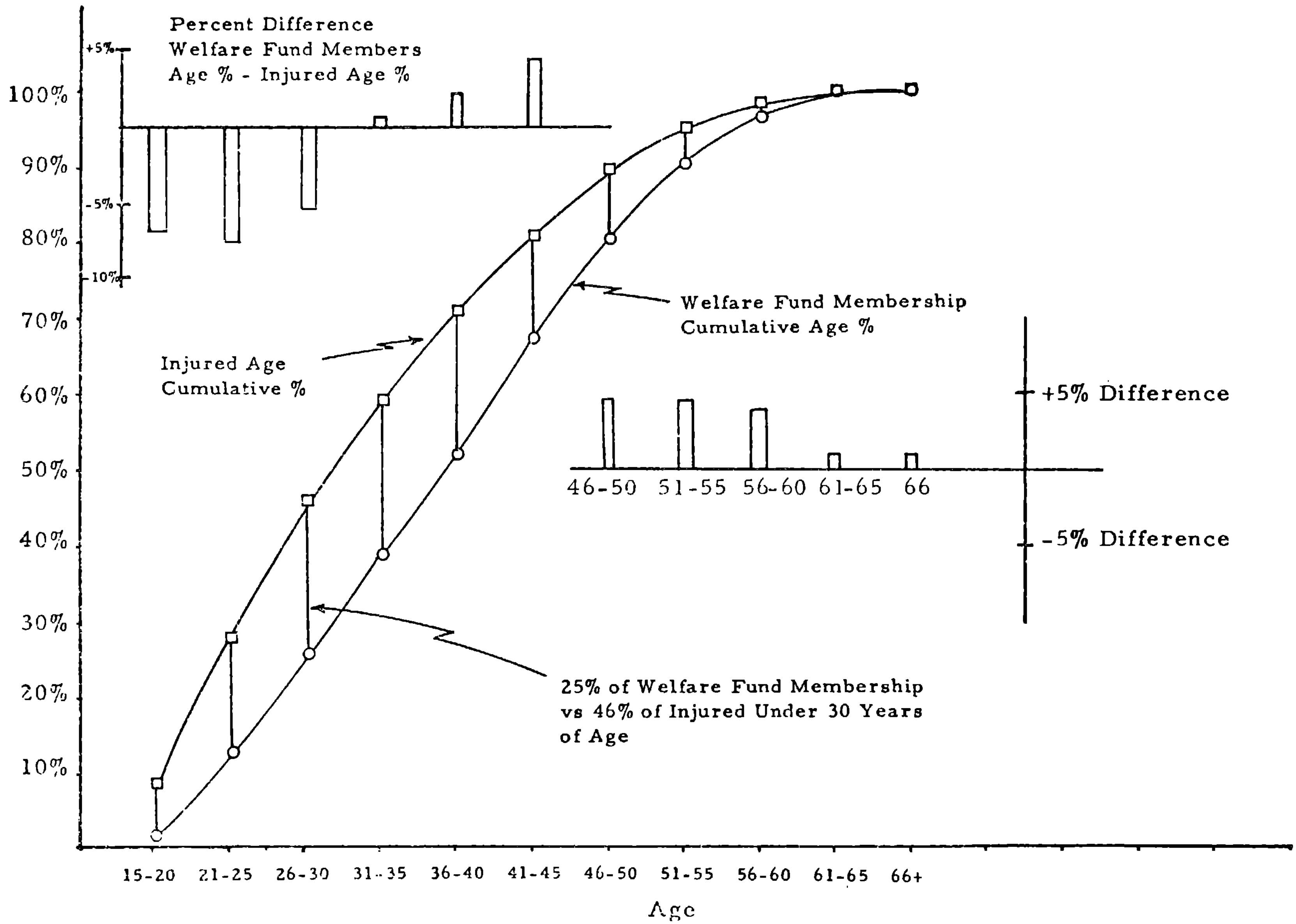
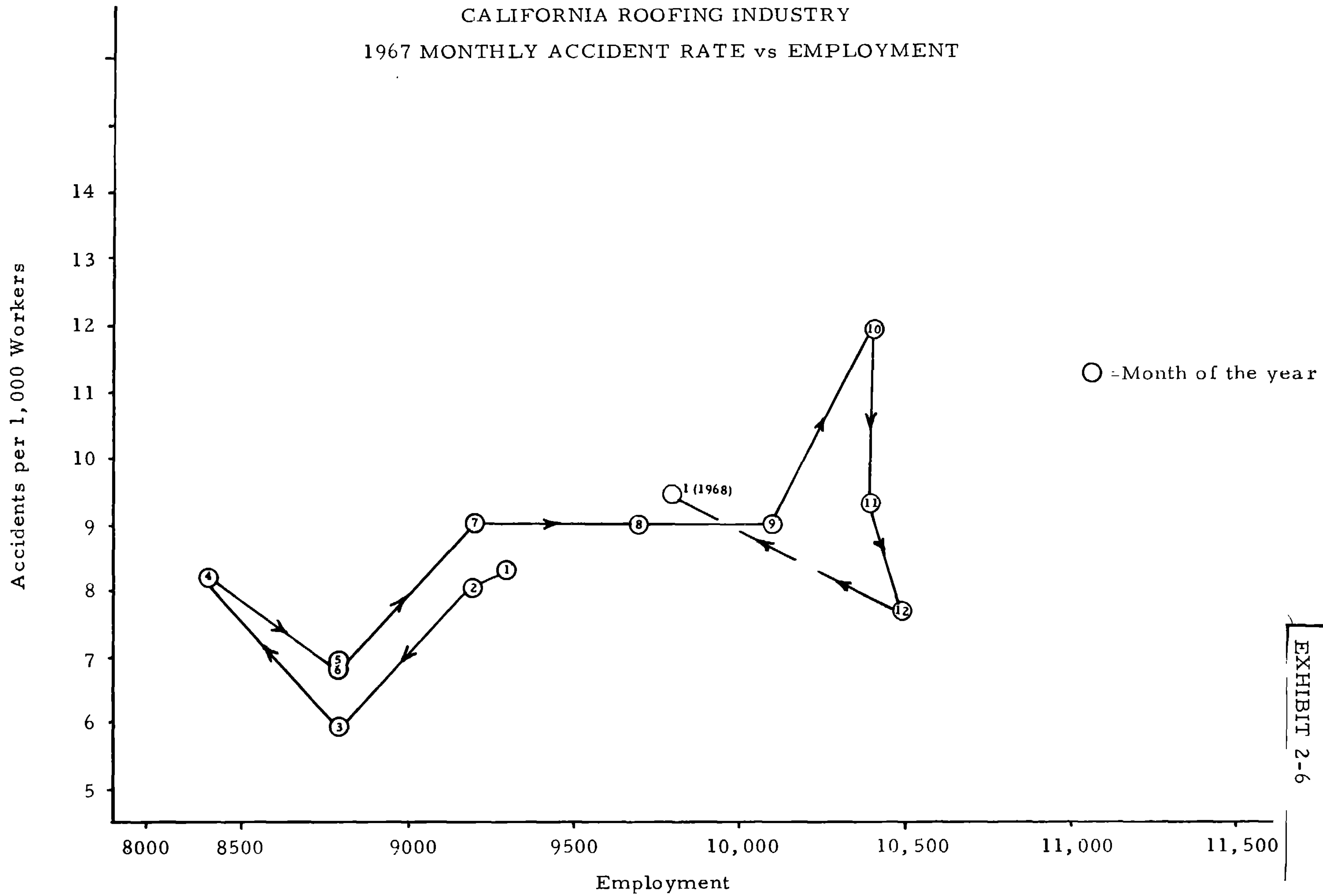


EXHIBIT 2-6

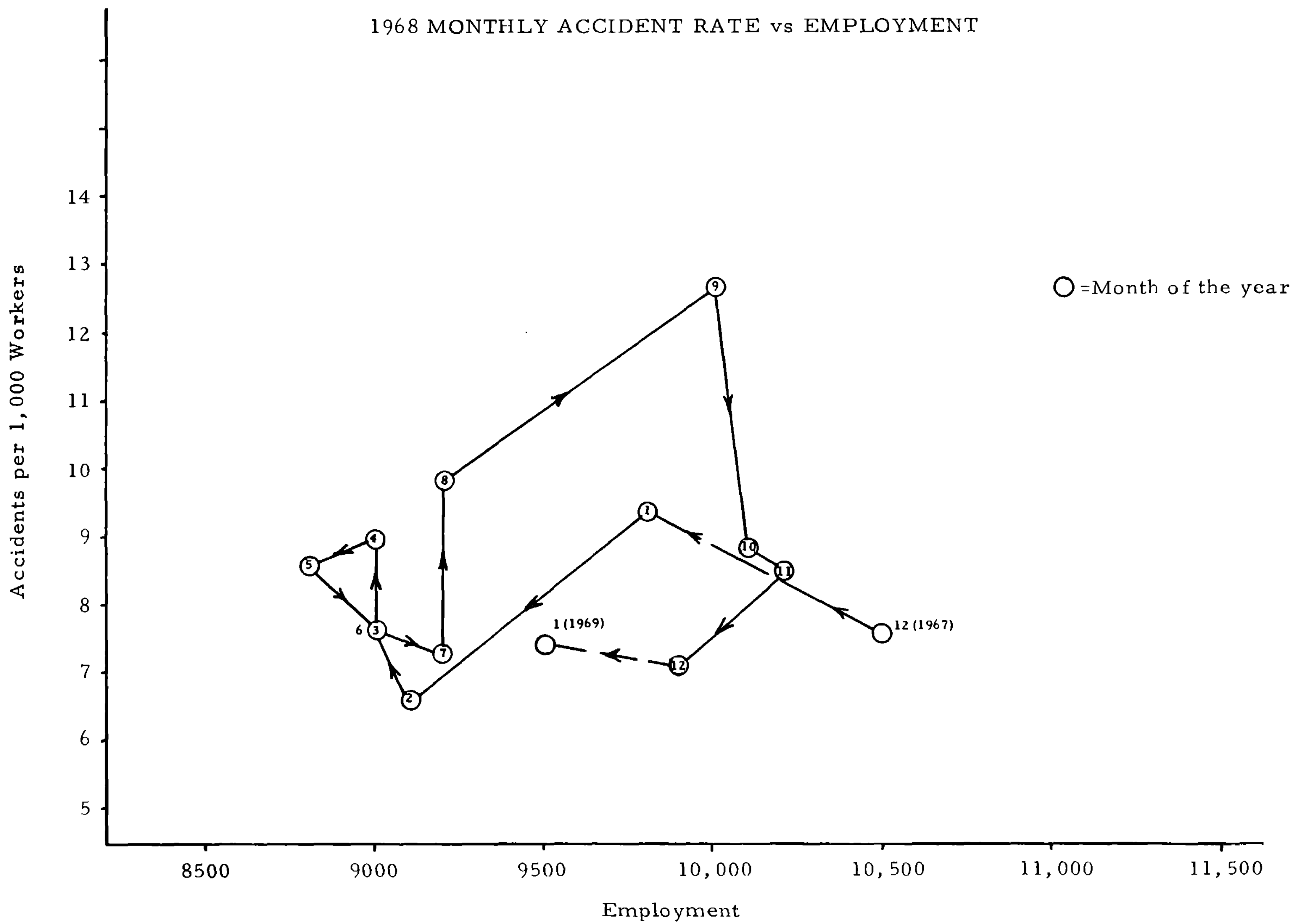
CALIFORNIA ROOFING INDUSTRY

1967 MONTHLY ACCIDENT RATE vs EMPLOYMENT



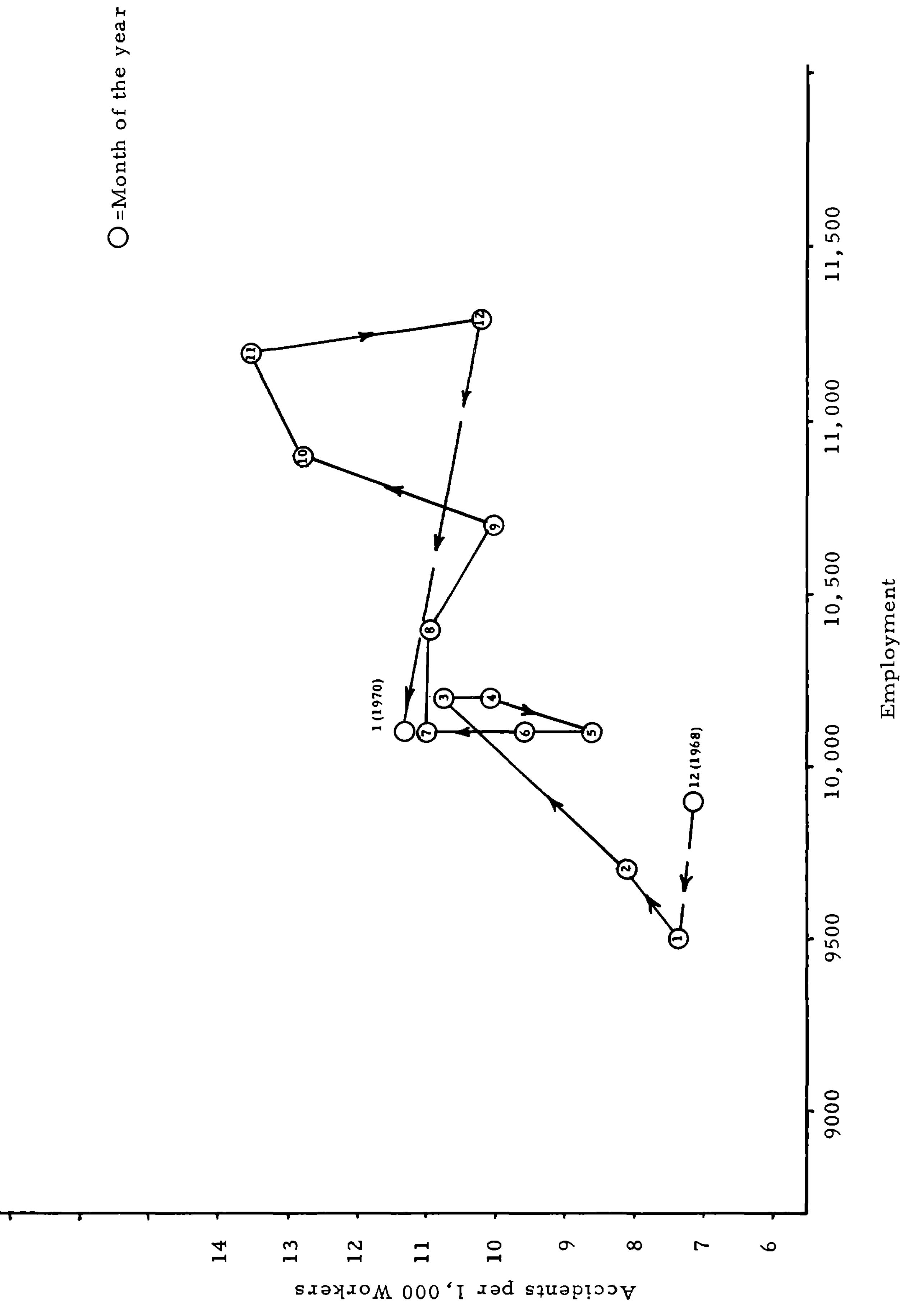
CALIFORNIA ROOFING INDUSTRY

1968 MONTHLY ACCIDENT RATE vs EMPLOYMENT

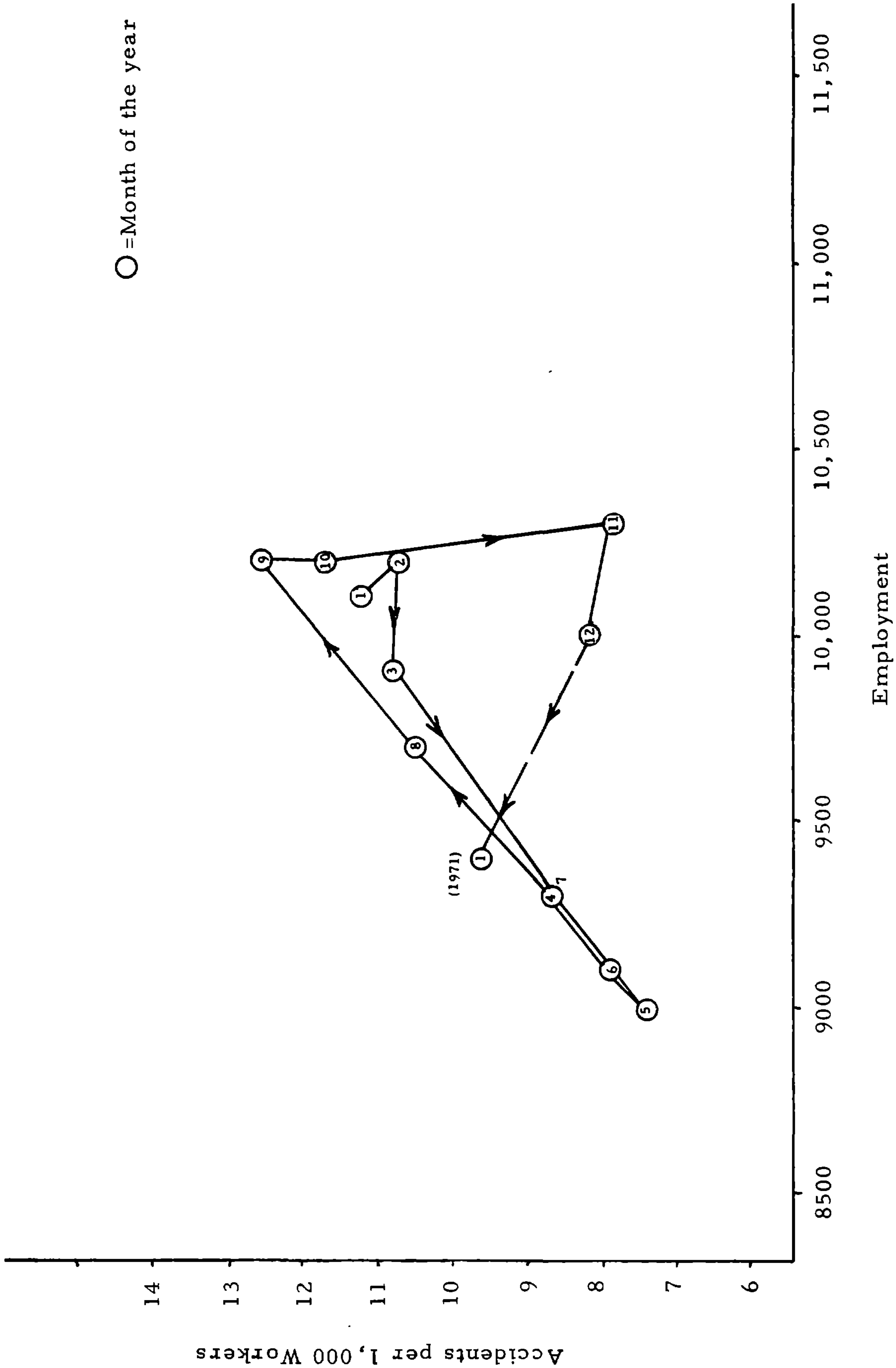


CALIFORNIA ROOFING INDUSTRY

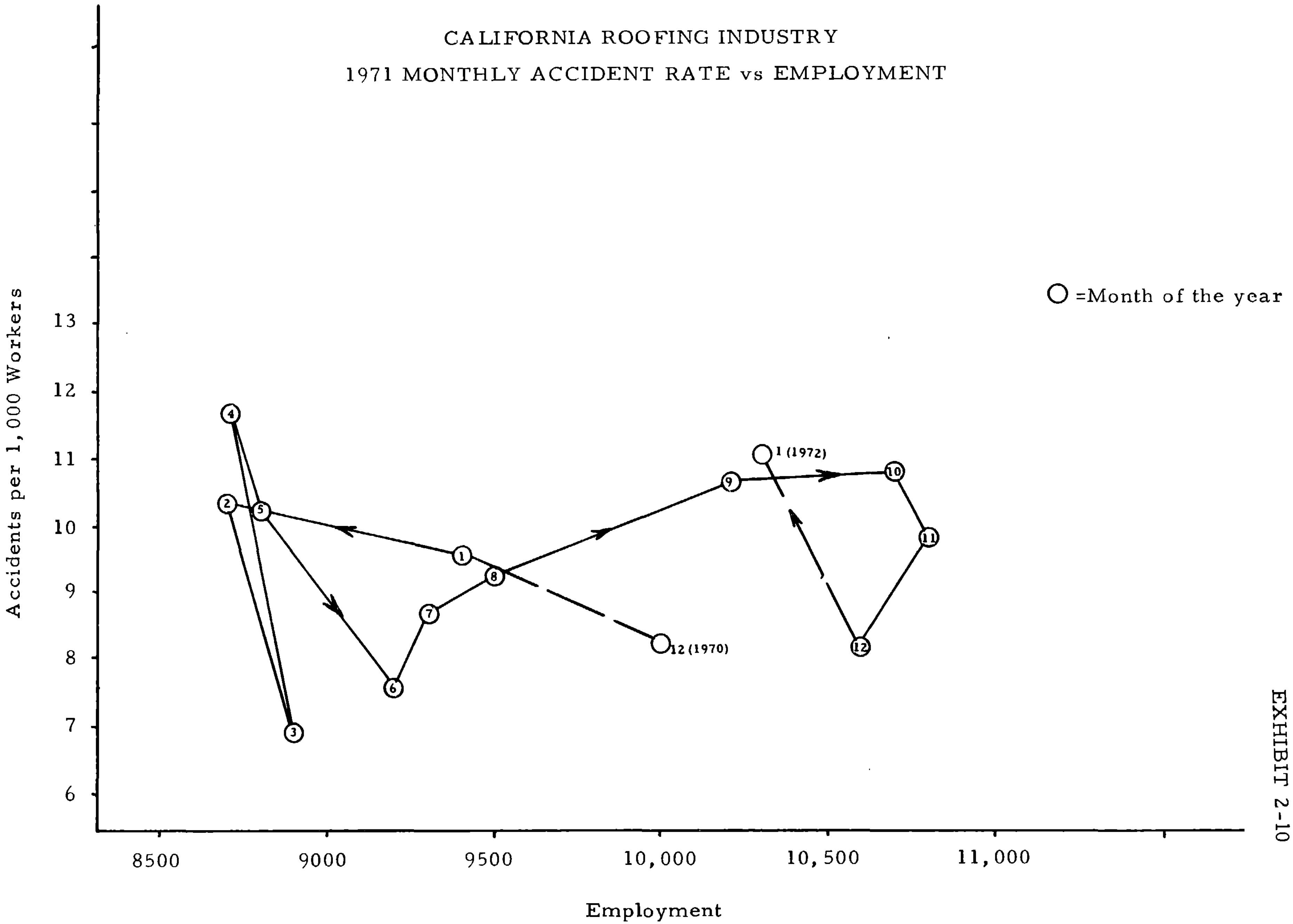
1969 MONTHLY ACCIDENT RATE vs EMPLOYMENT



CALIFORNIA ROOFING INDUSTRY
1970 MONTHLY ACCIDENT RATE vs EMPLOYMENT



CALIFORNIA ROOFING INDUSTRY
1971 MONTHLY ACCIDENT RATE vs EMPLOYMENT



Although coincidental data patterns can lead one astray, perhaps the general tendency of accident rate to climb with employment level is related to the hiring of marginal or inexperienced workers, heavy work pace pressure and/or considerable overtime work. The drop in accident rate once peak employment level was achieved could be related to rapid accident rate drop achieved by new workers during the first few weeks of employment i.e., the accident-avoidance learning curve effect.

Other seasonal factors, such as rainy or hot weather, may relate to the amount of re-cover versus new roofing work performed. No final conclusions can be drawn but further investigation with this data may prove very helpful in avoiding the apparent annual large seasonal increase in accident rates. Safety inspection effects would also seem to be more effective if concentrated in the August to October period in California.

Type of Roofing Accidents - Exhibits 2-11 and 2-12 provide data from California and New York on roofing accident frequency. The New York data also illustrate accident severity as defined by dollar compensation level. New York uses a slightly different classification of roofing accidents than California and the data are based on accidents whose lost time exceeded five working days versus California accident reports based on lost time exceeding one day. Although compensation is not a perfect indicator of severity, it is usually assumed that compensation roughly correlates with severity as defined by days lost from the job and the degree of serious injury in terms of permanent impairment to the victim.

- Slips and Falls - The slips and falls category for California, Exhibit 2-11, is the number one category in terms of accident frequency. As discussed elsewhere in the report, the accident category used for accident frequency ranking by the roofing workers did not include falls on the same level or slips as classified by California. This is because roofers tend to define a fall as "falling off a roof." They describe falling on the roof or falling on the ground as "stumbling" or "slipping," etc. Falling off the roof, in both the California and New York data, represent one of the most serious accident problems. It is high in both frequency and severity.

  Practical and effective fall prevention measures on a roof is obviously a priority safety issue. The three principal investigators visited a number of roofing sites in California during this study and only rarely observed sites either with roof perimeter guard rails, warning lines, headers, etc. Roof openings were sometimes covered, on our visits but still did not represent a high percentage of the sites we visited.

ACCIDENT TYPES
1970 California Roofing and Sheet Metal Disabling Injuries

Accident Types	Subtotal	Total Number of Injuries	Total Percent
1. Fall or Slip		329	29.1%
Fall from elevation**	200		
Fall or slip	55		
Fall or slip while stepping on, off, over object, stairs, etc.	33		
Fall or slip on ground	21		
Fall or slip (n. e. c. *)	20		
2. Contact With Hot Substance**		256	22.6%
3. Strain or Overexertion**		219	19.3%
Lifting object	145		
Pushing or pulling object	23		
Using hand tool	18		
Other	33		
4. Struck by or Striking Against**		202	17.8%
Falling object	69		
Hand tool in using	51		
Sharp object	34		
Other	48		
5. Foreign Substance in Eye		40	3.5%
6. Miscellaneous		86	7.7%
Motor vehicle	21		
Caught in/between	19		
Other	31		
Not reported	15		
		1132	100.0%

* Not elsewhere classified.
**Selected for pictorial ranking of accident types in test battery.

COMPENSATION BY TYPE OF ROOFING ACCIDENTS*

Compensated Work Injuries
New York State 1966-70
Roofing and Sheet Metal Work

	Number	Compensation $ (000)	$/Case
Struck against object	220	$ 268.4	$1,220
Struck by an object	490	876.0	1,788**
Caught in, by or between	79	85.8	1,086
Fall on same level	121	447.7	3,700
Fall to different level	673	3,818.7	5,674**
Slip or over-exertion	554	1,784.3	3,221**
Extreme temperature exposure	320	378.5	1,183**
Inhalation, absorbtion, etc.	23	36.6	1,592
Constant working activity	4	4.1	1,025
Other	36	145.4	4,039
All Cases	2,520	$7,845.5	$3,113

*From "Characteristics and Costs of Work Injuries in New York State", Volume II, December 1972

**Those categories selected for the accident scene rankings.

In regard to slips and falls on the roof, there does not seem to be any accepted standard for roofing footwear used by hot composition roofers. The research team observed everything from tennis shoes to street shoes with leather soles. They also saw boots with some sort of plastic sole that seemed to have partially melted when in contact with hot asphalt. Buildup of asphalt on the soles of boots also seems to be a safety problem. Footwear standards for roofers would seem to offer a potentially important safety investigation subject.

- Burns - Burns are usually mentioned first when one asks a California roofer about roofing accidents. There seems to be a very high consciousness level or fear of asphalt burns by the workers. Very often workers will volunteer rather morbid stories about men loosing a hand in a stream of hot asphalt or falling headlong into a pool of hot asphalt and loosing all the skin on their back, etc.

- Back Injuries - Another very important accident category is the over-exertion type of injuries. The roofer often refers to this category as the "back problem." Hot composition roofing involves a considerable amount of manual labor that involves lifting roofing materials (i.e. felt rolls, bags of gravel, asphalt cartons, etc.). The lifting and stooping required on the job can be described as "back breaking." It is not surprising that there are a significant number of lifting injuries and a large number of roofers with chronic back problems.

- Struck-by Injuries - A category that is almost never mentioned by roofers is the category of "struck by" injuries. The biggest item in this category are roofers injured by falling objects. A surprising amount of roofing material is either dropped from hoists or from the roof onto roofing workers on the ground or on a lower roof level.

Work Activities When Injured - Exhibit 2-13 categorizes work activities when injured, and we have grouped these activities into presumably their most logical location as follows, such as:

• On the roof	45.3%
• Material Handling on Roof or Ground	21.6%
• Personal Transport	13.4%
• Roofing Kettle	6.0%
• Not Reported	9.1%
	99.9%*

*Rounding error.

WORK ACTIVITIES WHEN INJURED
1970 California Roofing and Sheet Metal Disabling Injuries

Work Activities When Injured	Sub-Subtotals	Subtotal	Total Number of Injuries	Total Percent
1. Most Likely on the Roof *			513	45.3%
Applying dry roofing materials		192		
Applying/handling hot asphalt		173		
lifting, carrying bucket of hot asphalt	123			
pouring hot asphalt	26			
applying hot asphalt	24			
Walking on roof		49		
Using, handling hand tools		43		
Working on roof (not elsewhere classified)		32		
Removing old roofing material or debris from roof		24		
2. Material Handling Activities on Roof or Ground*			296	26.1%
Lifting or carrying		160		
roofing materials	124			
other (n.e.c.)	36			
Loading/unloading truck		79		
Operating conveyor, hoist		25		
Handling roofing materials		11		
Moving ladder, scaffold		11		
Lifting or pulling object		7		
Operating lift truck		3		

* Grouping of activities by TB&A on basis of most likely work site location.
**Not elsewhere classified.

(Continued)

WORK ACTIVITIES WHEN INJURED
(continued)

Work Activities When Injured	Sub-Subtotal	Subtotal	Total Number of Injuries	Total Percent
3. Personal transport activities (excluding 49 roof walking cases)			152	13.4%
Vertical Transport to/from Roof		88		
climbing/descending ladder	42			
climbing on/off roof	13			
walking on stairs	4			
standing on ladder	11			
standing on scaffold	18			
walking on ground floor	27			
Other Transport		64		
stepping on/off truck	23			
other stepping on/off	4			
driving/riding truck, car	10			
4. Kettle related activities			68	6.0%
putting asphalt in kettle	20			
moving or lifting kettle	7			
hooking up kettle	6			
cleaning kettle	4			
tending kettle (not classified)	31			
5. Activity not reported			103	9.1%
Total			1132	99.9%

Hot asphalt handling and lifting/carrying roofing materials was involved in 330 injuries or 30 percent of the accidents. It is difficult to form any conclusions from Exhibit 2-13. Each category needs to be related to other circumstances of the accident. Unfortunately these classifications may also be faulty in the sense that employers do not accurately describe activities on the accident reports and one cannot relate the activity to the operational phase of the roofing job.

Nature of Injury - Exhibit 2-14 consists of a selected nature of injuries classification that were cross tabulated against the part of body affected. Note the following:

- The strains and sprains injuries most often affect the back, and very often they result from lifting roofing materials. This suggests the need for training new men how to lift properly and potential rewards for screening men with existing or potential back problems that would result from heavy lifting and continuous stooping.

- Half the burn accidents are to the hands and fingers, suggesting the potential beneficial protection of gloves.

- Add adequately protective long sleeve shirts to protective gloves and potentially the effect of 80 percent of the burns would be mitigated. This assumes, of course, that these injuries involved men without shirts and gloves which, based on our site visits, is a good assumption much of the year in California.

- The cuts and lacerations also are heavily concentrated in finger and hand injuries. Possibly gloves would mitigate the injuring effect of some of these accidents.

The above observations offer some clues to the potential effects of better burn protection and the need to further study the "back injury" problem in roofing.

Detailed Injury Agency - Exhibit 2-15 shows a partial tabulation of the the injuring agency in 1132 accidents in California. Note the following:

- Working surface injuring agencies are very likely related to the slip and fall accidents.

- "Hot chemicals" means hot asphalt in all cases.

- Containers are likely related to falling objects and the lifting injuries.

SELECTED OBSERVATIONS

Nature of Injury Tabulation
1970 California Roofing Industry Accidents

A complete table of Nature of Injury versus Part of Body Affected is presented on page 17 in Work Injuries in Roofing and Sheet Metal Work 1970, State of California Department of Industrial Relations, Division of Labor Statistics and Research, July 1972. A few highlights are presented here:

			Number of Cases	Percent of 1,132 Cases
1. Strains, sprains, dislocations, hernias			330	29.2%
Back, Spine	180	55% of 330		
Trunk	+26			
	206			
Foot	40			
Leg	+32			
	272	82% of 330		

Note: There were 219 "strains or over-exertion" type of accidents in which 145 cases involved lifting an object, typically roofing materials.

2. Burns and scalds			273	24.1%
Hand	137	50% of 273		
Finger	+21			
	158	58% of 273		
Arm	43			
Body, Trunk, Back	27			
	228	84% of 273		

Note: There were 256 "contact with hot substance" cases in the accident type tabulations which did not include cases of explosions, eye burns, etc.

3. Cuts, lacerations, punctures, abrasions			140	12.4%
Finger	49			
Hand	30			
	79	56% of 140		
		Total	743	65.7%

SELECTED OBSERVATIONS

Tabulation of Injuries by Detailed Agency Involved*
1970 California Roofing Industry Injuries

	Subtotal	Number of Cases	% of 1,132 Cases
1. Working Surfaces		299	26.4%
Roof	173		
Ground	40		
Truckbed or Fender	38		
Scaffold	20		
Plank, Plat Form	11		
	282		
(Note: These injuries are very likely slip and fall types of accidents of which there were 329 cases.)			
2. Chemicals, Hot or Injurious Substances		212	20.7
Hot Asphalt or Pitch	212		
3. Containers		141	12.5
Bundles or Shingles or Shakes	49		
Rolls of Roofing Paper Felt	36		
Bag of Roofing Gravel	15		
Box	15		
	115		
4. Hand Tools		94	8.3
Axe, Hatchet	20		
Knife	13		
Power Saw	12		
Shovel	10		
Mop	8		
	63		
5. Roofing Kettles (Note: Only 11 kettlemen were reported injured.)		74	6.5
6. Ladders (Note: 42 falls from ladder were reported and 4 cases of struck by ladder.)		56	4.9

*Page 9, Work Injuries in Roofing and Sheet Metal Work, California 1970 (referenced elsewhere).

Tabulation by Agency (continued)

	Subtotal	Number of Cases	% of 1,132 Cases
7. Vehicles		43	3.8%
Truck	18		
Fork Lift	12		
	30		
8. Hoisting		25	2.2
9. Lumber (including 3 branches)		21	1.9
10. All Other or (not reported 1%)		145	12.8
		1132	100.0%

- The hand tool agencies are likely related to cuts, bruises, and lacerations, especially from axes and knives.

- Seventy-four roofing kettle injuries, versus only 11 kettlemen injured, may either be the result of faulty reporting or suggests the possibility of inexperienced men getting hurt.

It would be interesting to have been able to tabulate the injuring agency versus the accident type.

<u>Roofing Accident Data Conclusions</u> - Many important descriptive insights on roofing accident problems have been observed from the above data. On the other hand, this data raises questions that can only be obtained by developing more detailed accounts of roofing accidents. Some of the conclusions and questions raised by the data are listed below:

- Falls off the roof (or elevation) is the major serious injury problem and also has a high frequency rate. Guarding and footwear standards would seem to offer strong prevention possibilities. It would be helpful to know some of the following:

  - What was the roofer doing when he fell?
  - What phase of the roofing cycle did the accident occur?
  - Did he fall off the roof edge or through an opening?
  - What kind of roof was it?
  - Was it guarded?

- Slips and falls on the same level are also a major category apparently on the roof as well as the ground. An important question is what the roofer is doing at the time of the accident? Another related question would be, "Are most of these accidents stepping into roof holes or are they true slips on the roof surfaces?"

- Burns are a major frequency category. The important questions are:

  - What is the potential for gloves and forearm protection to reduce burn injuries?
  - What was the worker doing when burned?
  - How did the accidents occur?

- Lifting injuries, usually back injuries, are a major insurance cost. The questions are:

  - Were the men lifting properly when injured?
  - Should and could men be effectively screened at time of roofing employment for "bad backs?"
  - Do years of back-straining roofing work cause backs to become impaired in older men?
  - Are there any preventive measures to back problems such as, special exercises or periodic tests of back strength?

- Job experience seems to be the major factor in roofing accidents for apprentice roofers. This is a problem that can be eliminated very cost-effectively by simple training and certification standards. Also foreman certification should help this problem. Is this a job for state and federal regulatory agencies?

- Falling objects remain somewhat of a mystery to the research team It is hard to understand how so many of these accidents occur. Apparently hoist operation is one of the problems, but we do not know enough about how and when these accidents occur to draw any conclusions or even raise any specific questions.

Roofing Work Flow Charts and Task Descriptions

Introduction - To assist the reader in understanding the nature of roofing work, we have prepared two flow charts showing the work elements in a typical sequence of operations. The first flow chart shows the typical sequence of operations in which the final roofing layer is cap sheet, and the second flow chart is for operations whose coat is crushed rock. (See Charts No. 1 and No. 2.)

The box numbers on the flow charts correspond to the numbered operation descriptions that follow the flow chart. The two flow charts do not cover cover all the various types of roofing operations, but are sufficiently representative of operations to permit a basic understanding of the work content and basic operational sequence.

We attempt to describe the typical accidents that occur at each step of the flow charts. Unfortunately, we did not have access to any raw accident report data from which each step of the work cycle could be ascertained for each accident case to develop a relative accident frequency and severity distribution for the flow charts. Such a project ideally would be developed by coding the original accident report with the flow chart step number. Developing such data would empirically define the critical points of the work cycle. Knowing the relative times spent at each step of the cycle, the accident frequency per job time exposure could be calculated. Such an index could be called a relative danger or risk index. Then each of the critical steps of the cycle could be observed and analyzed intensively for risk reduction.

Such an analysis would help resolve the risk exposure increase-versus-decrease controversy about perimeter guard rails on the roof. For example, if most roofers are falling through roof openings and only rarely off the roof perimeter, then installing guard rails might increase rather than decrease the exposure of the roofers to fall off the roof edge because roofers presumably would spend more time exposed to the edge of the roof while installing the roof edge guard rails. Another question potentially resolved by such an analysis concerns forward-pushing versus backward-pulling felt machines. The basic question is whether falls are often involved with the operation of felt machines. Then it is also necessary to know the amount of roofing hours involving use of felt machines and the relative number of forward-pushing versus backward-pulling machines in use in the population being analyzed. In other words, an equipment and operation census is also needed with detailed accident data.

Hopefully, subsequent safety research efforts will extend what has been stated in the accompanying flow charts and the explanation that follow the charts:

ROOFING WORK FLOW CHART TASK DESCRIPTIONS

110.* YARD ASSIGNMENT OPERATION

Workers typically report to yard or shop for daily assignment and job instructions. In some companies that are involved in large on-going commercial jobs, workers may report directly to the work site.

120. LOAD TRUCK WITH EQUIPMENT

Typical Accidents: Falling or jumping off truck, material handling accidents, especially lifting injuries such as hernias or strained backs, or fork lift operation accidents.

121. Load Personal Tools and Belongings
Everyone in the work crew loads the gang-truck with their personal hand tools, lunches, water containers, etc. The roofing materials and supplies are typically loaded in advance by men assigned to the yard.

122. Load Company Tools
Foreman relays requirements of hand tools and materials to be loaded onto the truck, and workers load tools such as shovels, flashings, nails, asphalt cement, etc.

123. Load Felt Rolls
If necessary, foreman directs crew to load materials such as felt rolls, weighing about 80 pounds each, onto the truck. Sometimes this material is supplied directly to the job on pallets, and all trucks are loaded by yard personnel.

124. Load Cap Sheet
If necessary, cap sheet is loaded onto truck: sometimes not required, or it's already loaded by a yard man.

125. Load Fuel Tanks
If necessary, propane or butane tanks must be loaded for kettle fuel.

*Note the paragraph numbers correspond to the numbered operations on the flow charts.

126. Load Asphalt Cartons
Asphalt cartons, weighing about 100 pounds each, are sometimes brought to the job by the crew. If this is the case, they must be loaded on the rear of the truck so that they are easily loaded.

200. DRIVE TO JOB

211. Drive truck or personal cars to job.

310. POSITION KETTLE

Typical Accidents: Material handling injuries, slips and falls.

311. Place Kettle
Kettle must be placed in a spot which facilitates easy movement of asphalt from a central location for shortening travel time. Supports must be set to keep kettle level.

312. Install Kettle Pipe to Roof
Pipe from the kettle to the roof top must be assembled and placed in a spot which facilitates easy movement of asphalt to a convenient roof location. If asphalt is not pumped to the roof, then a pulley type hoist for buckets of hot asphalt would usually be installed. Actual pipe or hoist set up on the roof would follow setting up the ladders or other conveyance to the roof.

315. Unload Tools and Asphalt Cartons Close to Kettle
Hand tools and hand equipment must be unloaded at the kettle position. If necessary, asphalt cartons must be unloaded at this time.

317. Unload Other Materials and Supplies
If this is a new job site, or for other reasons, materials and supplies must be unloaded and located for easy access. This would include the unloading of materials in steps 122 through 125.

320. LOCATE SUPPLIES

Typical Accidents: Material handling, slips and falls on ground level.

321. New job locations often require locating or relocating pallets of asphalt, felt, cap sheet, or rock sacks to a spot which has easy access to a fork lift or to a hoist to roof level.

330. SET UP LADDER, INSTALL ROOF HOIST

Typical Accidents: Material handling, falling objects, ladder or hoist accidents.

331. Before anyone or any supplies can be located on the roof, a ladder must be put up. Ladders should be adequate in length, and tied down at the top with an adequate angle of inclination.

410. START KETTLE

Typical Accidents: Explosion, fires, or burns in kettle set-up.

411. Kettle heating must be started every morning and after the lunch break. Time requirements for the heating cycle vary depending on kettle size, how long the kettle has been off, and whether or not a fuel supply needs to be hooked up. This operation by the kettleman would come directly after operation number 311. In many ongoing jobs, the kettleman or foreman arrives before the shift to start the kettle heating so that work can begin promptly at the start of the shift.

420. CHOP ASPHALT

Typical Accidents: Lifting accidents, accidents involving improper use of an axe.

421. Asphalt cartons must be split open and chopped with a hand axe into small chunks which are then loaded into the kettle.

430. TRANSPORT TO KETTLE

Typical Accidents: In overheated kettles, the opening of the lid permits oxygen exposure to the asphalt vapors, and kettle flash, a flash fire or explosion can result.

431. Kettle lid must be opened to enable the asphalt chunks to be placed inside.

432. Asphalt chunks must be carried from the chopping location over to the kettle.

440. LOAD KETTLE

Typical Accidents: Careless dropping or throwing of chunks into hot asphalt kettle can result in a hot asphalt splash , especially if asphalt is not chopped into small pieces.

441. Asphalt chunks must be placed into kettle.

Typical Accidents: Hand burns on hot surface.

442. Close kettle lid.

450. CLEAN AREA AND SUPPORT CREW

451. Pick Up Cardboard Casings
Paper or cardboard casing covers that cover either the asphalt chunks or the rolls of felt should be picked up, and felt trimmings should be gathered to keep area clean and eliminate fire hazard.

454. Kettlemen Alert and Response
Any time a roof crew needs something from the ground level, they will alert the kettleman, and he will send up what is needed.

460. CHECK CREW REQUIREMENTS

461. Any time an asphalt container is filled, the kettleman must note how much is used so he can keep the kettle full. (A 100-pound carton equals about 20 gallons.)

510. LOAD ROOF WITH FELT

Typical Accidents: Hoist and ladder accidents, usually involving dropping material.

511. Convey Felt and Roofing Materials to Roof
Felt rolls can be loaded onto the roof by three common methods. If the job is large enough and the roof low enough, a fork lift will lift a pallet of felt to the roof level. Lift-bed trucks can also be used to unload from the truck to low roofs. On small operations, a hoist can be used to lift the rolls. Large multi-story construction will usually

have a portable elevator. Carrying felt rolls up a ladder is strictly forbidden in most state safety rules, but can be observed in the field.

512. Convey Equipment to Roof
Hand equipment is also unloaded to the roof level by fork lift or truck lift-bed.

520. FILL MOP BUCKET

Typical Asphalt Transport Accidents: Slip and falls on roof, often involving burns and serious falls through roof openings.

Note: This job description will apply to all asphalt filling operations following.

521. Roofers travel from roof working area to supply pipe which feeds roof level with asphalt from kettle. He will either take an empty bucket, bucket cart, or tank cart called the "high-boy."

Typical Asphalt Fill Accidents: Getting hand into asphalt fill stream, or splashes from handling containers.

522. Fill Asphalt Bucket, Mop Cart
Fill mop bucket, spreader bucket, five-gallon bucket, or mop cart. Time requirements vary, depending on asphalt transport method (pipe or hoist) and container size.

523. Fill High-Boy Tank Cart
Fill 25-gallon mobile "high-boy" tank cart from kettle supply pipe.

Typical Bucket Carrying Accidents: Splashes of asphalt out of bucket associated with tripping, slips or falls.

524. Travel from filling spot to work with full container.

530. MOP AND LAY FIRST FELT LAYER

Typical Accidents: Material handling, cuts, nailing accidents.

531. Insulation sheet is cut and laid on cement or metallic roof decks, or nailed to wood surfaces.

Typical Accidents: Asphalt splashes.

532. Mop surface.

533. Initial felt layer is rolled out and trimmed over freshly mopped surface.

540. NAIL DOWN AND CEMENT FLASHING

541. Flashings are the metal shields which surround and/or cover vents through the roof deck. These shields must be placed over the vents, sealed, and nailed to the roof to make the vents water proof. Asphalt cement is used as a sealer around, and sometimes under, these shields.

610. INSTALL NEW FELT ROLL

Typical Accidents: Slips and falls, back injuries.

611. Travel to felt roll location and back to machine with felt roll.

612. Load felt machine with roll.

613. Thread roll through or under roller cage.

620. FILL FELT MACHINE TANK WITH ASPHALT

621. See operations Number 521, 522 and, 524.

630. RUN FELT MACHINE

Typical Accidents: Machine operator falls off or through roof openings, usually by tripping near a roof opening or near a roof edge.

631. Felt machines are push- or pull-type equipment. In either case, the machines spread hot asphalt and roll out the felt in a single operation. Number and width of overlapping passes create a desired number of ply layers.

710. FILL MOP BUCKET

711. See operations Number 521, 522 and, 524.

720. MANUAL FELT FITTING

Typical Accidents: Hand burns, cuts, back strain.

721. Jobs with many vents require manual felt fitting. This process involves mopping a small area, rolling the felt while trimming around vents with a roofing knife.

Typical Accidents: Hand burns from asphalt on deck, cuts from knife.

722. Cut and roll out felt over freshly mopped area.

810. FILL MOP BUCKET

811. See operations Number 521, 522 and, 524.

820. CUT, MOP, AND LAY EDGING

Typical Accidents: Cuts.

821. Cut edging material to required sizes.

Typical Accidents: Asphalt splashes.

822. Mop backing of edging material. Performance times vary due to size.

Typical Accidents: Nailing accidents.

823. Lay edging onto location and nail for strength. Performance times vary due to size requirements.

ROCKING OPERATION

910. FILL ASPHALT SPREADER

911. See operations Number 521, 522 and, 524.

920. SPREAD HOT ASPHALT WITH SPREADER

921. Spreader is pulled along an approximate length of 20 feet, giving a three-foot by 20-foot strip of hot asphalt.

930. SUPPLY CREW WITH ROCK

931. By lift dump, or pallet sacks, one man supplies remainder of crew with rock. (3-1/2 sacks per square foot.)

940. UNLOAD ROCK AT SIGNAL

941. Upon receiving signal from spreaderman, rock is dumped into rock spreader boxes.

950. FILL ROCK SPREADER AND ALERT ROCKMAN

951. Spreader boxes are filled from sacks or bucket.

960. ROCKMAN GETS MORE ROCK

961. Rockman returns to pile for more rock or another pallet.

970. SPREAD ROCK OVER HOT ASPHALT

971. Immediately following operation Number 921, rock is spread over section of hot asphalt just applied.

980. SPREAD ROCK TO DETAIL AREAS

981. Rock is spread to obscure areas by shovel.

Roofing Unsafe Work Practices Film

To better communicate the unsafe roofing work practices, the contractor prepared, for NIOSH, a 30 minute film and a cassette tape narrating each unsafe work practices scene. All scenes are completely unrehearsed and were filmed on the job. The film, despite its home-made flavor, has some good photography and is truly a documentary on unsafe roofing work practices in Southern California.

The film was actually made by a Southern California Roofing Apprenticeship Instructor who cut out these scenes from film footage being gathered by the apprenticeship program for instructional purposes of actual work methods used in the field, good and bad.* Hence, one should not conclude that the film is representative of the observations one would make in a random sample of roofing sites in Southern California. On the other hand, these scenes are not that untypical based on the research team's own visits to many roofing sites during our study.

Examples of some of the scenes in the film include:

- A man throwing a large asphalt chunk into a kettle and getting burned on the hand by the splash back of hot asphalt.
- Various "tippy toe" scenes with felt layer machines and tear-off machines at the edge of roofs.
- Pulling a back pulling felt layer machine up to the edge of an uncovered skylight.
- Numerous worker scenes without shirts, gloves, hard hats, safety glasses or safety shoes. Tennis shoes or other unsuitable shoes show up a number of times in these scenes.
- A worker smoking near a kettle up to his knees in a "sea of trash paper."

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*Releasing this film on the part of the roofing contractors and the union locals involved, who jointly administer the Apprenticeship program, indicates an extraordinary act of good faith and good will. To let such a highly unfavorable document of roofing safety be made available for essentially public inspection in a Federal government research agency impressed the research team that a large number of roofing contractors and union officialls are truly dedicated to improving the safety record of roofing work. We have found some of the best critics of roofing safety right in the roofing industry, both among contractors and union officials.

- Numerous scenes of using overheated asphalt recognized by the tremendous amount of smoke emanating from the super hot asphalt.

The above list is only a partial list, but it provides an idea of the type of film that was prepared. The film should be very useful in dramatically illustrating the challenge of improving the accident record in the roofing industry for individuals unfamiliar with the industry.

A review of the accident data, the sequences of roofing work in the flow charts, plus a viewing of the film provided a rather comprehensive summary of roofing safety hazards. Having this as background, the research team was able to comb the literature with specific accident scenarios in mind, formulate interview questions and develop study hypotheses for the test batteries. The methodology for the test battery development follows in the next chapter.

CHAPTER 3

TEST BATTERY DEVELOPMENT AND ADMINISTRATION

A most critical step in the development of the test batteries was the identification of the roofer characteristics to be measured. That is, the determination of those characteristics of personality and performance capacity thought to be important to safe job performance. Hypotheses concerning these "key" characteristics were developed on the basis of a review of the relevant literature and job analyses of roofing work and the environment in which it is performed. To measure the selected characteristics, test instruments were obtained or constructed and volunteer roofers were recruited to take the test battery.

Review of Relevant Research Literature

A review of the psychological literature on accident causation should begin with some discussion of the concept of "accident proneness" and its evaluation, as it is this concept that has stimulated, directly or indirectly, much if not most of the research in this area.

Greenwood and Woods (1919) collected accident experience data on 14 groups of 50 to 750 women working in a British munitions factory during World War I, and observed that a relatively small number of workers accounted for the majority of accidents experienced. To explain this phenomenon, they offered the theory of Unequal Initial Liability which, with some specific reservations, they interpreted to mean that some individuals are inherently more likely to have accidents than others. While they did not speculate on any characteristics that might account for this observation, they did write that: "These conclusions indicate that varying individual susceptibility to accidents is an extremely important factor in determining the accident frequency distribution."

Newbold (1926), another statistician, followed up on the work of Greenwood and Woods with a study of the accident records of a large group of workers employed in British factories. Her results paralleled those of Greenwood and Woods in that she observed that the average number of accidents is much influenced by a comparatively small number of workers. She went on to conclude, with careful reservations, that while this finding may be due in part to differences in the conditions of work, some part is due to "personal tendency."

On the basis of these two studies, Farmer and Chambers (1929) made what is now considered the extravagant claim that: "previous statistical investigations have shown that industrial workers exposed to equal risks are unequal in their liability to sustain accidents, and that this unequal liability is a relatively stable phenomenon." Their own work, which involved the administration of "psychological tests" to London bus drivers with high and low accident experience records, led them to conclude that, "a relationship has been shown to exist in the subjects examined between accidents on the one hand, and poor aestheo-kinetic coordination and nervous instability on the other hand." (Farmer and Chambers, 1939). They then introduced the term "accident prone" to describe persons whose unsatisfactory accident record was due to "personal factors." They considered accident proneness to be an immutable characteristic, and therefore, individuals "are fixed in their inherent liability to incur accidents."

The concept of accident proneness as a stable and permanent characteristic of personality was accepted rather avidly by behavorial scientists and physicians, and subsequent research through the 1940's and 1950's aimed at finding a characteristic or group of characteristics, ranging from sensory-motor capacities to psyche, that would correlate with and predict accident experience. As will be seen in the paragraphs that follow, the research stimulated by the theory of accident proneness has produced results that are largely unclear and even contradictory. Whether these results are a function of methodological problems associated with research of this type or the fact that the assumption of accident proneness as an enduring and stable trait of personality is invalid, the concept has, in recent years, fallen into disrepute among informed workers in the field.

Today, it is most commonly believed that accidents are largely situationally determined by an interaction of the person and their environment. Various new terms have been proposed to describe persons who have more than their share of accidents, such as "temporary accident proneness," "variable accident tendency," and "accident repeater." The latter term suggested by Norman (1962) to describe the person "who has more than a given number of accidents in a given period, the repeater condition being either temporary or permanent," is probably the most widely accepted today.

Of those individuals who have been involved in more than the expected number of accidents in a given period of time, there are some whose behavior has been at least partially responsible for their accidents. There are others whose accidents, just as clearly, are a function of conditions and circumstances over which they have no control or influence. It is incorrect, then, to consider all accident repeaters accident prone. However, there are those among the first group who can still be considered, at least temporarily, accident prone. These are people whose ability to cope with the hazards in their job environments is curtailed significantly because they are either under emotional or physical stress, or they are suffering from some inner turmoil, or they are otherwise preoccupied. There may be others in that first group who might also be considered temporarily accident prone because of youthful impetuousness or some need to display their fearlessness or manliness.

The composition of this group of "temporary accident prones" is continually changing as people are affected by job and life stresses which then typically dissipate in time. In other words, if it is accepted that accident proneness is a temporary condition resulting from the interaction of job conditions and the effects of stress and preoccuptaion on worker behavior, it is conceivable that any worker could be considered accident prone at some point in his life. It is emphasized, though, that the accidents such people incur are just one symptom of their distressed or preoccupied state. Were it possible to study their behavior thoroughly, both on and off the job, other forms of behavioral aberration would likely be in evidence.

The temporary nature of the psychological and physical stresses and pre-occupations that contribute to accident causation has been a major problem to researchers in the field who have attempted to isolate and measure the personal characteristics associated with accident proneness. In many cases, the trait measurements are performed years after the occurrence of the accidents, so they may or may not be in evidence. The fact that the traits are not in evidence at the time of measurement does not preclude the possibility of their existence at the time the accidents occurred.

In the following paragraphs, a representative sample of the research on psychological factors in accident causation is described.

<u>Intelligence</u> - Intelligence would seem intuitively to relate to accident experience since so many accidents appear superficially attributable to stupidity. In fact, however, few significant relationships between intelligence as measured by various intelligence tests and accident frequency or severity have been found. This frequent finding of no relationship has been obtained with a variety of different work groups and in several different countries (e.g., Farmer and Chambers, 1929; Farmer, Chambers and Kirk, 1933; Brown and Ghiselle, 1947; Crawford, 1965; Kundo, 1961). In those studies that have produced results which disagree with this general conclusion, it has been observed that either the subjects were people of very low intelligence, below an IQ of 70, or the job task was very complex, such as flying an airplane (Tiffin, 1961). Studies using indicators of intelligence other than tests have generally yielded similar results (Davis and Coiley, 1959).

The only tenable conclusion from the published studies is that, above a very low minimum, there is no overall relationship between measured intelligence and accident experience. The intuitively logical relationship between intelligence and accident experience is more likely a function of the complex and multiply determined process of judgement than of intelligence alone. Nonetheless, intelligence is a factor that must be accounted for or controlled in any study of group or individual differences in the performance of complex behavior such as that involved in roofing.

Personality - Any research on personality variables, as they relate to accident experience, suffers from a number of technical difficulties, not the least of which are: (1) the difficulty of obtaining reliable and valid measures of the personality variables under investigation, (2) the difficulty of determining what is cause and what is effect, (3) the problem of determining what factors affect the reporting of the accidents and what the causation, (4) the question as to whether the personality characteristic(s) under consideration is a stable trait or a temporary one that may even be situationally determined. It is not surprising, then, that the studies of the personality correlates of high accident experience industrial populations have not produced clear-cut results. In many cases, conflicting results and conclusions have been found; and in those studies that have produced significant results, interpretation is confused by methodological flaws.

A most common orientation in the investigation of the personality correlates of high accident experience is that the accident is assumed to be a symptom or expression of emotional disturbance. Smiley (1955) is one researcher who has emphasized the importance of emotional disturbance in accident causation. In a group of high-accident factory workers, he found that 72 percent had some sort of clinically observable emotional disturbance versus eight percent in a control group. His results must be questioned, however, because he did not demonstrate that the risk exposure was equivalent for his two groups. Additionally, the reliability and validity of his subjective assessment of "neuroticism" was not established.

Smart and Schmidt (1960) studied patients hospitalized for ulcer treatment and found that they had a higher incidence of automobile accidents than did a group of patients hospitalized with other physical ailments. They concluded that an underlying tendency to anxiety was responsible for both the ulcers and the accident experience. Again, this conclusion must be treated with caution since the two groups were not matched on such vital variables as age and miles driven.

Tiffen and McCormick (in 1962) reported the results of a study of workers in the Cleveland Railway Company which found that 32 percent of the accidents had as a causative factor at least one of four personality variables: sense of guilt, irritability and fear, depression, and agitation. This finding was based on the workers' subjective judgments of their mental states at the time of the accidents. However, these judgments were made some time after the accidents occurred.

Whitlock and Crannell reported (1949) on a study in which they compared 100 "major accident cases" and 200 "accident-free cases" among steel mill workers on a number of tests of intelligence, personality and mechanical comprehension. They found no significant relationship between either the intelligence or mechanical aptitude test scores and the occurrence of accidents. However, they did find significant differences between the two groups on several scales of the Bernreuter Personality Inventory. The results suggested that the accident-free group was less neurotic, less introverted and more self-confident. On the other hand, in a relatively well-controlled though small sample study of chemical workers, Tydlaska (1952) found no significant differences between high and low accident groups on several tests administered prior to employment. Her battery included the Otis Test of Mental Ability, the Kuder Preference Record and the Minnesota Multiphasic Personality Inventory. A similar result was obtained by Harris (1949) when he tested a group of 25 accident repeaters and a group of 25 accident-free employees in a manufacturing plant. He matched his groups for age, sex, job and experience on the job and administered selected items from the Bernreuter, the Rosenzweig Picture Frustration Test, and certain multiple choice variations on the Rorschach. However, this study had several potentially serious weaknesses, not the least of which was taking test items out of context. By such action, Harris may well have destroyed the validity of the test items.

Excessive aggression has also been postulated as a causative factor in industrial accidents. Support for this hypothesis is at best indirect. Suchman (1965), in discussing the greater severity rate of accidents among male drivers in the United States, explained it in terms of the role of the male in American society as an aggressive risk taker. Held (1961) concluded that driving accidents are a sign of "unintegrated aggressiveness" based on his observations of patients under psychoanalytic treatment.

Eysenck's theory that extroverts are less bound by prescribed rules and less highly socialized than introverts has yielded the corollary that extroverts break safety rules as readily as they break any other rules. Therefore, he reasons, extroverts are more likely to have accidents than introverts. Consistently, a number of studies have obtained significant positive correlations between accidents and the personality trait of extroversion as measured by the Minnesota Multiphasic Personality Inventory and the Eysenck Personality Inventory.

Fine (1963) found that automobile drivers scoring highly on the extroversion scale of the EPI had more recorded accidents and driving violations than those who scored as introverts or intermediate between the two extremes. Craske (1968) found that extroversion and accident history were correlated in a sample of patients hospitalized for accident trauma. He further concluded that it was the impulsive elements of extroversion that were responsible for the correlation.

MacKay et al (1969) found a mean extroversion score among drivers with high accident records that was higher than the average for the general population. Powell et al also reported a correlation between extroversion and accident rate in a study of accidents among factory

workers. While the reported studies of extroversion and accident experience are relatively consistent in their findings, they suffer from the same flaws as the investigations of other personality traits.
A different approach to studying personality as it relates to accident experience has derived from the general postulate that accidents are a function of life style or adjustment. Tillmann and Hobbs (1949) studied two groups of taxi drivers, one with a high accident rate and one accident-free, matched on a milage basis. The high accident drivers were found more often to have a self-reported history of aggressiveness in childhood, truancy and disciplinary problems at school, dismissal from previous employment, admitted dishonesty at work, and frequent absence without leave during military service. A well-controlled but small sample study by Wong and Hobbs on brewery workers conducted in 1949 produced similar findings. The high accident workers were found more likely to have had dealings with the juvenile courts, courts dealing with offenses other than driving violations, the social service organizations, pawn offices, and the public health offices. These differences were not compared statistically because the two samples were very small, involving only 17 cases each. Nevertheless, the differences in the raw data were distinct enough to lead the authors to conclude that the high accident group, unlike the low accident group, was marked by "evidence of aggression and intolerance of restrictions placed upon its behavior by family, society and superiors at work." Harper (1968) supported this view that people work as they live by providing data suggesting that high accident experience workers in a machine shop had more accidents at home than their low accident co-workers.

Attitudes - A considerable amount of work has been done, particularly since the early 1950's, in attempting to relate workers' attitudes toward the various aspects of their jobs to accident experience. The theory, or more accurately the assumption, underlying this work is that dissatisfaction and negative attitudes distract the worker's attention from his job and cause him to miss danger signs. It is also assumed that such negative attitudes may cause workers to adopt unsafe work practices because they either refuse or cannot be bothered to obey the rules.

A number of studies have found significant correlations between workers' attitudes and their accident experience, but interpretation is confused by many of the same methodological limitations that have plagued the work on personality variables in accident causation. In one of the better pieces of work in this area, Davids and Mahoney (1957) administered a job attitude questionnaire to a group of high accident and a group of no accident factory workers matched for age, sex, education, intelligence, and exposure to hazard. They found a highly significant correlation between high accident experience and negative attitudes towards employment. Harper and Kalton (1968) also found a significant correlation between high number of accidents and "low morale" among coal miners.

Morale was measured by a single question which asked the miners if they thought they could find a better or worse job outside the mines.

Less direct evidence of a relationship between attitudes and accident experience has been found in studies by Kerr (1950) and Keenan, Keer & Sherman (1951). Both of these studies compared the accident rates of different departments in an automotive plant with ratings on such factors as degree of manual work involved, comfort of shop environment, promotion prospects, team cooperation, quality of supervision, etc. They found that the departments where most accidents occurred were those in which there was no possibility of promotion as judged by the raters. The departments wherein the accidents were most severe were those in which the chances of promotion were judged to be slight. The authors concluded that a source of accident causation lay in the dissatisfaction of the work force as evidenced by the poor promotion prospects. This dissatisfaction was inferred by the authors from the ratings of the independent judges; the inference may or may not have been valid. A more serious flaw in the study lay in the fact that no effort was made to equate risk. Neulch et al (1957) found that German factory workers who had previously been employed on better jobs than those they held at the time of inquiry had higher accident rates than their coworkers on the same jobs. As in all the studies in this area, it is impossible to draw any sound conclusions of cause and effect. Dissatisfaction and negative attitudes appear to be related to accident experience, but they could just as likely be a reaction to having had accidents as a predisposing or causative factor.

Researchers in a number of different countries have studied the relationship between attitudes toward coworkers and group cohesiveness and accident rate. Speroff and Kerr (1952), for example, found a correlation of - 0. 54 with popularity and accident rate among workers in a steel mill. The studies of Mertens de Wilmar (1967) which are frequently referred to in the safety literature also suggest a relationship between interpersonal attitudes among workers and safety on the job. He investigated group cohesion along with group attitudes toward safety, productivity and knowledge of safety rules and principles among German coal miners. He found the groups with the lowest accident experience to be the ones with the highest cohesion and the strongest positive orientation toward safety as opposed to production. Significantly, though, the groups with high cohesion and strong orientation toward production were safer than the groups with low cohesion and strong orientation toward safety.

Hill and Trist (1953) considered relationship between steel workers and their company in a study of absence and accidents. They found that accident repeaters had significantly more unsanctioned absences than their accident-free coworkers and inferred a negative attitude toward the company as common to the accident repeaters. Again, however, the question of cause and effect must be raised. Castle (1957) repeated this study in a photographic processing plant, but failed to replicate the results.

Several studies have considered attitude toward risk and risk-taking behavior as important factors in accident causation. The study by Harper and Kalton (1968), referred to previously, demonstrated that accident rate among coal miners was correlated with how dangerous the miners perceived the work to be. This finding that workers with high accident records judge their job risks to be greater than do workers with low accident records has been supported in studies by Robaye et al (1963) and Spaltro (1967). Robaye showed his subjects a series of pictures depicting work situations and asked them to estimate the risks involved in each. He found that subjects with high accident records judged the risks in the various situations depicted in the pictures to be greater and that they experienced the situations more often than did the subjects with low accident records. The accident repeaters also underestimated the frequency and severity of injuries which could result from the situations.

In another effort to relate attitude toward risk and accident experience, Molitor and Mosinger (1967) administered a questionnaire to steel workers which asked the subjects to rate a series of items having to do with fire on a scale of desirability. The items ranged from sparks to atom bombs. Their results showed the accident repeaters had low fear scores on the scale while accident-free workers had either very high or very low ones.

Rockwell (1967) conducted a series of studies of risk-taking behavior using a task simulator. He found that accident repeaters took greater risks on the simulator than did workers with low accident records. Merz (1967) obtained similar results with steel workers in Luxembourg. Rockwell also found that the subjects' judgment of risk was not directly related to hazard as measured by performance capabilities. This finding is similar to that obtained by Cohen et al (1956) in their studies of performance capabilities and risk taking by bus drivers.

The research evidence produced so far would seem to suggest that attitude toward risk may be a factor in accident causation, but the exact nature of the relationship is still unclear.

The element in the work situation that has been considered most in conflict with safety is the management emphasis on production. It is not surprising, then, that this assumed conflict has been a focus of attitudinal research. Schlag-Rey et al (1961) in a study of French coal miners observed that the majority of the workers included believed that safety acted as a limit on productivity. Faverge (1967), in one of the studies commissioned by the European Coal Community, studied work methods in both French and Belgian coal mines. He observed that the safe method of timbering in coal mining was used only when it involved little more time and effort than the unsafe method.

Results of Field Visits

Almost simultaneous to the conduct of the literature review, the three members of the study team made observations of roofers at work on a variety of sites. These observations were made at about 15 work sites that are representative of the varied types of roofing construction done in the Los Angeles area. Job analysis sites included residential and commercial new construction of both the high rise and low rise types as well as re-roofing of older structures. Observations were restricted to roofing jobs that involved the application of hot composition materials including asphalt and coal tar pitch.

In addition to job site observations, interviews were conducted with roofers, their foremen, members of roofing company management and union leaders. These interviews and job site observations were made to determine the nature of the work conditions, hazards, company variations, safety and supervisory practices that appear or are believed to influence the incidence of roofer accidents. From these observations and interviews, hypotheses regarding the psychological and behavioral characteristics that might account for differences in accident experience among roofers were developed.

The research team noticed very quickly that roofers seem to take needless risks at many job sites, and in many cases violated many consensus safety standards for roofing . For example, falls from roofs represent one of the most serious roofing accident risks in both severity and frequency. Nevertheless, workers would often not cover roof openings, tie down ladders, or use guard rails on roofs as required by OSHA. A very controversial OSHA regulation regarding the requirement of guard rails on the roofs of one story buildings has been both sustained and overturned in different Federal Courts and has not yet been resolved in the appeal process. California safety regulations and union contracts require either roof perimeter warning lines or "headers." (Headers are roofing material strips laid parallel to the roof edges prior to laying the rest of the roofing material.) Apparently these measures have not been strictly enforced by safety inspectors or by union personnel.

In many large commercial construction jobs, the general contractor is supposed to have the guard rails installed and roof openings covered prior to the starting date for roofing operations. If these measures are not performed, the roofing contractor and/or the roofers assigned to the job are tempted to proceed without these safety measures, avoiding costly delay. Significantly many roofers on the job were apparently unconcerned about whether these and other safety precautions were performed. In many cases, roofers and contractors alike tended to minimize the importance of such measures. Some men were convinced that installing guard rails actually increased the likelihood of a fall because of increased worker exposure during the guard rail installation process. In summary, considerable controversy existed about fall protection or fall prevention measures among roofers and contractors who were visited on the job.

Perhaps even more significant was the varied behavior of individual workers in regard to wearing protective clothing. Workers, when questioned about safety hazards, were most likely to mention hot asphalt burns which undoubtedly represent the accident type with the highest frequency, especially if one includes all the unreported burns incidents. Many of these cases cause lost time and require first aid, but the worker can continue working on the same day.

Despite the awareness of the burn hazard, we often saw workers on the job mopping or carrying a bucket of hot asphalt at 450 degrees F without gloves, with no shirts or wearing short sleeve shirts. Getting a tan or keeping cool was a stronger motivation factor than the risk of incurring a burn injury. The risk and/or potential consequences of such behavior tended to be minimized by the workers in our informal conversations with these workers. For examples, workers with fresh undressed small burns on the job would typically deny that the fresh wound bothered them in any way. In fact some workers seemed to be rather proud of their burn scars and seemed to enjoy showing them off.

Obviously there are some elements of this behavior that seems to coincide with a role concept or worker self image of "manly" behavior which includes a general disdain or disregard for safety measures. Undoubtedly this behavior is socially reinforced on some roofing crews. A number of roofers, union officials, and contractors described roofers like one man who said roofers are a "hell-raising, hard-drinking bunch." The use of drugs or alcohol on or off the job was not investigated in this study, but it was often mentioned in informal conversations by roofers.

In contrast to the above behavior, we visited a few job sites in which there was a definite concern for safety. These job sites were neat and orderly, equipment well maintained, protective clothing was worn, etc. The best sites we happened to visit were very small non-union contractors with excellent safety records who operated only one crew who had worked together for many years.

Ironically, the worst sites we visited were also small, non-union contractors with the worst insurance rates and accident records. In fact, most union personnel and some contractors agreed that many of the contractors with the worst safety regulations were the smaller non-union contractors. To some extent the insurance rate modifiers tended to substantiate the observation that the smaller the firm, the higher the insurance rate, with the notable exceptions being that a few small firms also have the lowest insurance rates.

It was interesting to the research team that some contractors, especially contractors with union workers, complained that they could not enforce safety rules on the job. They complained that the roofers would not follow the safety rules and were always stealing the first aid kits and fire extinguishers from the job sites, obviously indicating a complete lack of concern about safety on the part of the workers. In addition, several selected union officials in private conversations pointed out it was bad politics to stress safety in union meetings if one were to win an election in the local. On the other hand, union roofers almost universally complained that contractors "didn't give a damn" about safety and worked men at an excessive work pace, but we never observed such a situation. During the study the investigators met many roofers, roofing contractors, union officials, and apprentice personnel who were genuinely disturbed and concerned about the safety problems, but nearly all agreed that the concern for safety needed desparately to be increased in the industry.

The above observations were not derived from a scientifically representative sample of job sites or interviews with contractors or roofers. Nevertheless, the direct observation of work and the informal discussions with various parties helped the investigation team recognize safety problems and issues useful in preparing the test batteries, the worker interviews and the filmed observations.

Characteristics Selected for Study

The following characteristics of sensory-motor behavior, cognitive process, personality, attitudes, and adjustment were isolated for investigation on the basis of conclusions derived from the literature review and the job safety analysis:

- Sensory Motor Behavior
  - Balance or ability to maintain equilibrium
  - Visual acuity
  - Auditory sensitivity
  - Eye-finger and eye-hand coordination
  - Simple Reaction Time
  - Choice reaction time
  - Relationship between performance speed and accuracy

- Cognitive Process
  - Adaptability
  - Short-term memory
  - Ability to make quick decisions
  - Assessment of risk vs. consequences
  - General intelligence

- Personality
  - Reflectiveness vs. impulsiveness
  - General activity level
  - Emotional stability
  - Introversion vs. extroversion
  - Ascendency vs. submissiveness

- Attitudes
  - Work itself
  - Working conditions
  - Supervision
  - Co-Workers
  - Work pace
  - Hazards
  - Risk taking
  - Company
  - Union
  - Security

- General Life Adjustment
  - Marital stability
  - Family size
  - Employment stability
  - Relationship with agencies of law enforcement
  - Living conditions
  - History of nonwork accidents

- Accuracy of Perception of Danger or Risk
  - Accident Frequency
  - Accident Severity

A more detailed description of each of the characteristics in the above list, are presented with a justification for its inclusion in the study in the following paragraphs:

- Sensory Motor Behavior
  - Balance - A study of job-related injuries in roofing and sheet metal work by Jones for the California Department of Industrial Relations which was published in 1972 indicated that falls and slips are "responsible for more injuries suffered by workers in the roofing industry than any other single type of accident." This study further observed that loss of balance is a critical factor in disabling accidents in the roofing industry due to the roofers' frequent use of ladders and temporary scaffolding, not to mention the elevated surfaces on which they habitually work. Our own field observations corroborate the importance of balance in roofers' work

  - Visual Acuity - The visual task involved in roofing is admittedly not very demanding, since it is performed under ample illumination and requires little or no training or specialized visual skills, but it is critical to safe performance on the job.

  - Auditory Sensitivity - Eighteen percent of roofing accidents as summarized by Jones (1972) are attributed to workers being struck by or struck against some object. A relatively large proportion of these accidents involve workers being struck by falling objects, such as dropped tools, discarded roofing materials, etc. To the extent that some of these "struck by" accidents are preceded by shouted warnings, a roofer's auditory sensitivity may influence his accident rate. Older workers in particular may suffer from undiagnosed hearing impairment. At least one foreman interviewed in the field mentioned a worker's inability to hear shouted instructions over a reasonable distance as a factor that could influence his job performance and safety.

- Eye-Finger Coordination - Jones (1972) implicates the use of hand tools (saws, axes, hatchets, knives, etc.) in a large proportion of roofing accidents. Our own field observations revealed the hazard associated with the razor blade knives used by roofers to trim roofing paper sheets to fit irregular roof openings. Injuries to fingers in particular were cited by workers we interviewed as attributable to reaching for or using trimming knives usually worn in holsters, belts, or pockets. The use of such tools requires fairly accurate eye-finger and eye-hand coordination, particularly when careful trimming must be done in proximity to fingers that are holding a piece of roofing material in place.

- Choice Reaction Time - a roofer may be able to prevent an accident if he is able to respond rapidly and correctly to an immenent hazard. If a bucket of hot asphalt is seen falling, for example, a roofer may be able to avoid scalding if he can decide how to move himself from its path by one of a number of safe or unsafe routes. This ability to avoid an accident depends not only upon motor capacities, but also upon decision making capabilities. There is also a modicum of evidence (e.g. Laurer et al, 1952) that choice reaction time may be related to error rates in certain industrial tasks.

- Performance Speed vs. Accuracy - Profitability for roofing companies, particularly small ones, depends principally upon minimizing labor costs. Strong pressures are therefore exerted on foremen to encourage workers to work as rapidly as union rules will permit. It is commonly observed that accuracy of skilled performance is inversely related to speed of performance. If inaccuracy in the manual skills involved in roofing is associated with accidents, as seems intuitively reasonable, a test of workers' inclination to be careless to achieve speed may offer some predictability of accident rates.

- Cognitive Performance

  - Risk Preference - Much roofing work is repetitive and tedious. A busy apprentice servicing a number of journeymen may find himself climbing a ladder with a hot mop or a tar bucket several times in the space of a few minutes instead of using a rope hoist.

Temptations on the job, especially under production time pressure, cause men to take hazardous shortcuts, such as trying to carry too heavy a load, attempting to carry too many tools or materials, or running with a bucket of hot asphalt. The roofer must, therefore, balance the risk associated with the hazardous shortcut against the payoff in reduced workload.

- Transfer of Training and Reversal Learning - Roofers typically work for short periods of time (measured in days or weeks at most) at a given site, using different materials at different job sites, and performing different tasks under different circumstances. Thus, both the jobs the workers perform and the materials and methods of application that they employ are continually changing. Controls on the machinery that they use are not well standardized. For example, the gas valves may be dissimilar on a number of frequently used tar kettles. Even experienced workers must, therefore, be able to switch frequently from one set of skills to another. To the extent that confusion over similar skills associated with different materials or tasks can be implicated in accident causation, tests for reversal learning and transfer of training may be important in discriminating between low and high accident rate workers.

- Short-term Memory and Preceptual Span - A roofer working at a particular task may be interrupted frequently for any of a number of reasons. For example, he may run out of hot material, he may be called to help another worker, or the foreman may stop work to issue warnings or other instructions. After each interruption the roofer must resume work where he left off. Safe resumption of work may require the roofer to recall how hot a piece of material is, estimate how rapidly it may have cooled, remember where knives or other hand tools have been placed, and so forth. These requirements depend, in part, on the adequacy of the roofers' short-term memory.

- General Intelligence - Few significant relationships between industrial accident experience and intelligence have been found, and those that have been identified have involved complex tasks such as flying an airplane. Nevertheless, it is a factor that must be controlled or accounted for in any study of group or individual differences in the performance of complex behavior.

- Personality

  - Reflectiveness vs. Impulsiveness - This dimension of personality might be defined in other words as the degree to which the inddividual exercises personal discipline and self-control. Given the overwhelming frequency with which the term "carelessness" is used by roofers and their supervisors to explain the cause of accidents, it was determined that the differences between high and low accident experience roofers in the degree to which they interpose thought between stimulus and action should be explored. In other words, the degree to which roofers think of the consequences to their actions as opposed to responding impulsively may directly affect their accident experience. As implied above this conclusion is based on the empirical observations of the investigators and men working in various capacities in the roofing industry; it has not been investigated in the literature.

- General Activity Level - Again, based on observation and discussion with workers, extreme hyper or hypoactivity would appear to be a potentially significant source of accidents. Hyper and hypo active persons tend to be out of pace with their co-workers, and this could be significant as roofing is largely a coordinated group function. Hyperactive workers tend also to over react to foreman speed up exhortations or potential danger situations and possibly thereby cause or incur an accident in their excessively aroused state of mind.

- Emotional Stability - Tension, anxiety, emotional stress from any source can be and frequently is a source of distraction, or a barrier to concentration on the task at hand. This dimension is one of the few that has found support in the literature as an accident correlate. (Smiley, 1955; Smart and Schmidt, 1960; Tiffin and McCormick, 1962; Whitlock and Crannell, 1949).

- Introversion vs. Extroversion - In a group or team task, ability or inclination to relate to people on the part of the individuals who make up the group influences the integrity and cohesiveness of the work group. This is a variable of seeming importance to job safety in roofing because the individual roofers depend greatly on their co-workers to warn them of danger and generally to look out for them. Of interest also is the extroversion extreme of this dimension with its connotation of exhibitionism and the general lack of control and inhibition it implies.

- Ascendency vs. Submissiveness - The ascendency extreme of this dimension is associated with extreme independence and resistance to authority, a potential source of conflict in the group and therefore a source of distraction. It may also be reflected in a refusal to follow procedures and policy, for example a refusal to wear safety equipment. The submissiveness end of this dimension may be associated with a willingness to perform unsafe acts as directed by superiors rather than refusing or protesting.

- Attitudes

As indicated previously, worker attitudes toward certain aspects of their jobs and work environment and their job satisfaction in general have been found to relate to accident experience. Whether or not such a relationship does in fact exist is questioned because of the methodological flaws with which research in this area has been fraught. None the less, an assessment of roofers' attitudes toward certain important aspects of their job and their satisfaction with roofing in general was included in this study in an effort to gain insight into the nature of the work as perceived by the roofer, and to identify and isolate for further investigation specific attitudinal variables of potential significance in accident causation. The specific attitudinal variables included in this study are as outlined on page 3-12.

- General Life Adjustment

It has been asserted that accidents are a symptom or reflection of life style or degree of social adjustment. Those gross measures of adjustment that have found some support in the literature were included for investigation in this study. If the assumption that people work as they live is valid, and if a lack of domestic harmony reflects a general inability to cope, then a higher frequency of divorce and separation might be expected among high accident roofers than among their low accident counterparts. Similarly, a history of difficulty with the law and dismissal for cause from previous employment might more likely be expected among the accident repeating roofers. It might be expected also that high accident roofers will have a greater frequency of accidents in the home or away from the job than low accident roofers. If, as commonly believed, the owning of a home is evidence of permanency, stability, and defined goal or direction in life, then home ownership might be more common among low accident roofers.

- Accuracy of Perception of Danger or Risk

As indicated earlier in this report, a number of studies have obtained results which suggests that accident repeaters are inclined to judge their work as involving greater risk than are their low accident co-workers. This subjective estimation or valuation of risk is of interest, but a variable of seeming greater significance in industrial accident causation is the real accuracy with which workers perceive the dangers and hazards to which they are exposed. It would seem reasonable to to assume that accurate perception of the risk or danger associated with the work would reflect a degree of reflectiveness and conscious attention to the task at hand that would be to some extent incompatible with the "carelessness" that is a most commonly attributed cause of roofing accidents.

Test Hypotheses

Any hypotheses concerning the above characteristics, identified as potentially significant in roofing accident causation, must be based on an assumption regarding the validity of the concept of accident proneness. If the assumption of accident proneness as a stable and enduring human characteristic is rejected, it should be hypothesized that the two groups of roofers examined in this study do not differ significantly on any of the dimensions described above. On the other hand, if the assumption of accident proneness as a permanent trait is accepted as possibly valid, then the literature and the results of the job analysis would support the expectation that the high accident experience roofers would evidence one or more of the following attributes or tendencies in contrast to their low accident experience co-workers as listed below:

Psychological

Psychological attribute hypotheses for high-accident experience roofers:

- Greater impulsivity and less restraint and personal discipline.
- Negative attitude or orientation toward people as reflected in such traits as intolerance, hostility, hypercriticalness, uncooperativeness, beligerance, seclusiveness, etc.
- More dissatisfaction with roofing as a job and negative attitudes toward the various aspects of the work and the environment in which it is performed.
- Poorer social adjustment as evidenced in a greater incidence of divorce, job dismissal, difficulty with the law, etc.
- Less accuracy in the perception of risk associated with roofing work.

Behavioral

Behavioral, sensory-motor performance hypotheses for high-accident experience roofers:

- More likely to have one or more gross defects in hearing, vision or balancing ability.
- Poorer eye-finger coordination.

- Slower decision time relative to motor response time in choice reaction test.

- More likely to choose speed rather than accuracy in speed-accuracy trade-off test.

- Poorer short-term memory performance.

- Greater tendency to "gamble" or choose higher-risk alternatives in risk preference test.

- Poorer reversal learning.

Selection of Test Instruments

The objective of the testing program was to determine if measurable differences could be established between the high and low accident experience roofers on the behavioral and psychological characteristics hypothesized as critical in accident causation. In selecting tests for inclusion in the batteries, the following principles were emphasized:

1. High reliability in terms of test and retest repeatability.

2. Validity in terms of applicability to the hypothesized skills and characteristics.

3. Standardization in terms of availability of performance information on reference populations.

4. Economy of administration in terms of both time and equipment.

Sensory Motor/Performance Battery

- Equilibrium Duration Test

  Subjects were asked to stand erect with one leg bent at the knee, both eyes shut, and arms outstretched. A stopwatch was used to record the duration of the period that subjects were able to maintain the stance before returning the second foot to the ground. The test was repeated with the alternate leg after a short rest. An equilibrium duration test was selected from a number of potential measures of gross balancing ability primarily for pragmatic reasons. First of all, it requires no special apparatus to be transported from site to site. Second, it is easily scored and requires no extensive instructions to workers. Third, it can be quickly administered and it is not sensitive to experimental or learning artifacts as are certain balance tests that utilize specialized apparatus.

- Visual Acuity Test

  A standard Landolt Ring Test, utilizing broken circles with slits oriented in random directions, was administered to workers individually to assess gross visual acuity. The reader is referred to Geldard (1972) for a discussion of the superiority of this technique over the more familiar Snellen Letter Charts. Administration of the Landolt Ring Test requires only a readily transported chart and tape measure to insure the targets subtend a five degree angle at the subjects eye. (See Figure 3-1)

- Auditory Sensitivity Test

  Minimum audible hearing levels were measured for pure tone frequencies, 500-4000HZ, utilizing a portable type audiometer (Zenith, Model No. ZA-110T). The test sounds were presented by earphones to the left and right ears of each subject in a closed room. While no ambient measures were taken, this test environment was believed to be reasonably quiet for defining any significant elevations in hearing thresholds. (Figure 3-1)*

- Eye-Finger Coordination Test**

  Using specially designated testing apparatus, Figure 3-1, subjects were instructed to press the response buttons of each hand corresponding to the illuminated lights immediately above them. The number of lights illuminated on each trial varied at random from one to four, depending on experimental conditions. Fifty trials' practice with a standard display condition was required before data was taken. Twenty-five trials were administered in each of two display conditions. The measure of performance was timed (to the nearest millisecond) from the onset of a display to depression of the correct combination of response buttons.

- Choice Reaction Time Test**

  Subjects were first instructed to press a response button immediately upon seeing a display light flash. Thirty trials were administered at a fixed pace of approximately one every two seconds. The measure of performance was average elapsed time on correct trials. As a second test condition, subjects were required to make the identical response contingent upon the presence of a second display light. False alarms (responses made in advance of signal) and misses (responses made in the absence of the confirming signal) were tabulated. The two measures of performance under the second condition were number

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**The tests so marked with the double asterisks required special test apparatus described on page 3-22.

of correct trials and average elapsed time on correct trials. The above procedure permits rough estimation of the motor and decision time components of reaction time. The average choice reaction time minus the average simple reaction time gives some indication of decision time.

- Speed Accuracy Trade-Off Test**

Subjects were instructed to alternately depress response buttons beneath each index finger. The number of depressions with the same finger before alternation was determined by the number of lights illuminated. After the first depression of the left-hand button, a single light was illuminated to cue the depression of the right-hand buttons. After the right-hand button was depressed, two depressions of the left-hand button illuminated a second light, to cue the depression of the right-hand button twice, and so forth. In general, increasing numbers of successive repetitions of response sequences were required before the next higher number of display lights was illuminated. The measure of performance was elapsed time from the start of an alternating sequence to its conclusion.

Cognitive Performance Tests

- Short-Term Memory and Perceptual Span Test**

Subjects were instructed to press buttons corresponding to illuminated lights in a delayed paradigm. Lights were illuminated after which subjects were required to produce the pattern of lights with their response buttons. The measure of performance was the total of correct trials out of a sequence of 20. As a second test condition, subjects were exposed to a similar display, but were not permitted to respond until a 10 second waiting period had elapsed. During the waiting period subjects were required to sit with fingers crossed to preclude overt motor response rehearsal. The measure of performance was total number of correct trials out of a sequence of 10.

- Risk Preference Test**

Subjects were instructed to depress one of four response switches to extinguish a light. The four switches were associated with probabilities of 1.0, .50, .25, and .125 of extinguishing the light. Points awarded for extinction of the light varied inversely with the probabilities, yielding a constant expectation for all of the buttons. The choice of buttons was therefore governed by a worker's risk preference rather than his expected gain. The risk preference was measured by dividing the worker's score by the number of times the light was extinguished in a set of 100 trials. The resulting scale revealed the average risk level assumed by the worker.

- Transfer of Training and Reversal Learning Test**

  The general conditions of this test were similar to those of the short-term memory test. The two major differences were that subjects were instructed to depress response buttons corresponding to non-illuminated lights, and that the assignment of columns of lights to hands was reversed. No practice trials were permitted.

- General Intelligence Test

  The SRA Nonverbal Test, a measure of general intelligence, was selected because of its nonverbal format which makes it relatively free of cultural bias; its brevity which facilitates administration; and its standardization on relevant populations. The test was designed as a measure of general intelligence among people with less than high school education or some language handicap. Its format presents a series of tasks of increasing difficulty involving the perception of relationships which are expressed pictorially. It is a paper and pencil standardized test, and as such, is suitable to group administration.

Sensory-Motor and Cognitive Performance Special Test Equipment

- Many of the sensory-motor tests noted in the previous section required the construction of special test apparatus. The Bolt, Beranek and Newman engineering staff, under the direction of Dr. Sanford Fidell, designed and built the field portable apparatus shown in Figures 3-2 and 3-3. The equipment, except for the power supply, is contained in a metal suitcase and can be operated from an electrical power supply unit or batteries.

  This test apparatus contains over 200 integrated circuits and about 3,000 wire-wraps. The equipment is self-scoring which means it internally determines the number of correct versus incorrect trials, and contains a digitized, millisecond timing clock. The calculator section automatically calculates means and standard deviations of performance scores.

  The subject side of the test unit contains a light display consisting of two vertical columns of four lights each (see Figure 3-2). Beneath the columns of lights are two sets of four response buttons, one for each hand. The other side of the suitcase, for the test technician, contains the switches and counters necessary to initiate and score trial sequences and the answer displays from the digital clock and calculator section. The logic for the apparatus was built completely with integrated circuitry requiring no mechanical or moving parts.

Personality Test

- The Guilford Zimmerman Temperament Survey

After reviewing the various personality investories available on the market in terms of the applicability of their scales to the characteristics hypothesized as critical in roofing accident causation and their technical soundness, the Guilford Zimmerman Temperament Survey was selected for use in this study. The instrument is composed of 300 items descriptive of behavior, feelings, and motivation to which the subject agrees or disagrees as they apply to him. The test yields scores on 10 factors or dimensions of personality. These factors are listed below. Their similarity to the personality characteristics isolated for study in this investigation is evident in the descriptive titles.

Guilford Zimmerman Temperament Survey Test Dimensions :

- High general activity and energy vs. inactivity and slowness.
- Restraint, seriousness vs. impulsiveness.
- Ascendance and social boldness vs. seclusiveness.
- Social interest, socialability vs. shyness, seclusiveness.
- Emotional stability vs. emotional instability.
- Objectivity vs. subjectivity, hypersensitiveness.
- Friendliness, agreeableness vs. unreflectiveness.
- Cooperativeness vs. intolerance, criticalness.
- Masculinity vs. femininity

Attitude Assessment Instruments

- Interview Questionnaire

The subjects' attitudes toward and opinions about the various elements in their work environment, which were hypothesized as potentially important correlates of roofing accident experience, were assessed through a structured interview questionnaire. This questionnaire, a a copy of which is included as Appendix I at the end of this report, was designed specifically for this study to elicit the subjects' opinions, feelings and attitudes toward the critical elements in their job and work environment. It was administered to each subject individually by a psychologist in the privacy of a closed room.

- Projective Test

The subjects were shown sketches depicting the four most common roofing accident situations. These sketches, which were created

FIGURE 3-1

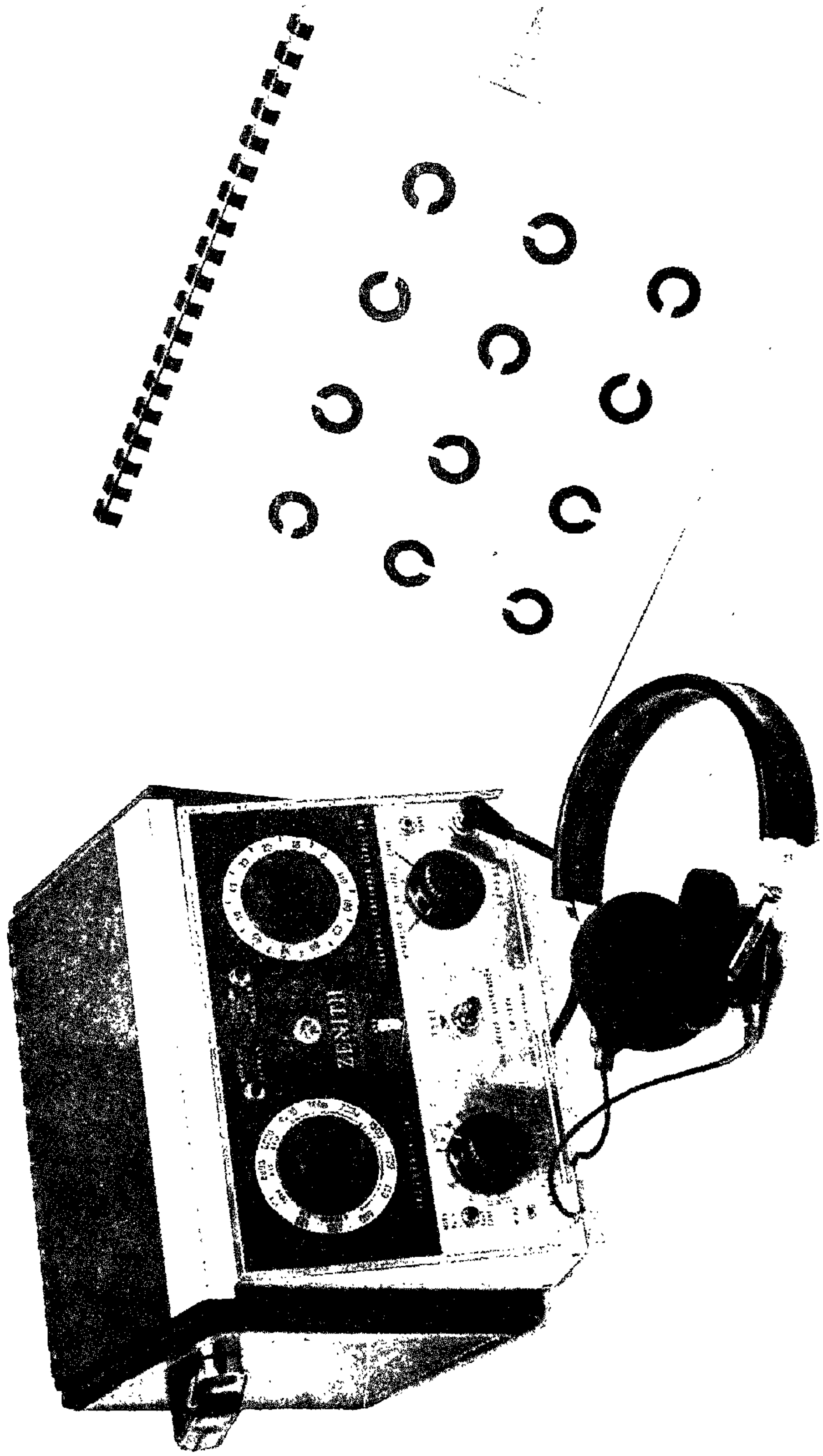
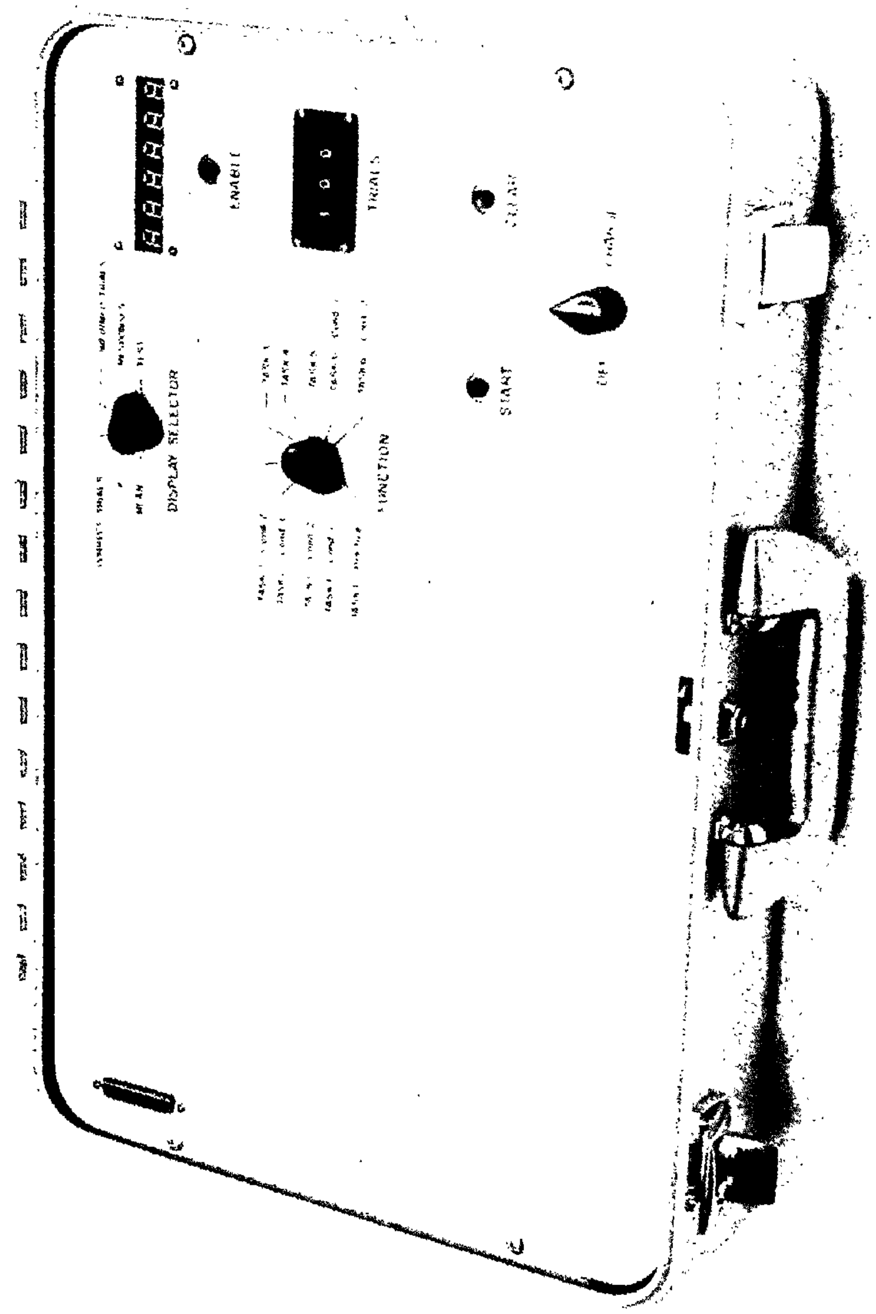


FIGURE 3-2

FIGURE 3-3



specifically for this study, respectively depict roofers in situations that are likely to produce burn, fall, strain, and struck-by accidents. Copies of the four sketches are included as Appendix IV at the end of this report. The subjects individually were asked to describe in their own words what was going on in each picture and the likely consequences. It was assumed that the subjects' responses would reveal information concerning their perception of and attitudes toward work-related hazards.

General Life Adjustment

- Interview Questionnaire

  Differences that might exist between the high and low accident experience roofers in their general life or social adjustment, as reflected in such factors as marital and work stability, were investigated through the Interview Questionnaire described above and included as Appendix I. The biographical questions relevant to this dimension are among the first questions of the Interview Questionnaire.

Accuracy of Perception of Danger or Risk

- Pictorial Ranking Test

  Subjects were given the four sketches depicting the four most common types of roofing accidents, as documented by the California accident data of 1970. These sketches were similar to those used as the projective test described above, and are shown in Appendix V. The subjects were asked to rank the sketches, first in order of their belief regarding the frequency of the four types of accidents depicted, and then in order of their opinion regarding the severity of the four types. The measure of accuracy of perception of danger on each test was the number of placements which were correct according to the California and New York accident statistics described in the last chapter.

Obtaining Test Subjects

Having developed a test battery protocol, another critical problem was selecting workers with high versus low accident records. The project director contacted both the roofing union and the local roofing contractor association which was composed primarily of contractors with union workers.

Initial skepticism on the part of both the union and the contractor associations was overcome after a series of personal meetings and presentations at regular member meetings. Then he wrote letters to all the area contractors and to all the union members in the largest union local briefly explaining the study. When he appeared at contractor association or union meetings he asked for volunteers.

The detailed process of selecting roofers was a delicate and frustrating task. We openly mentioned, in all worker and employer contacts, an interest in talking to roofers who had experienced several accidents because we wanted to obtain descriptions of how the accidents occurred. Similarly we mentioned our desire to talk to workers with few or no accidents to obtain suggestions on how to avoid accidents.

The first 83 workers tested were from Southern California and were nearly all union members. Most of these workers with high accident records were identified by our personal visits and/or telephone inquiries to local roofing contractors. Many workers also volunteered through the union. We announced the program at union meetings, sent letters to members through the union, and wrote articles for the union newspaper describing the study in general terms.

When we obtained the worker's name, address and telephone number, we called the worker at home in the evening. In the case of volunteers, we carefully asked the worker about his work and accident experience to see if the worker met our selection criteria. If so, the worker was invited to participate in the test battery and interview, which were usually conducted on Saturdays.

The 40 workers from three Northern California roofing unions were obtained with the volunteer assistance of the local union business agents. They explained the project at their union meetings, asked members to fill out accident and experience surveys. From that data we selected the men who we wished to contact. We contacted the men by telephone at home and conducted a confirming screening interview. Then we asked the men to participate in the interviews and test battery.

We feel our accuracy in identifying the worker's accident history was reasonably good, especially for high accident record workers. We had almost no unverified volunteers in the high accident record category, because it was easier to obtain data on accident repeaters from only several years of company accident data.

However, selecting workers with low accident records is more difficult if they have worked many years. Most studies of this type select high accident record versus non-high accident record subjects. In the case of an approximate 0.1 emperical probability of a roofing accident per year per worker in California, the worker with one or more accidents in one year can be considered to have incurred a high accident record with a chance probability of 0.1 (10 percent) or less. However, workers with no accidents share a chance accident probability of 0.9 which cannot be considered to be a "low" accident record. A worker must work for about 23 years without an accident to have a chance probability less than 0.1 (10 percent) if the annual probability of an accident is 0.1. Hence, we had to rely more on the honesty of the worker in regard to his accident record if he had 30 years of roofing experience, because we could not easily verify an accident record with present or former employers for that period of time. Such an employee might have worked for more than 30 employers over that period of time.

Statistical Selection Criterion

From the previous brief discussion of high versus low accident record probabilities, one can see that an accurate statistical selection of subjects for the test battery is a difficult project. Ideally, one would gather empirically the accident and job experience data from the population and determine empirically the high and low accident record categories of the population.

We tried, several times, to get a random sample accident experience survey stratified by either age or total job experience from the union locals membership with whom we were working. Unfortunately, we were unable to persuade the union locals to let us perform these surveys or for the union locals to conduct the surveys themselves. The union officials were reluctant for us to have access to their membership roster.

Union officials were willing to let volunteers fill out the surveys anonymously at union meetings so we tried this approach. Unfortunately, only workers with self-claimed, accident-free work records voluntarily filled out the forms. Hence, we finally abandoned the idea of obtaining an empirical accident record distribution based on the accident records of the union membership in the locals from whom we were selecting men for the test battery.

The next best approach was to assume the classical probability distribution that has been observed almost universally to closely fit empirically observed accident data. This distribution is named the Poisson distribution and among accident data analysts, is often called the pure chance distribution. This distribution assumes the following:

- That the probability of an accident is constant over time for all workers.

- The probability of an accident occurring is completely independent and unrelated to the number and timing of any previous accidents.

Then, the probability of x number of accidents in time (t) can be expressed:

$$P(x,t) = \frac{e^{-rt} rt}{x\,!}$$

Where x	=	Number of accidents 0, 1, 2, 3....
r	=	Average accident rate (accidents per unit of time)
t	=	Time period
e	=	Constant (approximately 2.7)

In tables "rt" is usually expressed as "λ" in increments of 0.1, 0.2, 0.3, etc. Hence, we derived the table shown in Exhibit 3-1 as follows:

Total 1970 average employment in California Roofing Industry	=	9,800 workers
Number of lost time injuries in 1970	=	1,132 injuries
Average number of accidents/worker/year, r	=	$\frac{1,132}{9,800}$
$\therefore$ r	=	0.116

Then let $r \simeq 0.1$ (accident rate per year)
Let t = 1, 2, 3.... (years of experience)

t = 1, rt = 0.1
t = 2, rt = 0.2
t = 3, rt = 0.3

o
o
o

Hence, we used the commonly printed textbook Poisson table for our selection criteria as shown in Exhibit 3-1.

Purists can argue that the above Poisson derived table, does not fit our union roofer population because:

- High worker turnover favors retaining workers in the work force with good accident records if for no other reason than workers who are killed and permanently disabled are removed from the work force.

In addition, an accident occurrence encourages temporarily disabled workers to leave roofing to find an easier or safer occupation. Also, employers attempt to eliminate workers with high accident histories from their work force.

- The union roofer is the more stable permanent worker who is presumably better trained and supervised in the roofing trade when compared to the non-union worker. Hence, the accident rate is likely lower for union versus non-union roofers.

- The accident rate is not stable over time as seen by the California monthly accident rates nor is the annual average accident rate constant over a number of years. (However, the annual accident rate has been relatively stable for all the years we could find data.)

- Workers are not exposed to equal hazards over time. Some company accident rates are consistently higher than others for long periods of time.

Despite the above reasons, we felt the selection table was a reasonable approximation of chance probabilities of accident occurrence per years of experience. Thus we used 20 percent upper and lower limits on the distribution as shown in Exhibit 3-1.

However, as mentioned in the previous section, we immediately encountered the problem that the table by definition would not define a worker under 34 years of age (18+16 years of experience) as having a low accident record. This presented a problem for the sensory human performance tests which depended on various kinds of reaction times which are normally age dependent. Thus, we ended up selecting balanced age groups under 34 years of age (or 16 years of experience) as having "low" accident records. Otherwise workers were selected according to the table.

Seventy-six of the 123 workers selected met the selection criteria as defined by the Poisson table 20 percent limits. The other 47 workers were primarily workers under 35 years of age without a lost-time accident selected to balance the high accident records of workers who were also under 35 years of age. We tested three extra workers over the required 120 because the marginal cost of testing three extra men on our last testing day was small and we wanted to be certain of having valid test results on 120 men in case some subject was rejected from the sample. See Table 3-1.

Despite our best efforts to stick to the selection criteria above, there were a few selection deviations. For example, we tested a few union officials whether they met the selection criteria or not as a means to enlist their cooperation and support in obtaining other volunteers. These union leaders were instrumental in reducing the apprehensions of union workers who we had identified and contacted for participation in the test batteries. We also tested a couple of men by mistake, and their test results were discarded unless their accident records were either reasonably high or low.

A few workers who initially claimed to have few or no lost-time accidents over their work history in our initial screening interview remembered an extra accident occurrence in their test battery interview with the psychologist. These workers were asked to describe each of their accidents in detail in the test battery interview. Also workers with many admitted or known lost-time accidents (as known from a composite of company records) would tend to describe to the psychologist only about three accidents in detail and then claim not to remember any more accident occurrences. These accident record discrepancies between the full interview and our short screening interview caused us much concern at first, but all our double checking indicated that our initial screening interviews were nearly always accurate. Thus, we used the accident record data from the initial screening interview for selection and classification unless we knew otherwise about the worker's accident record from company data or other sources.

We tabulated the data in terms of high versus low accident record groups and for the extreme high versus low accident record groups (by the 20 percent criteria). The only problem with the extreme high versus extreme low accident grouping was a definite age bias in the low accident category that almost eliminated men under 35 years of age in the extreme low categories as explained above. These distinctions and groupings turned out to be rather unimportant in terms of any differences in the test battery scores.

TABLE 3-1

	Low			High			Total		
Age	Number[1]	Average Experience[2]	Average # of Accidents[3]	Number[1]	Average Experience[2]	Average # of Accidents[3]	Number[1]	Average Experience[2]	Average # of Accidents[3]
18-35	21	4.4	0.13	28	5.4	1.61	49	5.0	0.92
36-50	27	22.8	0.59	19	12.9	1.79	46	18.7	1.09
51+	15	30.9	1.00	13	25.8	4.00	28	28.5	2.58
Total	63	18.60	0.52	60	12.2	2.18	123	12.2	1.32

1. Number of roofers tested with low accident records, etc.
2. Average roofing experience in years.
3. Average number of lost-time accidents during the entire roofing career.

ACCIDENT RECORD SELECTION TABLE - CHANCE DISTRIBUTION

PROBABILITY OF ACCIDENT = 0.1 PER YEAR

Years of Experience		Total Number of Accidents 0	1	2	3	4	5	6	7	8	9
1		.90	.10(1+)			Upper 20%					
2		.82	.16	.02(2+)							
3		.74	.22	.04(2+)							
4		.67	.27	.06(2+)							
5		.61	.30	.09(2+)							
6		.55	.33	.10	.02(3+)						
7		.50	.35	.12	.03(3+)						
8		.45	.36	.14	.05(3+)						
9		.41	.37	.16	.06(3+)						
10		.37	.37	.18	.08(3+)						
11		.33	.37	.20	.10(3+)						
12		.30	.36	.22	.09	.03(4+)					
13		.27	.35	.23	.10	.05(4+)					
14		.25	.35	.24	.11	.05(4+)					
15		.22	.33	.25	.13	.08(4+)					
16		.20	.32	.26	.14	.08(4+)					
17	Lower	.18	.31	.26	.15	.10(4+)					
18	20%	.17	.30	.27	.16	.10(4+)					
19		.15	.28	.27	.17	.08	.05(5+)				
20		.14	.27	.27	.18	.09	.05(5+)				
22		.11	.24	.27	.20	.11	.08(5+)				
24		.09	.22	.26	.21	.13	.09(5+)				
26		.07	.19	.25	.22	.14	.07	.06(6+)			
28		.06	.17	.24	.22	.16	.09	.06(6+)			
30		.05	.15	.22	.22	.17	.10	.09(6+)			
32		.04	.13	.21	.22	.18	.11	.11(6+)			
34		.03	.11	.20	.22	.19	.13	.07	.05(7+)		
36		.03	.10	.18	.21	.19	.14	.08	.07(7+)		
38		.02	.09	.17	.20	.19	.15	.09	.09(7+)		
40		.02	.07	.15	.20	.20	.16	.10	.10(7+)		
50		.01	.03	.08	.14	.18	.18	.15	.10	.07	.06(9+)

Administration of the Test Batteries

All of the tests in Southern California were administered on non-working days in the offices of Theodore Barry & Associates, or in comparable facilities. These facilities afforded sufficient room, quiet, light, and privacy, as well as optimal accessability for the subjects. The Northern California tests were given in two union office facilities similar to the TB&A offices.

The various behavioral tests were administered individually to the subjects by a trained technician. The interview questionnaire was administered to each subject individually by a psychologist, and the projective and pictorial ranking tests were given by a trained technician. The two paper-and-pencil tests, the Guilford Zimmerman Temperament Survey and the SRA Nonverbal Test, were administered to subjects in groups of up to five.

The order of administration of test conditions for the human performance test battery was invariant over workers. After preliminary auditory and visual screening tests and a short equilibrium duration test, the various tasks of the test battery were administered in the same sequence. Means and standard deviations were automatically computed and manually recorded for each worker's performance in the eye-finger coordination, reaction time, and reversal learning tasks. Mean times to completion were recorded in the speed-accuracy trade-off task; numbers of correct trials in the perceptual span and short term memory tasks, and numbers of successful trials and total points in the risk preference task. The test equipment rounded all response latencies to the nearest millisecond.

The numbers of workers who contributed valid data to the test battery tasks varied slightly from task to task. The inequality of sample sizes probably introduced no major biases in the data, since the variation in number was typically on the order of five percent. Among the reasons for failures to collect data were the starting of the data collection shortly before all of the tasks were operational, the inability of some workers to perform some of the tasks, and the failure to collect data under some conditions because of time constraints and mechanical problems of test administration.

CHAPTER 4

ANALYSIS OF DATA FROM PSYCHOLOGICAL AND HUMAN PERFORMANCE TEST INSTRUMENTS

PSYCHOLOGICAL BATTERY

The data derived from the personality and attitude assessment instruments were compared for the high and low accident experience groups. These comparisons were made between the two groups encompassing the entire sample of 123 roofers, as well as between the two extreme groups involving a total of 82 roofers whose accident or safety records met the pure Poisson statistical selection criteria as illustrated in Exhibit 3-1.

- Personality Tests

The mean scores of the high and low accident experience groups (total sample) on each of the scales of the Guilford Zimmerman Temperament Survey are presented in Table 4-1 below.

TABLE 4-1

Mean Scores, Guilford Zimmerman Temperament Survey
Total Sample

Scale	High Accident Experience		Low Accident Experience		
	M*	SD**	M*	SD**	t***
General Activity	17.65	5.48	18.33	4.62	0.74
Restraint	15.27	4.76	16.60	4.31	1.63
Ascendency	16.88	5.38	16.89	5.61	-
Social Interest	19.12	6.16	19.79	5.14	0.67
Emotional Stability	18.87	6.03	19.33	5.30	0.45
Objectivity	16.30	5.70	17.06	5.54	0.74
Friendliness	13.70	5.74	13.79	5.07	-
Thoughtfulness	17.67	5.20	17.11	4.59	0.64
Personal Relations	15.25	5.32	15.36	5.54	-
Masculinity	19.27	4.70	19.78	3.85	0.65

*Mean N High = 60 N Low = 63
**Standard Deviation
***Value of t for differences between means

In reviewing Table 4-1 it is clear that there are no differences of statistical significance between the high and low accident experience groups on any of the personality dimensions measured by the Guilford

Zimmerman Survey. The mean scores for the two groups suggest a slight tendency for the low accident roofers to exhibit greater restraint and control as well as greater emotional stability and a more positive and cooperative orientation toward people than their high accident experience counterparts; but none of these differences are of a magnitude that could be considered meaningful. The mean scores for both groups on each of these dimensions fall at or about the points that represent the median for the general population. In other words, there is no evidence of the personality extremes in either group that might be suggestive of aberrant behavior either on or off the job.

The above findings and conclusions are consistent with those that were obtained in the comparison of the two groups that represent the extremes of high and low accident experience. The mean scores of the two extreme groups, on each of the Guilford Zimmerman scales, are presented in Table 4-2.

TABLE 4-2

	High Accident Experience		Low Accident Experience		
Scale	M*	SD**	M*	SD**	t***
General Activity	17.55	5.65	17.89	4.29	0.34
Restraint	15.13	4.98	17.51	3.98	1.40
Ascendency	16.28	5.52	16.34	5.67	0.05
Social Interest	18.98	6.70	19.97	5.09	0.76
Emotional Stability	18.68	6.36	19.37	5.63	0.52
Objectivity	16.17	6.01	16.60	5.44	0.34
Friendliness	13.55	5.91	14.40	5.21	0.69
Reflectiveness	17.34	5.62	17.29	4.42	0.05
Personal Relations	14.85	5.66	16.60	5.25	1.49
Masculinity	19.36	5.00	19.20	3.80	0.16

*Mean N High = 47 N Low = 35
**Standard Deviation
***Value of t for differences between means

It is evident in Table 4-2 above, that the high and low accident groups do not differ significantly on any of the factors measured, even when means are obtained on extreme samples that have been statistically determined to be distinctly different in terms of accident experience. It must be concluded, then, that the hypotheses of greater impulsiveness, less emotional stability and more negative attitudes toward people among the high accident roofers, are not supported by the data obtained in this study, at least as the relevant dimensions are measured by the Guilford Zimmerman Temperament Survey.

In order to evaluate the possible existence of a relationship between the personality dimensions measured and accident experience that might have been concealed by the age composition of the two samples, the two groups were divided in half at their respective age medians, and the differences between means for high and low accident experience roofers within age categories were tested. Again, however, no significant differences were found on any of the factors measured. It would appear, then, that the age composition of the two samples was not a factor in the failure to find a relationship between personality and accident experience.

- Interview Questionnaire

A copy of the Interview Questionnaire, is shown in Appendix I of this report. Distribution of the responses of the entire sample of 123 subjects to each question, is included in Appendix II. A similar distribution of the responses of the 82 subjects who represent the extremes of high and low accident experience, is presented in Appendix III. The responses are tabulated by accident experience group in each exhibit. In reviewing both Appendices II and III, it is evident that the two groups are very similar in terms of their expressed attitudes and opinions toward the various aspects of their work.

Pace of Work - On only one item (item number 60) out of the 59 questions directed toward the elicitation of the roofers' feelings, attitudes and opinions was there a significant difference between the high and low accident experience groups. This one difference was found to be significant in both the total sample distribution and the extreme sample distribution, but in each distribution, it was the only difference of significance. One statistically significant comparison out of 59 obviously cannot be considered meaningful, but the finding is worthy of note because it concerns feelings about the pace of the work which, as will be discussed later in this report, is believed by a high percentage of all the roofers interviewed to be one of the most common causes of accidents.

In response to the question, "How hard do you have to work to do what is expected of you?", 17, or 28 percent, of the high accident roofers responded that they "feel under pressure to work as fast as I can throughout the shift." Only seven, or 11 percent, of the low accident experience roofers expressed this feeling. The corresponding percentages for the two groups in the extreme sample were 32 and 11. Consistently, significantly more of the low than high accident roofers expressed the belief that " the pace is fast at times, but it slows down at others, so it's not stressful."

While it is true that over one-half of the subjects in the high and low accident experience groups expressed the opinion that the pace is not excessive enough to be stressful, pressure induced by work pace is a commonly enough believed cause of accidents among roofers that it should be given careful scrutiny and emphasis in prevention efforts.

Awareness of Danger or Risk - In considering the work itself, it is significant to note that the great majority of both groups regard roofing as dangerous work, 87 percent of the high accident group in the total sample and 78 percent of the low accident group expressed this belief. There seems to be clear recognition that the work is dangerous, but in considering just how dangerous it is in Item 30, neither group seems to feel that it is "extremely dangerous" or "more dangerous than almost any other kind of work." In fact, however, the accident statistics indicate that roofing is extremely dangerous and perhaps a more dangerous occupation than almost any other kind of work. Inaccuracy of perception of the magnitude of the danger to which they are exposed would also seem to be supported by the fact that in Item 30, fully one-third of the roofers in both groups expressed the belief that roofing is no more dangerous than most other kinds of work. This finding suggests that there is a need for improvement in communicating to the roofers the nature of the very real dangers associated with their work.

Formal Safety Programs - The latter conclusion concerning the need for more clear communication of the dangers in roofing would seem to be supported by the subjects' responses to Item 44, "Does your company have a formal safety or accident prevention program?" As can be seen in Appendix II, over half of the subjects in each group responded "no" to this question. Clearly, an object of any accident prevention program would be to communicate the very real and exact nature of the hazards to which the workers are exposed.

In the context of accident prevention and safety programs, the subjects responses to Item 50, "How do roofers learn to become safe workers," are of interest. In selecting the most important source of job safety knowledge, only seven percent of the low accident subjects and 16 percent of the high accident subjects in the sample mentioned formal training, either through the apprenticeship program or other programs sponsored by the company or union. Equally as significant is the fact that only 10 percent of the high accident subjects and six percent of the low accident subjects mentioned the foreman as the most important source of knowledge of safe work practices. The overwhelming majority of the subjects in both groups indicated that such practices were picked up informally, either by the roofer's own experience or from older, more experienced co-workers. These findings appear to lend further support to the conclusion that there is a vital need for more formalized programs of accident prevention in the industry. In this regard, it would appear also that the role of the foreman as a professional who trains as well as "pushes" needs to be emphasized.

Responsibility for Job Safety - This latter conclusion is supported by the subjects' responses to Item 47, "Who do you think has primary responsibility for safety on the job?" As can be seen in Appendix II, in both groups 'the foreman' was the response selected most frequently. In other words, the foreman is perceived by over half of the subjects in the total sample as having primary responsibility for safety on the job but of being a relatively unimportant source of knowledge regarding safe work practices. The fact that a high percentage of the subjects in both groups indicated, in response to Question 45, that their foremen place "a great deal of emphasis "on safety is not inconsistent with this finding. Rather, it suggests that the roofing foreman may be misguided in what he emphasizes or ineffectual in the manner in which he emphasizes safety. All of this points up the need to upgrade the level of professionalism among roofing foremen.

Stress - It has been our observation that a worker in any industry may feel stress resulting from a conflict between his allegiance to the union and the company for which he works. It has also been thought that this conflict and its resultant stress could be a source of distraction on the job that could lead to accidents, particularly in a high risk occupation.

The subjects responses to questionnaire Items 67, 68 and 69, as tabulated in Appendix II, clearly indicate that the roofers' first allegiance is to their union. However, substantially over half of the subjects in each group expressed the opinion that the interests, goals and objectives of the company and the union are the same or compatible in response to Item 71. Only 18 percent of the high accident subjects and 21 percent of the low accident subjects indicated a belief that there is a conflict between company and union in what they want for the industry. This perceived compatibility between the union and the company is further supported by the fact that almost 75 percent of the total sample of subjects responded "yes" to Item 66, "Do you think the top management of this company is really concerned or interested in you and the other roofers?" All of these findings suggest that an atmosphere exists in the industry wherein safety and accident prevention programs and measures promoted by the union and/or management would be well received by the roofers.

Job Satisfaction - Job satisfaction has been found to bear some relationship to accident experience in past industrial studies (Davids and Mahoney, 1957; Harper and Kalton, 1968), but the exact nature of the relationship, if it in fact exists, is confused by a variety of intervening variables. Job satisfaction was considered in this study in Items 57 through 63 of the Interview Questionnaire. As can be seen in Appendices II and III, no significant differences were found in the responses of the two groups to these questions. The subjects' responses to Questions 59, 61, 62 and 63 suggest that, at least in this geographic region, roofers are generally satisfied with their occupation and accept the fact that it is about as well as they can do under their circumstances.

On the other hand, in responding to questions 57 and 58, almost one-half of the subjects in both groups indicated that they would not be roofers if they had it to do all over again, and the majority indicated that they would not want their sons to be roofers. The responses to all of the job satisfaction items suggest that while roofers may not have basic pride in their occupations, they are generally satisfied and happy and therefore not agitated or stressed in a way that might distract them on the job. In other words, it would appear that the level of job satisfaction among roofers is such that it is not a significant factor in accident causation.

Conflict Between Safety and Productivity - As evidenced in the responses to Items 41 and 85, as presented in Appendix II, there is some difference of opinion among roofers concerning the often discussed conflict between safety and productivity. Sixty-three percent and 76 percent of the subjects in the high and low accident experience groups, respectively responded "yes" to Item 41, "Do you think it is possible to be maximally productive when you follow the the safest working procedures?" A similar, but less distinct, opinion was expressed by the subjects in response to Item 85, wherein 53 percent of the high accident subjects and 63 percent of the low accident subjects indicated that crew safety consciousness was either unrelated to productivity or a direct correlate of it. While the majority of the subjects do not appear to perceive a conflict between safety and productivity, a substantial proportion of the sample does feel there is a conflict. Comments made by the subjects during the interview suggest that those who perceive a conflict may confuse work pace with productivity. If a similar difference of opinion exists among members of supervision and management, consideration should be given to initiating a study directed at determining the point at which any increases in production resulting from increased work pace are offset by increased accident costs.

Corrective Action - Questionnaire Item 49 is an open-end question in which each roofer was asked, "If you had the power to do anything you wanted in order to make roofing less dangerous, what would you do?" The responses to this question are of particular interest in that they lend further support to the conclusions made in the preceeding paragraphs and suggest additional areas of potential for accident prevention. The 10 most common responses to this item are presented in Table 4-3 ranked in order of the frequency with which they were mentioned by the subjects.

TABLE 4-3

Ten most common responses of subjects to Questionnaire Item 49, "What would you do to make roofing less dangerous?" ranked in order of frequency. 123 subjects.

Response	Rank		
	High Accident Group	Low Accident Group	Total Sample
Slow down work pace	2	1	1
Better equipment maintenance	1	4	2
Better worker training	4	2	3
Strict enforcement of safety law	3	3	4
Better job management	6	4	5
Eliminate hot tar	4	6	6
Strict enforcement of safety clothing rules	7	7	7
Better/more frequent inspections	8	7	8
Replace bad ladders	9	10	9
Inspection by union officials	9	10	9

The importance of the points made earlier regarding: (1) the need for improved training or communication to the roofers about safe and unsafe work practices; (2) the need to upgrade the level of professionalism among job supervisors and; and (3) the need for systematic evaluation of work pace as it relates to productivity and safety, are reflected in the frequency with which they were mentioned in response to this unstructured question. Additional conclusions to be emphasized are the need for improved standards in equipment maintenance, and the need for more rigorous inspection and enforcement of safety regulations.

- Projective Test

The Projective Test given to the subjects required that they respond to four sketches which respectively depict roofers in work situations that are likely to produce burn, fall, strain and struck-by accidents. It was assumed that by having the subjects describe the action in the sketches, the consequences, and the thoughts and feelings of the roofers pictured, they would reveal their own perceptions and attitudes toward the hazards associated with their work.

In fact, however, the subjects found it very difficult to relate to this task beyond the concrete description of the scenes, and as a consequence, their responses contain little in the way of feelings and attitudes. In their descriptions of the scenes, however, the subjects frequently expressed opinions as to the causes of the accidents or impending accidents depicted. These "accident cause" themes and the frequency with which they were expressed are summarized in Table 4-4 on the next page.

As is evident in Table 4-4, the two groups are very similar, both in the relative frequency with which they expressed the various themes and the number of themes expressed. This same analysis was performed on the responses of just those subjects included in the extreme high and low accident experience groups with esssentially the same result.

It is worthy of note that the most common causes of accidents, as expressed in the subjects' responses to the Projective Test, are much the same as those expressed or implied in their responses to the Interview Questionnaire items discussed earlier in this report. They can be summarized as follows:

- Failure of supervision to properly instruct roofers and manage jobs. Most foremen and field supervisory personnel in the roofing industry evolve into their positions through years of experience on the job. Few of them receive any formal supervisory or job management training. What is perhaps more critical is the fact that their knowledge of roofing safety is also acquired through this same informal experience on the job. When this circumstance is considered in light of the fact that the foreman is regarded by many in the industry as having primary responsibility and control over safety on the job, it becomes clear that there is a need to upgrade the quality of supervision and management of the job. Formal training in supervision, management techniques and roofing safety should be initiated in the industry, and all candidates for the position of foreman should be required to qualify against defined standards of knowledge and demonstrable competence.

- Poorly trained roofers. Just as the need to upgrade the quality of supervision and management in the industry was emphasized in the subjects' responses to the projective and Questionnaire items, the need for more formal training in roofing methods and safety procedures was also stressed.

TABLE 4-4

Distribution of Accident Themes in
Subject Responses to Projective Tests
123 Subjects

Theme	High Accident Group Frequency	High Accident Group Percent	Low Accident Group Frequency	Low Accident Group Percent	CR *
Carelessness, Inattention or Preoccupation	76	28%	63	22%	1.55**
Pressure for Production	42	16%	38	14%	-
Failure of Supervision to Instruct or Control	39	15%	48	17%	-
Improper Dress	35	13%	39	14%	-
Failure to Erect Barriers or Cover Holes (Negligence of Contractor or other not specified)	28	10%	38	14%	-
Faulty or Inappropriate Equipment or Tools	12	4%	25	9%	-
Ignorance on Part of injured Roofer	12	4%	10	4%	-
Lack of Teamwork or Cooperation (Failure of Others to Perform)	9	3%	7	2%	-
Desire to Impress Boss or Others	5	2%	12	4%	-
Belief that "it won't happen to me"	4	2%	1	-	-
Accidents Inevitable in Trade	4	2%	-	-	-
Failure to Ask for Help	2	1%	-	-	-
TOTAL	268	100%	281	100%	

*Value of critical ratio for difference between percentages.
**CR of 1.96 required for significance at .05 level.

- Failure to enforce safety regulations. Covers over openings in the roof, guard rails, perimeter warning markers, secured ladders, etc., are all required by law. However, lack of compliance with some or all of these regulations can be seen on almost any roofing job site. Similarly, while most companies require that long sleeved shirts and gloves be worn by roofers working with hot asphalt, it is not at all uncommon to see roofers working bare-handed and shirtless.

  It is argued by some that many of these regulations are arbitrary and that compliance with certain of them contributes additional hazard to the job, rather than safety. There is a need first, then, for empirical documentation of the value of the various safety regulations. The importance of compliance with those proven to be valid must then be stressed to the roofers themselves, as well as to the contractors and union officials. Voluntary compliance is particularly important in this industry which is characterized by a great many small companies, small jobs and other conditions that make enforcement difficult.

- Inappropriate or poorly maintained equipment. The need for standards in equipment and equipment maintenance was emphasized in the subjects' responses to the projective and the Questionnaire items. This point was confirmed in the investigators' observations on job sites, wherein roofers were frequently observed using the wrong kinds of buckets to carry and pour hot asphalt and working around kettles with broken temperature gages and controls.

- Excessive pressure for production. Complaints of excessive work pace are common of workers in all industries, however, the fact that it was mentioned with such frequency by the roofers as a primary cause of accidents suggests that there is a need for systematic evaluation of work pace as it relates to production and safety in the roofing industry.

- Pictorial Ranking Test

An important determinant of safe work behavior is an awareness on the part of the worker of the dangers to which he is exposed on the job. Two tests were devised to assess the degree of this awareness among the roofer subjects. The first test required the subjects to rank, in order of frequency of occurence, four sketches depicting four common kinds of roofing accidents. The second test required the subjects to rank the same accident scenes in terms of the degree of severity of the type of accident depicted. (The pictures are in Appendix 5.)

The proper ranking of the roofing accident sketches in order of frequency are:*

- Burns
- Falls from roof
- Strains
- Struck by falling object

When these same accident sketches are ranked in terms of severity, as measured by average lost time in days, the order becomes:

- Falls from roof
- Strains
- Struck by falling object
- Burns

Performance on these two tests was scored in three ways:

- The absolute number of correct placements made by the subject. For example, a subject whose severity rankings were (1) falls, (2) burns, (3) struck by falling object, and (4) strains, would get a score of two by this scoring method for correctly recognizing that falls produce the most severe injuries and that "struck by" accidents rank third in severity of injury.

- Number of accident scenes correctly ordered, regardless of correct placement. For example, a subject whose frequency rankings were (1) strains, (2) struck by falling object, (3) falls, and (4) burns, would receive a score of two for correctly ordering "strains" and "struck by falling object" accidents, even though the two types of accident were not correctly placed in the absolute sense. It was assumed that in any given work situation involving the possibility of occurence of both of these types of accidents, the accuracy of the assessment by the roofer of their relative frequency or severity could be an important element in his judgement and consequent behavior.

- Accurate recognition of the single most frequent and single most severe accident types, regardless of the subject's awareness of the relative frequency or severity of the other accident types.

The distribution of scores on the accident frequency measure, according to the first scoring technique (number of accurate placements) is presented in Table 4-5 for the entire sample of 123 subjects.

*Refer to page 2-21 for discussion of accident types.

TABLE 4-5

Number of Correct Placements - Accident Frequency
123 Subjects

Score	High Accident Group Frequency	High Accident Group Percent	Low Accident Group Frequency	Low Accident Group Percent
4	1	2%	2	3%
2	18	30%	18	29%
1	19	32%	29	46%
0	21	35%	14	22%

It is evident in Table 4-5 that the two groups were very similar in the accuracy with which they were able to place the four accident types in terms of relative frequency. What is particularly noteworthy, however, is the fact that only one subject in the high accident group and two subjects in the low accident group were able to rank all four accident types accurately, and fewer than one-half of the subjects were able to place even two out of four.

The distribution of scores on the accident frequency measure, according to the second scoring technique (number of correctly ordered accident types) is presented in Table 4-6.

Again, it can be seen that the two groups differ little, and the accuracy with which they were able to perform the task was low. The overwhelming majority of the subjects in both groups were able to accurately order no more than two of the four types of accidents.

TABLE 4-6

Number of Correctly Ordered Accident Types - Accident Frequency
123 Subjects

Score	High Accident Group Frequency	High Accident Group Percent	Low Accident Group Frequency	Low Accident Group Percent
4	1	2%	2	3%
3	6	10%	3	5%
2	19	32%	30	48%
0	33	55%	28	44%

In Table 4-7, the number of subjects in each group who were able to accurately recognize burns as the single most common kind of roofing accident is presented.

TABLE 4-7

Number of Subjects Able to Recognize Single Most Common Type of Accident

High Accident Group		Low Accident Group	
Frequency	Percent	Frequency	Percent
11	18%	16	25%

As can be seen in Table 4-7, no more than 25 percent of the subjects in either group was able to accurately recognize burns as the most frequently occuring type of roofing accident.

The corresponding distributions of scores on the test of awareness of the relative severity of the accident types, by the three scoring techniques, are presented in Tables 4-8, 4-9, and 4-10.

TABLE 4-8

Number of Correct Placements - Accident Severity
123 Subjects

	High Accident Group		Low Accident Group	
Score	Frequency	Percent	Frequency	Percent
4	2	3%	1	2%
2	23	38%	20	32%
1	22	37%	28	44%
0	10	17%	12	19%

TABLE 4-9

Number of Correctly Ordered Accident Types - Accident Severity
123 Subjects

	High Accident Group		Low Accident Group	
Score	Frequency	Percent	Frequency	Percent
4	2	3%	1	2%
3	0	0%	3	5%
2	24	40%	31	49%
0	31	52%	26	41%

TABLE 4-10

Number of Subjects Able to Recognize
Single Most Severe Type of Accident

High Accident Group		Low Accident Group	
Frequency	Percent	Frequency	Percent
35	58%	35	56%

Review of Tables 4-8, 4-9, and 4-10 indicates again that the two groups are very similar; and, with the exception of the most severe accident type, their ability to discriminate between accident types in terms of relative severity is poor.

The same analysis was performed on the scores obtained by the subjects included in the two extreme accident experience groups. No significant differences were found between the two groups, and the overall distributions were very similar to those presented above on the total sample.

It is recognized that these findings could have resulted because the discrimination tasks presented to the subjects were too difficult. That is, the differences in the actual frequencies with which the four types of accidents occur and the differences in their actual severity may be too small for the roofers to reliably discriminate. But, the alternative conclusion that roofers are not as aware as they should be of the dangers to which they are exposed on the job, must also be considered. This latter conclusion is consistent with that derived from the subjects' responses to certain of the Questionnaire items as discussed previously in this report. Again, emphasis is given to the need for a more formalized program of accident prevention in which systematic education concerning the nature of the hazards associated is consistent with roofing is emphasized.

- General Life Adjustment

Information on a number of biographical variables that are believed to be related to stability and general adaption or adjustment in life was obtained in the interviews to test the hypothesis that accident repeaters are less well adjusted socially than their low accident experience counterparts.

The biographical data are summarized in Tables 4-11 and 4-12. In Table 4-11, the entire sample of 123 subjects is separated into high and low accident groups which are compared on each variable.

In Table 4-12, high and low accident experience groups, which include only the extreme cases meeting the most rigorous statistical criteria for selection, are compared on the same biographical variables.

In reviewing Table 4-11, it is evident that the two groups are similar with respect to most of the variables considered. Differences of statistical significance were found, however, on four of the variables: (1) tenure with present company, (2) self reported absenteeism during the past 12 months, (3) home ownership, and (4) marital status. The first two of these differences are in the expected direction and are supportive of the hypothesis of greater social adjustment among low accident workers. However, the third and fourth differences are contrary to expectation. A significantly greater percentage of the low accident subjects were found to be renting their homes as opposed to buying them; and a significantly higher incidence of divorce or divorce and remarriage was found in the low accident group.

The comparisons presented in Table 4-12 are more meaningful in terms of the hypothesis because the two groups represent distinctly different populations with regard to accident experience. As can be seen in Table 4-12, significant differences between the two groups were found on five of the twelve variables: (1) years of formal education, (2) tenure with current company, (3) incidence of major illness or death in the family, (4) absenteeism, and (5) home ownership. All of these differences are in the excepted direction with the exception of that concerning home ownership.

These latter findings lend some support to the hypothesis that low accident workers are more stable and better adjusted than their high accident experience co-workers. These findings also suggest the possibility that further research into the use of biographical information in roofer selection could prove fruitful.

TABLE 4-11

Comparison of High and Low Accident Experience Groups on Selected Biographical Variables

Total Sample

Description	Low Accident Group N	Low Accident Group Mean	Low Accident Group S. D.	High Accident Group N	High Accident Group Mean	High Accident Group S. D.	t
Age	63	42.19	13.09	60	37.68	13.11	1.91
Years of Schooling	63	10.94	3.07	60	10.60	2.55	
Years of Apprenticeship	63	1.02	1.42	60	1.27	1.31	
Number of Children	63	2.49	2.09	60	2.18	1.95	
Months Tenure with Present Company	63	299.08	43.90	60	117.73	208.47	6.6 x^2 43

Marital Status	Low: Single	Low: Married	Low: Divorced	High: Single	High: Married	High: Divorced
	(5)8%	(31) 49%	(11) 18%	(7) 12%	(32)53%	(2) 4%

	Low: Remarried	Low: Widower	High: Remarried	High: Widower	t
	(14)22%	(1) 2%	(18) 30%	(1) 2%	2.14

Description	Low: Yes	Low: No	High: Yes	High: No	t
Permanent Residence Local	(61) 97%	(2) 3%	(55) 92%	(5) 8%	
Major Illness	(24) 38%	(37) 59%	(30) 50%	(30) 50%	1.33
Difficulty with Law	(17) 27%	(45) 71%	(20) 33%	(40) 67%	

Description	Low: Rent	Low: Own	High: Rent	High: Own
Home Ownership	(27) 43%	(33) 52%	(24) 40%	(35) 58%

Description	Low: N	Low: Median	High: N	High: Median	x^2
Absenteeism	63	0	60	7.88	136

Description	Low: Left	Low: Right	High: Left	High: Right
Dominant Hand	(3) 5%	(59) 94%	(7) 12%	(53) 89%

TABLE 4-12

Comparison of High and Low Accident Experience
Groups on Selected Biographical Variables

Extreme Sample

Description	Low Accident Group			High Accident Group			
	N	Mean	S.D.	N	Mean	S.D.	t
Age	29	33.28	12.47	47	37.70	13.59	1.45
Years of Schooling	29	12.31	2.56	47	10.66	2.49	2.75
Years of Apprenticeship	29	1.62	1.50	47	1.23	1.32	1.12
Number of Children	29	2.10	2.47	47	2.30	1.98	0.47
Months Tenure with Present Company	29	353.86	304.72	47	106.79	204.10	3.86
							x^2
							4.5

Description	Low: Single	Low: Married	Low: Divorced	Low: Remarried	Low: Widower	High: Single	High: Married	High: Divorced	High: Remarried	High: Widower	t
Marital Status	(5) 17%	(15) 52%	(5) 17%	(4) 14%	0	(4) 9%	(26) 55%	(2) 4%	(14) 30%	(1) 2%	2.14

Description	Low: Yes	Low: No	High: Yes	High: No	t
Permanent Residence Local	(29) 100%	0	(43) 92%	(4) 8%	
Major Illness	(7) 24%	(21) 72%	(23) 49%	(24) 51%	2.27
Difficulty with Law	(11) 38%	(18) 62%	(16) 34%	(31) 66%	

Description	Low: Rent	Low: Own	High: Rent	High: Own	t
Home Ownership	(17) 59%	(12) 41%	(17) 36%	(29) 61%	2.01

Description	Low: N	Low: Median	High: N	High: Median	x^2
Absenteeism	29	0	47	9.80	8.4

Description	Low: Left	Low: Right	High: Left	High: Right
Dominant Hand	(3) 10%	(26) 90%	(7) 15%	(40) 85%

Human Performance Test Battery

The two tests of sensory capabilities produced no sizeable differences attributable to group membership. The rationale for the visual screening was to detect workers whose vision was seriously impaired, since workers with reasonably good vision would easily be able to resolve one minute of arc. Thus the screening procedure was tantamount to detecting the workers who needed corrective lenses but did not wear them. Although a number of workers were found who could not have passed the acuity screening without their corrective lenses, all of the workers' vision was satisfactory with the use of corrective lenses permitted. Thus, by inference, it appears that the use of glasses by workers who need them is unrelated to safety records.

The auditory acuity testing was similarly intended merely to detect unusually poor hearing. Pure tone audiometric determinations of thresholds were made at 500, 1000, 2000, and 4000 Hz in each ear. The screening criterion permitted deviations of as much as 15 dB from ISO recommendation R-229 as an allowance for the commonly observed deterioration of hearing with age and noise exposure. Many workers in each group had hearing that was substantially worse than the screening criterion, including several instances of unilateral losses in excess of 50 dB. The average hearing loss of workers in the low and high accident rate groups (defined as the sum of the losses in each ear at each frequency beyond the 15 dB expected loss) was 10.9 and 9.0 dB, respectively. This difference is well within the probable error of measurement. Thus, although many workers in each group had marked hearing losses, there was no evidence that these losses contributed differentially to job safety.

Performance scores for the remainder of the test battery are summarized in Table 4-13. As may be seen, differences in mean performance between groups are uniformily small, ranging from less than one percent in the number of correct trials in the perceptual span test to about 26 percent in choice reaction times. Variances for each of the tabled measures were generally of similar magnitude for the two groups of workers. The lack of large mean differences and the similarity of variances suggest the data of the two groups may have been generated by similar processes.

In fact, given the present sample sizes and observed variances, it was not possible to exclude chance factors as likely sources of mean differences of the magnitudes observed. A tabulation of approximate sample sizes required to achieve statistical significance of such mean differences is found in Table 4-14. The sample size estimates are based on assumptions that mean differences in larger samples will be similar to those currently observed, that the data will be normally distributed, and that the variances will be reduced in proportion to the square root of the number of observations.

It is important to note that for most measures the mean to standard deviation ratios were reasonably large - on the order of 2:1 or greater. Thus, the failure to observe statistically significant differences in mean performance measures was not primarily due to "noisy" or highly variable data. Instead, it appears attributable simply to the absence of any substantial difference in performance by workers in the two groups.

Considering the small magnitude of observed mean differences and the likelihood of their generation by chance, there is little justification for attempts at interpretating them.

Although the foregoing analysis of the mean performance measures revealed no substantial differences between groups, consideration of the form of the distribution of scores for each group yielded a slightly different view of the data. Table 4-15 compares the proportions of scores in the low and high accident rate groups that are greater than the median score for all workers. If workers had been randomly assigned to groups without regard for their safety records, equal proportions of scores in each group would have been expected to fall above and below the overall median score.

Several of the distributions of scores with respect to the overall median, are unlikely to have arisen by chance alone. At least one of them (the distribution of choice reaction times) differs from a chance distribution sufficiantly to meet conventional criteria for significance. The chi square values for the two by two contingency table containing numbers of scores above and below the grand median in each group was 10.74. With one degree of freedom, this value of chi square occurs a little more than one time in a thousand by chance alone.

If attention is further restricted to the direction of the differences between groups (rather than the magnitude of the differences), it could easily be argued that the present data support the hypothesis that human performance measures can be used to discriminate between workers on the basis of their safety records. This could be accomplished by any number of non-parametric tests of the signs of the differences if prior predictions of the direction of the differences were made.

The fallacy in such an argument, however, would be the ad hoc nature of the predictions of directions of differences. Although intuition might suggest that one group or the other might perform better in certain tasks, there is no formal basis for such predictions. Thus, attempts to contrive a rationale for predicted differences would be fundamentally arbitrary. No amount of statistics can compensate for a lack of theory.

In short, although with sufficient sophistry the current data could be used to support arguments for differential behavior of low and high accident rate workers, little would be so gained. Equally reasonable explanations for the lack of major differences in the current data include many factors other than accident rates. For example, one might question the meaningfulness of the criteria by which workers were assigned to groups, the adequacy of the experimental design (which precluded testing of workers who suffered severe accidents), and so forth.

TABLE 4-13

SUMMARY OF GROUP PERFORMANCE SCORES

Task	Low Accident Group Mean	Low Accident Group Median	Low Accident Group σ	High Accident Group Mean	High Accident Group Median	High Accident Group σ
Equilibrium (Seconds)	10.30	4.70	13.20	14.60	6.30	21.80
Eye-Finger Coordination (1) (Seconds)	2.93	2.78	0.94	3.23	2.81	1.96
Eye-Finger Coordination (2) (Seconds)	3.42	3.27	1.11	3.79	3.10	2.93
Simple Reaction Time (Seconds)	0.65	0.63	0.15	0.62	0.61	0.15
Choice Reaction Time (Seconds)	0.96	0.78	1.28	0.76	0.72	0.24
Speed-Accuracy Trade (Seconds)	45.97	42.04	22.44	48.70	36.62	29.38
Risk Preference (Scale Units)	1.81	1.78	0.38	1.87	1.89	0.56
Reversal Learning (Seconds)	56.88	44.70	54.43	53.40	45.60	34.50
Perceptual Span (# Correct)	16.10	17.70	4.10	16.00	17.20	4.60
Short-Term Memory (# Correct)	8.80	9.10	1.30	8.60	8.80	1.70

TABLE 4-14

Approximate Sample Sizes Required by Two Tail Significance Tests at .05 Level for Observed Mean Differences

Task	Estimated Sample Size
Equilibrium	135
Eye-Finger Coordination (1)	200
Eye-Finger Coordination (2)	275
Simple Reaction Time	190
Choice Reaction Time	160
Speed-Accuracy Trade	700
Risk Preference	500
Reversal Learning	1300
Perceptual Span	14600
Short-Term Memory	440

TABLE 4-15

Proportion of Scores Above Grand Median
in Low and High Accident Rate Groups

Task	Grand Median	Proportion of Scores Greater than Median Low	High
Equilibrium	5.59	.44	.51
Eye-Finger Coordination (1)	2.79	.50	.50
Eye-Finger Coordination (2)	3.22	.56	.46
Simple Reaction Time	0.62	.54	.49
Choice Reaction Time	0.75	.67	.35
Speed-Accuracy Trade	38.88	.54	.46
Risk Preference	1.84	.52	.62
Reversal Learning	45.55	.50	.50
Perceptual Span	17.50	.56	.44
Short-Term Memory	8.93	.69	.61

Summary

In considering the results of this analysis, very few differences were found between the high and low accident experience roofers. Those differences of significance that were found are so few, relative to the number of comparisons made, that they cannot be considered meaningful in a statistical or practical sense. This finding tends to support the prevalent belief among researchers in this field that accident proneness as a stable and enduring human characteristic is not a valid concept. Of course, such a conclusion cannot be drawn unequivocably from the results of this study because the possibility remains that real differences between the groups did exist, but went unidentified because of inadequacy in the instruments used to measure them.

In any case, it would appear safe to conclude that factors in the work environment, other than personal characteristics of the roofers themselves, should be stressed in future research and efforts to reduce accidents in the industry. Opportunities of potential for roofing accident reduction suggested by this analysis would include the following:

- Improvement in quality and professionalism of supervision, particularly at the foreman level.
- Development of formalized accident prevention programs to be administered through the individual companies and the union.
- Greater emphasis on formalized training of roofers on the job regarding safe and unsafe work practices.
- Development of programs and techniques to instruct roofers on, and continually stimulate their awareness of, the exact nature of the risks associated with their work. Particular emphasis should be given to the relative frequency and severity of the various types of roofing accidents.
- Development and enforcement of standards of equipment maintenance.
- Systematic evaluation of work pace as it relates to productivity and accident causation.
- More rigorous or more realistic enforcement of safety regulations.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Brief Summary of Findings

A summary of the roofing accident analysis findings is presented at the end of the accident analysis section in Chapter 2. Similarly, the test battery results are summarized briefly at the end of Chapter 4. In many ways the 1970 California accident data tables in Chapter 2 tell their own story but a few highlights are listed below:

Accident Analysis Findings

- The accident rate of apprentice roofers appears to be twice that of roofing journeymen in California.
- The monthly accident rates in California vary by a factor of two. They reach a seasonal maximum at peak employment levels in the fall but drop rapidly for the month when peak employment is reached or when it levels out.
- Twenty-five percent of the roofers in the union are under 30 years of age, but almost half of the injured roofers are under 30 years of age. This implies that men under 30 years of age might be three times more likely to have an accident than men over 30 years of age.
- The above three findings strongly suggest a very strong accident avoidance learning curve during the first few months of work experience. In other words, inexperienced roofers incur an extremely high initial accident rate which drops rapidly during the first few weeks and months on the job.
- Burns are the accident types with the highest frequency of occurrence. More than half of the burns are to the hands and fingers.
- Slips and falls on the roof or ground, and falls off the roof, are two of the most important roofing accident types in terms of both frequency and severity.
- Other major accident categories are strains and sprains (usually lifting or back problems) and injuries resulting from falling objects, presumably from the roof.
- The lack of detailed accident data and industry census data leads to the formation of controversial opinions about the causes of roofing accidents. Without the facts it is difficult to devise and justify needed safety remedies. For example, how, when, and where, do

falls on the roof or off the roof occur? Without empirical verification of critical accident occurrence details, proposed safety remedies will remain controversial and some will be intensely resisted by both the roofer and the roofing contractor.

Test Battery Findings Highlights

- Despite differences found in a few variables, no substantial differences were found in the test and interview data between the two groups of high and low accident record roofers.

- The majority of roofers see the foreman as the person most responsible for their safety on the job but few roofers cited the foreman as an important source of knowledge regarding safe work practices.

- Although most of the men had become roofers prior to the establishment of the apprenticeship program, only small percentages of the men mentioned the apprenticeship program as a source of job safety knowledge. Safe work practices were said to have been learned informally from experienced co-workers or from their own work experiences. (Note: Most men actually start work prior to the beginning of apprenticeship classes.)

- Although a majority of roofers consider roofing as dangerous work fully one-third of the roofers perceived that roofing was no more dangerous than other kinds of work. Moreover, very few roofers were able to correctly rank or place either accident frequency or severity of four of the largest and most important types of roofing accidents. In general we sensed a deficiency of knowledge and understanding of accident risks among the men tested and interviewed.

- About 30 percent of the high versus 10 percent of the low accident record roofers expressed that they "feel under pressure to work as fast as I can throughout the shift." Also "slow down work pace" was the most frequency cited suggestion to make roofing safer from all the roofers. When asked if a conflict exists between productivity and safety, almost half of the roofers believe such a conflict exists. The roofers usually made no distinctions between work pace and productivity.

- Most workers cited lack of equipment maintenance, lack of safety training, and lack of enforcement of safety rules as the other major factors in the high accident rates.

- In general, roofers indicated a lack of pride in the trade. Although they indicated personal job satisfaction, they indicated strongly they would not become roofers "if they could do it all over again" and they wouldn't recommend the trade to their sons.

Recommendations

1. Collect a detailed accident data base with industry census data. This will resolve questions and controversies about how certain roofing accidents occur so that remedial measures can be evaluated. For example:

   - Do roofers usually fall through roof openings or over the roof edge?

   - Are forward-pushing felt machines safer than backward-pulling felt machines?

   - What are roofers doing most frequently when they are burned? or when they slip or fall?

2. Design and conduct a study on the effect of supervision on roofing safety. Roofers are very strong in their opinion that the foreman is the man most responsible for the safety of the roofers on the job. Work pace and productivity tend to be controlled by the roofing foreman because the foreman usually performs the pace setting job and he also plans and directs the other job tasks. High work pace and the conflict of safety versus productivity were cited by many roofers as major factors in high accident rates which relates importantly to supervisory roles. Moreover, very few roofers cited the foreman as an important source of knowledge about safe work practices.

3. Devise experimental safety certification programs for new workers to reduce the high accidents associated with job inexperience. New workers would be required to demonstrate performance of safe procedures as well as knowledge of the rules of safe behavior after one or two days of off-the-job orientation before being allowed on the job. Using control groups, the effectiveness of such experimental programs on reducing accident rates and providing a more productive new employee could be measured.

   Also worthy of consideration would be experimental foreman certification programs that stress roofing task planning, worker coordination, effective ways of giving directions, training, motivating and disciplining workers. A test similar to the Kirkpatrick Safety Supervisory Test could be used as part of a certifying test instrument in addition to roofing knowledge.

4. Conduct Safety research to develop suitable protective clothing standards for roofers especially in regard to gloves and boots. Boots should ideally be able to provide maximum friction on roof surfaces, resist asphalt build-up and protect against nail punctures, besides having the usual hard toes. Gloves ideally would be resistant to asphalt build-up, provide burn protection, permit the hand to "breathe," and provide no loss of

dexterity and grasping ability. Clothing for roofers should provide burn and wind protection, insulation against cold, and a cooling function in hot weather.

5. Conduct a Human factors analysis review of all roofing equipment and work procedures. This study should investigate such issues as the following:

   - Are felt machines too hard to pull or push? Can the design be improved?
   - What are the hazards of kettle operation?
   - What about the so-called splashless kettle top designs?
   - Can buckets be designed to reduce splash?
   - What if the weight of asphalt chunks and other roofing materials were reduced?

   The above list are typical questions that would arise in a needed systematic human factors analysis of roofing work.

6. Develop a safe work practices manual which emphasize highly productive work practices. The study should compare the productivity of contractors with good and poor safety records. Most of the contractors with good safety records that we interviewed claimed they have productivity rates as high or higher than their competition with poor safety records. This view, of course, conflicts with the view held by many roofers and contractors that unsafe work practices are necessary to reduce costs and remain competitive in labor costs.

7. Develop effective safety training program, safety literature, and films that thoroughly convey the relative risks of various types of accidents incurred to the roofer and to contractors. The consequences of various kinds of injuries should be stressed in terms of lost wages and in terms of employee pain and suffering. Many roofers who have not incurred serious injuries seem to feel that a permanent disabling injury is a lucky break and that the insurance benefits will provide them with leisure and financial prosperity for the rest of their lives. We heard a different story from the men we interviewed who had received such permanent disabilities. Filmed interviews with permanently disabled victims might be an effective means to combat this myth.

8. Develop more effective enforcement measures of safe roofing work conditions and especially safe work procedures. We believe many roofing safety regulations need to be revised and others formulated, based on better accident data and a complete analysis of safe and efficient work practices. It would seem, theoretically, that good enforcement of safety regulations by the contractor would be a worthwhile investment. However, few contractors are of sufficient size and have the resources to afford the equivalent of a safety engineer or an industrial engineer. The union locals in many areas have seriously proposed having a union safety inspector, but the contractors resist such proposals on the basis that they would loose their management prerogative. Theoretically the idea has merit, however, we do not see much prospect for either the contractors or the union to get together to have such an inspector that would be shared among them. The idea, however, is worth additional discussion and consideration.

We believe that the opportunity to improve the safety records in roofing have never been greater than the present time. There is a well recognized need to improve the safety record on the part of both the roofing contractors and the roofing union. The average insurance rates are approximately $14.00 per $100.00 of payroll in California for workman compensation insurance for roofers. Thus, a strong economic incentive exists for improvement.

The National Roofing Contractors Association and the International Roofers Union have recently formed a joint safety committee to study the problem and to work together in improving the safety record in roofing. This is an unprecedented step between roofing contractors and the union to face up to the safety problems. The research team is optimistic that this step coupled with support from concerned government agencies, such as NIOSH, will help assure rapid progress in improving the safety record of the roofing industry.

APPENDIX 1

OMB No.: 68-S72035

APPENDIX I

INTERVIEW QUESTIONNAIRE

Construction Accident Study

Interviewer's Name ____________________

Date of Interview ____________________

Name of Interviewee ____________________

Introduction

I'm ______________________________ from Theodore Barry & Associates. We are consultants employed by NIOSH to conduct a study of accidents and their causes in the construction industry. Right now we are particularly interested in roofing work. We want to find out as much as we can about why and how accidents occur in roofing and what can be done to make the job safer. In order to do this, we think that we have to start with roofers. You are the men who know the work and the hazards better than anyone else. We want to learn as much as we can about roofers and their experience with roofing accidents. You may have had a roofing accident yourself, or you may have seen some. In either case, your thoughts and ideas will be helpful to us.

I am going to ask you some questions about yourself and your opinions about various aspects of your job. Hopefully, your answers will help to make roofing a safer occupation. As you know, you are a volunteer in this study and your answers to all my questions are voluntary. Some of the things I will ask you may seem personal, and if you prefer not to answer them, it's entirely all right. I also want to assure you that everything you say will be kept completely confidential. Information that might identify you will never be seen by anyone outside of our research staff.

Do you have any questions before we begin?

APPENDIX I (continued)

I. To begin with, I'd like to get some information about you. We think that by studying characteristics of succesful roofers we may find information that might be helpful in the future in selecting people for and training them in roofing apprenticeship programs.

1. How old were you on your last birthday? ________
2. How many years of schooling have you had? ________
3. How many years of apprentice training have you had? ________
4. What is your marital status? S M D
5. Do you have any children? How many? ________
6. How long have you worked for this company? ________
7. Did you work for other roofing companies before joining this one? Yes No
8. What other roofing companies have you worked for?

Name of Company	Years	Reason for Leaving
1(last).		
2(prior).		
3(prior).		

9. Do you live in this area all year? Yes No

   If not, where else do you live? ________

   Are you renting or buying your home? ________

10. How many days would you guess you have been absent from work in the past year? ________

APPENDIX I (continued)

11. Have there been any deaths or major illnesses in your family in recent years? Yes No

12. If so, what was the relationship and when did it occur?

Relationship	Nature of Illnesses	Dates

13. Have you ever had any difficulty with the law? Yes No

14. Which do you consider your *dominant* hand? L R

SECTION II AT END OF QUESTIONNAIRE

III. Let's talk about roofing in general now.

29. Do you think it is dangerous work? Yes No

30. How dangerous is it in your opinion? Would you say it is:

Extremely Dangerous -- more so than almost any other kind of work________
More dangerous than most kinds of work________
About as dangerous as most kinds of work________
Less dangerous than most kinds of work________

APPENDIX I (continued)

31. What would you say are the three most dangerous operations in roofing in order?
(1)________
(2)________
(3)________

32. Do all roofers have about the *same* exposure to these operations? Yes No

Explain No:

33. As you gain experience in roofing, do you find that it is more or less dangerous than you believed at first? More Less

34. You've had only 0-1-2-3 *accidents* in your years as a roofer. How have you managed to avoid having *more*? (Most important reason only)

I'm careful________
I'm lucky________
I work for a good company________
The men I work with are careful________

35. Do you think you can continue to work in roofing indefinitely without (another) accident?

I am certain I can________
I think it is most likely that I can________
There's no way of telling________
I think it is most likely that I can't________
I am certain that I can't________

36. This is a hard question to answer but if you stay in roofing until you retire, what do you think your chances of having a minor/major accident are?

	Minor	Major
I'm sure I won't have one	____	____
I think it is most unlikely that I will ever have one	____	____
There's no way of telling	____	____
I think it's most likely that I'll have at least one	____	____
I'm sure I'll have at least one	____	____

37. Everyone is a little bit different in the care they exercise on the job. How would you describe yourself?

Very careful -- always act in a way that avoids or minimizes risk. ________
Generally careful -- usually act in a way that avoids or minimizes risk. ________
About as careful as the average roofer. ________
Could be more careful -- could take fewer chances. ________
Tend to be very careless -- just try to get the work done as fast as possible and don't think about risk or danger. ________

38. In the accidents or near accidents you have seen in which carelessness was the cause, what do you think made the man act as he did?

Trying to save time or effort ________
Just didn't think of the consequences ________
Was trying to show off ________
Other (explain) ________

39. How much control do you feel the roofers themselves have over what happens to them on the job?

Almost no control ________
Almost total or complete control ________
Primary control but luck is a factor ________
Little control, mostly a matter of luck ________

40. Do you think most roofers feel like accidents are going to happen no matter what? Yes No

41. Do you think it is possible to be maximally productive when you follow the safest working procedures? Yes No

V. Many people think that the company that one works for has a lot to do with safety. In other words, some companies are safer to work for than others.

42. Do you believe this? Yes No

43. Which of the following pieces of safety equipment does your company require you to wear on the job?

Safety shoes ________
Hard hat ________
Gloves ________
Safety glasses ________
Other - ________

44. Does your company have a formal safety or accident prevention program? Yes No

What are the features of the program?

45. How much emphasis does your foreman place on safety on the job?

A great deal -- he regularly and frequently makes us aware of dangerous conditions, equipment or procedures. ________
About average -- he occasionally points out the most dangerous conditions, procedures and equipment. ________
Very little emphasis -- he seldom or never mentions danger or safety. ________

46. Do you think that new men and apprentices get proper safety instruction in this company? Yes No

47. Who do you think has primary responsibility for safety on the job?

The roofer himself ________
The foreman ________
The company ________
The Union ________
Other (explain) ________

48. How important is the safety of the roofers to the management of this company?

Very important -- they do about as much as possible to make the job safe. ________
They are concerned about safety, but they could do more than they are doing to make the job safe. ________
They are really only interested in getting the jobs done as fast and cheaply as possible. Safety is the roofer's responsibility as far as they are concerned. ________

49. If you had the power to do anything you wanted in order to make roofing less dangerous, what would you do?

50. How do roofers learn to become safe workers? Pick the single most important source.

Their own experience on the job ________
Formal training through the apprenticeship program or other programs sponsored by the company or union. ________
From the foreman ________
From the more experienced roofers ________

51. Do you know anything about the Southern California Roofing Association? Yes No
If yes ask the following:

52. Do you feel this association has had any effect on roofing safety? Yes No

53. Have you seen or read the safety bulletins or articles of this or any other roofing contractor associations? Yes No

54. What role does the roofing contractor's association have in emphasizing safety in apprenticeship programs?

V. Now I'd like to get some of your thoughts about roofing as a career or job.

The Work

55. You've been a roofer for several years now. What do you like about this kind of work?

56. I guess every job has some bad features, too. What are some of the things you don't like about roofing?

57. If you had it to do all over again, would you be a roofer? Yes No

58. If you had a son, would you want him to be roofer? Yes No

59. Do you think this kind of work allows you to use your abilities and the training you've had to the fullest? Yes No

60. How hard do you have to work in order to do what is expected of you?
- Feel under pressure to work as fast as I can throughout the shift. ____
- The pace is fast at times, but it slows down at others so it's not stressful. ____
- The pace is generally slow, there is a lot of waiting time and it even becomes boring at times. ____

61. How do you feel about the pay scale and other benefits associated with roofing?
- Very satisfied -- better than I could do at any other job. ____
- Satisfied -- think the pay and benefits are fair. ____
- Rather dissatisfied -- other trades and crafts are paid better for the work they do. ____
- Very dissatisfied -- actively wants to get into another line of work. ____

62. When you consider everything about roofing work (work itself, pay, conditions, danger, men, etc.) how satisfied are you with it as a career?
- Very satisfied -- never consider changing. ____
- Generally satisfied -- don't think I could find anything much better. ____
- It's a job -- that's all. ____
- Generally dissatisfied -- would like to do something else but am not really looking. ____
- Very dissatisfied -- will quit as soon as I can. ____

63. How secure is roofing for you as a year round job?
- I can work as much as I want -- there's plenty of work. ____
- I'm generally sure of having work but it can be slow at times. ____
- It's pretty uncertain; you're never sure. ____
- It's very uncertain -- only thing you can be sure of is that you'll be out of work at least part of the year. ____

The Company

64. How is ____________ as a company to work for, considering all things (pay, conditions, equipment, people, management, etc.)?
- Excellent -- can't imagine a better one to work for. ____
- Good -- better than most. ____
- Average -- no better or worse than the rest. ____
- Poor -- I've worked for better or I think it's probably worse than most. ____

65. How would you judge ____________? (the company(-ies) that subject worked for at time of his accident(s))

	A	B	C
Excellent -- can't imagine a better one.			
Good -- better than most.			
Average -- no better or worse than the rest.			
Poor -- think it's probably worse than most.			

66. Do you think the top management of this company is really concerned or interested in you and the other roofers? Yes No

Supervision

72. How is your foreman as a man to work for?
    - Excellent -- the best in almost every respect. ________
    - Good -- better than most foremen I've seen. ________
    - Just O.K. -- no better or worse than most. ________
    - Poor -- don't think he's as good as most roofing foremen. ________

73. Do you think your foreman lays out the work and runs the job in any orderly way? Yes No

74. Do you think your foreman causes you and the other men in the crew to feel pressured or stressed? Yes No

75. Do you think your foreman knows you well? Yes No

76. Is your foreman the kind of person you can discuss your problems with? Yes No

77. Does your foreman fully recognize how hard you work and how much you do for the job? Yes No

78. Is your foreman well liked by the men in the crew? Yes No

79. Is he respected by the men in the crew? Yes No

80. Think back to the job on which you were injured or last saw an accident. How would you rate the foreman on his over-all ability to run a job?
    - Excellent -- the best in almost every respect. ________
    - Good -- better than most foremen I've seen. ________
    - Just O.K. -- no better or worse than most. ________
    - Poor -- don't think he was as good as most roofing foremen. ________

81. What were his strong points?

What were his weak points?

APPENDIX I (continued)

The Crew

82. How would you rate your present crew over-all as a group of men to work with?
    - Excellent -- couldn't imagine a better group to work with. ________
    - Good -- better than most crews I've worked with or seen. ________
    - Average -- no better or worse than other roofing crews. ________
    - Poor -- think it is worse than most roofing crews. ________

83. Thinking back to your last accident or the last accident that occurred in one of your crews, how would you rate that crew over-all as a group of men to work with?
    - Excellent -- couldn't imagine a better group to work with. ________
    - Good -- better than most roofing crews I've worked with or seen. ________
    - Average -- no better or worse than other roofing crews. ________
    - Poor -- think it is worse than most roofing crews. ________

84. Do you think that the men you work with have any effect on your safety or is safety more an individual responsibility?
    - Crew ________
    - Individual ________

85. In your experience, have you found that the roofing crews that are most conscious of safety are:
    - Also the ones that get the most work done. ________
    - Somewhat slower and less productive than other crews. ________
    - The safety consciousness of the crew really doesn't affect production one way or the other. ________

86. How well do the men in your crew get along with each other?
    - Very well -- almost no conflict or disagreement in the group. ________
    - Pretty well -- less conflict and disagreement than you find in most crews. ________
    - Average -- about as much conflict or disagreement as you find in any group. ________
    - Poor -- there is more conflict or disagreement among the men than you have seen in other crews. ________

87. Do you consider the men you now work with to be:

An important source of pleasure and enjoyment to you both on and off the job.	______
Generally a source of pleasure at least while on the job.	______
Unimportant to me one way or the other.	______
Frequently a source of dissatisfaction or unhappiness during the shift.	______
A source of dissatisfaction or unpleasantness that affects me both on and off the job.	______

88. Would you say that the men you work with generally (not just on this job) are important to you or is one crew pretty much the same as another as far as you're concerned?

Important	______
Indifferent	______

II. Now I would like to talk to you about your own personal experience with accidents.

15. Have you ever been injured on the job? Yes No

(if no, skip to question 24.)

16. Will you tell me a bit about that (those) injury.

A.

B.

C.

Burn	______
Break	______
Sprain	______
Contusion	______
Abrasion	______

APPENDIX I (continued)

17. What do you think was the cause of the accident?

	A.	B.	C.
Your carelessness	______	______	______
Carelessness of someone else	______	______	______
Faulty equipment	______	______	______
An act of God or an unavoidable circumstance that was nobody's fault	______	______	______

18. How long ago did you have the accident?

	Year	or	Time
A.	______		______
B.	______		______
C.	______		______

19. What company were you working for at the time of your accident(s)?

A.______

B.______

C.______

20. How long had you been a roofer when the accidents happened?

A.______

B.______

C.______

21. What kind of job was it?

	Apartment House	Single Family Home	Shopping Center	Office Bldg.
A.				
B.				
C.				

22. Would you consider it a large or small job?

	Large	Small
A.	________	________
B.	________	________
C.	________	________

23. Could you briefly describe the circumstances at the time of the accident? What led up to it?

24. Accidents are something that we all live with in our lives away from the job. Have you ever had an accident in your home or elsewhere that resulted in an injury requiring medical attention? Yes No

How many times? ________

APPENDIX I (continued)

25. What do you think was the cause of the accident?
Your carelessness________
Carelessness of someone else________
Faulty equipment or mechanical failure________
An act of God or unavoidable circumstance________

26. Have you ever had a driving accident? Yes No

How many? ________

27. I've been asking you about accidents that you have experienced. Have you seen any accidents involving others in the past year or so? Yes No

Think of the one that stands out most clearly in your mind. What do you think was its cause?
Carelessness on part of the injured________
Carelessness of someone else________
Faulty equipment________
An act of God or unavoidable circumstance________

28. Do you believe there is such a thing as an accident prone worker or in other words, do some roofers have more than their share of accidents? Yes No

APPENDIX 2

APPENDIX II

Distribution of Subjects' Responses to Interview Questionnaire Items

Total Sample
123 Subjects

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
29 Do you think it is dangerous work?				
Yes?	52	86.7	49	77.8
No?	8	13.3	13	20.6
Other?	0	0	1	1.6
30 How dangerous is it in your opinion? Would you say it is:				
Extremely dangerous-- more so than almost any kind of work?	12	20	14	22.2
More dangerous than most kinds of work?	29	48.3	27	42.9
About as dangerous as most kinds of work?	19	31.7	20	31.7
Less dangerous than most kinds of work?	0	0	1	1.6
Other?	0	0	1	1.6
31 What would you say are the three most dangerous operations in roofing in order?				
32 Do all roofers have about the same exposure to these operations?				
Yes?	44	73.3	47	74.6
No?	14	23.3	16	25.3
Other?	2	3.3	0	0
33 As you gain experience in roofing, do you find that it is more or less dangerous than you believed at first?				
More?	23	38.3	26	41.3
Less?	33	55.0	32	50.8
Same?	4	6.7	5	7.9
34 You've had only 0-1-2-3 accidents in your years as a roofer. How have you managed to avoid having more? (Most important reason only)				
I'm careful	43	71.7	54	85.7
I'm lucky	5	8.3	6	9.5
I work for a good company.	2	3.3	1	1.6
The men I work with are careful.	9	15.0	2	3.2
Never had accident.	1	1.7	0	0

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
35 Do you think you can continue to work in roofing indefinitely without (another) accident?				
I am certain I can.	5	8.3	3	4.8
I think it is most likely that I can.	8	13.3	14	22.2
There's no way of telling.	32	53.3	29	46.0
I think it is most likely that I can't.	9	15.0	9	14.3
I am certain that I can't.	6	10.0	5	7.9
Other.	0	0	3	4.8
36 This is a hard question to answer, but if you stay in roofing until you retire, what do you think your chances of having a minor/major accident are?				
Minor: I'm sure I won't have one.	1	1.7	1	1.6
I think it is most unlikely that I will ever have one.	2	3.3	2	3.2
There's no way of telling.	13	21.7	19	30.2
I think it's most likely that I'll have at least one.	19	31.7	14	22.2
I'm sure I'll have at least one.	23	38.3	23	36.5
Other.	2	3.3	5	8.0
Major: I'm sure I won't have one.	6	10.0	2	3.2
I think it is most unlikely that I will ever have one.	7	11.1	15	23.8
There's no way of telling.	42	70.0	37	58.7
I think it's most likely that I'll have at least one.	1	1.7	2	3.2
I'm sure I'll have at least one.	2	3.3	3	4.8
Other.	2	3.3	4	6.3
37 Everyone is a little bit different in the care they exercise on the job. How would you describe yourself?				
Very careful--always act in a way that avoids or minimizes risk.	24	40.0	32	50.8
Generally careful--usually act in a way that avoids or minimizes risk.	24	40.0	24	38.1
About as careful as the average roofer.	7	11.7	4	6.3
Could be more careful--could take fewer chances.	5	8.3	3	4.8
Tend to be very careless--just try to get the work done as fast as possible and don't think about risk or danger.	0	0	0	0

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
38 In the accidents or near accidents you have seen in which carelessness was the cause, what do you think made the man act as he did?				
Trying to save time or effort.	33	55.0	31	49.2
Just didn't think of the consequences.	20	33.3	26	41.3
Was trying to show off.	3	5.0	1	1.6
Pushed by Supervisor.	4	6.7	4	6.3
Careless.	0	0	1	1.6
39 How much control do you feel the roofers themselves have over what happens to them on the job?				
Almost no control.	2	3.3	1	1.6
Almost total or complete control.	38	63.3	45	71.4
Primary control but luck is a factor.	15	25.0	12	19.0
Little control, mostly a matter of luck.	5	8.3	5	7.9
40 Do you think most roofers feel like accidents are going to happen no matter what?				
Yes?	26	43.3	22	34.9
No?	34	56.7	41	65.1
41 Do you think it is possible to be maximally productive when you follow the safest working procedures?				
Yes?	38	63.3	48	76.0
No?	22	36.7	15	23.8
42 Many people think that the company that one works for has a lot to do with safety. In other words, some companies are safer to work for than others. Do you believe this?				
Yes?	50	83.3	52	82.5
No?	10	16.7	11	17.5
43 Which of the following pieces of safety equipment does your company require you to wear on the job?				
44 Does your company have a formal safety or accident prevention program?				
Yes?	16	26.7	23	36.5
No?	43	71.7	39	61.9
Other?	1	1.7	1	1.6

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
45 How much emphasis does your foreman place on safety on the job?				
A great deal--he regularly and frequently makes us aware of dangerous conditions, equipment or procedures.	34	56.7	30	47.6
About average--he occasionally points out the most dangerous conditions, procedures and equipment.	14	23.3	24	38.1
Very little emphasis--he seldom or never mentions danger or safety.	12	20.0	8	12.7
Other.	0	0	1	1.6
46 Do you think that new men and apprentices get proper safety instruction in this company?				
Yes?	40	66.7	41	65.1
No?	20	33.3	20	31.7
Other?	0	0	2	0
47 Who do you think has primary responsibility for safety on the job?				
The roofer himself.	26	43.3	22	34.9
The foreman.	29	48.3	35	55.6
The company.	0	0	3	4.8
The Union.	4	6.7	1	1.6
Don't know.	0	0	2	3.2
Nobody.	1	1.7	0	0
48 How important is the safety of the roofers to the management of this company?				
Very important--they do about as much as possible to make the job safe.	28	46.7	30	47.6
They are concerned about safety, but they could do more than they are doing to make the job safe.	17	28.3	21	33.3
They are really only interested in getting the jobs done as fast and cheaply as possible.	15	25.0	11	17.5
Safety is the roofer's responsibility as far as they are concerned.	0	0	1	1.6
49 If you had the power to do anything you wanted in order to make roofing less dangerous, what would you do?	0	0	0	0

APPENDIX II (continued)

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
50 How do roofers learn to become safe workers? Pick the single most important source.				
Their own experience on the job.	20	33.3	24	38.1
Formal training through the apprenticeship program or other programs sponsored by the company or union.	4	6.7	10	15.9
From the foreman.	6	10.0	4	6.3
From the more experienced roofers.	30	50.0	25	39.7
51 Do you know anything about the Southern California Roofing Association?				
Yes?	21	35.0	16	25.4
No?	38	63.3	47	74.6
Other?	1	1.7	0	0
52 Do you feel this association has had any effect in roofing safety?				
Yes?	6	10.0	10	15.5
No?	16	26.7	8	12.7
Other	38	63.7	45	71.4
53 Have you seen or read the safety bulletins or articles of this or any other roofing contractor associations?				
Yes?	12	20.0	15	23.8
No?	10	16.7	3	4.8
Other?	38	63.3	45	71.4
54 What role does the roofing contractor's association have in emphasizing safety in apprenticeship programs?				
None.	7	11.7	3	4.8
D.K.	50	83.3	60	95.2
Much.	3	50.0	0	0
55 You've been a roofer for several years now. What do you like about this kind of work?	0	0	0	0
56 I guess every job has some bad features, too. What are some of the things you don't like about roofing?	0	0	0	0
57 If you had to do it all over again, would you be a roofer?				
Yes?	29	48.3	37	58.7
No?	29	48.3	26	41.3
Other?	1	1.7	0	0

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
58 If you had a son, would you want him to be a roofer?				
Yes?	9	15.0	17	27.0
No?	50	83.3	46	73.0
Other?	1	1.7	0	0
59 Do you think this kind of work allows you to use your abilities and the training you've had to the fullest?				
Yes?	41	68.3	46	73.0
No?	18	30.0	17	27.0
Other?	0	1.7	0	0
60 How hard do you have to work in order to do what is expected of you?				
Feel under pressure to work as fast as I can throughout the shift.	17	28.3	7	11.9
The pace is fast at times, but it slows down at others so it's not stressful.	39	65.0	54	85.7
The pace is generally slow, there is a lot of waiting time and it even becomes boring at times.	3	5.0	2	3.2
61 How do you feel about the pay scale and other benefits associated with roofing?				
Very satisfied--better than I could do at any other job.	9	15.0	9	14.3
Satisfied--think the pay and benefits are fair.	29	48.3	27	42.9
Rather dissatisfied--other trades and crafts are paid better for the work they do.	20	33.3	26	41.3
Very dissatisfied--actively wants to get into another line of work.	1	1.7	1	1.6
Other.	1	1.7		
62 When you consider everything about roofing work (work itself, pay, conditions, danger, men, etc.) how satisfied are you with it as a career?				
Very satisfied--never consider changing.	11	17.5	15	25.0
Generally satisfied--don't think I could find anything much better.	33	52.4	30	50.0
It's a job--that's all.	9	14.3	11	18.3
Generally dissatisfied--would like to do something else but am not really looking.	6	9.5	1	1.7
Very dissatisfied--will quit as soon as I can.	4	6.3	2	3.3

Questionnaire Items	High Accident Group N	Percent	Low Accident Group N	Percent
63 How secure is roofing for you as a year round job?				
I can work as much as I want--there's plenty of work.	20	33.3	22	34.9
I'm generally sure of having work but it can be slow at times.	28	46.7	30	47.6
It's pretty uncertain; you're never sure.	4	6.7	4	6.3
It's very uncertain-- only thing you can be sure of is that you'll be out of work at least part of the year.	6	10.0	6	9.5
Other.	1	1.7	1	1.6
Other.	1	1.7	0	0
64 How is_______ as a company to work for, considering all things (pay, conditions, equipment, people, management, etc.)?				
Excellent-- can't imagine a better one to work for.	28	46.7	18	28.6
Good-- better than most.	21	35.0	29	46.0
Average-- no better or worse than the rest.	7	11.7	12	19.0
Poor--I've worked for better or I think it's probably worse than most.	2	3.3	3	4.8
Other.	1	1.7	1	1.6
Other.	1	1.7	0	0
65 How would you judge______? (the company [-ies] that subject worked for at time of his accident [s])				
Company A.				
Excellent--can't imagine a better one.	18	30.0	9	14.3
Good--better than most.	19	31.7	12	19.0
Average--no better or worse than the rest.	10	16.7	6	9.5
Poor-- think it's probably worse than most.	5	8.3	2	3.2
Other.	8	13.4	34	54.0
Company B.				
Excellent.	8	13.4	2	3.2
Good.	14	23.3	4	6.3
Average.	9	15.0	3	4.8
Poor.	5	8.3	0	0
Other.	24	40.0	54	85.7

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
65 Continued....				
Company C.				
Excellent.	4	6.7	0	0
Good.	7	11.7	0	0
Average.	12	20.0	0	0
Poor.	2	3.3	1	1.6
Other.	35	58.4	62	98.4
Company D.				
Excellent.	2	3.3	0	0
Good.	4	6.7	0	0
Average.	2	3.3	0	0
Poor.	2	3.3	0	0
Other.	49	81.7	63	100.0
Company E.				
Excellent.	2	3.3	0	0
Good.	3	5.0	0	0
Average.	2	3.3	0	0
Poor.	1	1.7	0	0
Other.	52	86.7	63	100.0
66 Do you think the top management of this company is really concerned or interested in you and the other roofers?				
Yes?	42	70.0	49	77.8
No?	16	26.7	14	22.2
Other?	1	1.7	0	0
Other?	1	1.7	0	0
67 Do you think there are any differences between union and non-union jobs in roofing?				
Yes?	46	76.7	55	87.3
No?	12	20.0	4	6.3
Other?	2	3.4	4	6.3
68 Do you think that overall you are better off as a member of your union than you would be as a non-union roofer?				
Yes?	51	85.0	51	81.0
No?	7	11.7	8	12.7
Other?	2	3.4	4	6.3
69 How good a job do you think the union does in representing your interests?				
Excellent.	13	21.7	14	22.2
Good job.	23	38.3	21	33.3
Just adequate.	15	25.0	15	23.8
Poor.	5	8.3	6	9.5
Other.	4	6.7	7	11.1

APPENDIX II (continued)

Questionnaire Items	High Accident Group N	Percent	Low Accident Group N	Percent
70 Which do you think is more important to your welfare and future--the union or this company?				
Union.	40	66.7	38	60.3
Company.	12	20.0	9	14.3
Equal.	7	11.7	12	19.0
Other.	1	1.7	4	6.3
71 Do you think the interests, goals, and objectives of this company and the union are:				
The same.	9	15.0	10	15.9
Compatible.	29	48.3	32	50.8
Unrelated.	10	16.7	4	6.3
In conflict.	11	18.3	13	20.6
Other.	1	1.7	4	6.3
72 How is your foreman as a man to work for?				
Excellent-- the best in almost every respect.	21	35.0	23	36.5
Good--better than most foremen I've seen.	27	45.0	26	41.3
Just O.K.--no better or worse than most.	8	13.3	7	11.1
Poor--don't think he's as good as most roofing foremen.	2	3.3	6	9.5
Other.	2	3.3	1	1.6
73 Do you think your foreman lays out the work and runs the job in any orderly way?				
Yes?	49	81.7	47	74.6
No?	9	15.0	14	22.2
Other?	2	3.3	2	3.2
74 Do you think your foreman causes you and the other men in the crew to feel pressured or stressed?				
Yes?	17	28.3	18	28.6
No?	41	68.3	42	66.7
Other?	2	3.3	3	4.8
75 Do you think your foreman knows you well?				
Yes?	49	81.7	52	82.5
No?	9	15.0	10	15.9
Other?	2	1.7	1	1.6
76 Is your foreman the kind of person you can discuss your problems with?				
Yes?	44	73.3	48	76.2
No?	13	21.7	13	20.6
Other?	3	5.0	2	3.3

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
77 Does your foreman fully recognize how hard you work and how much you do for the job?				
Yes?	52	86.7	52	82.5
No?	6	10.0	8	12.7
Other?	2	3.3	3	4.8
78 Is your foreman well liked by the men in the crew?				
Yes?	50	83.3	55	87.3
No?	7	11.7	5	7.9
Other?	3	5.0	3	4.8
79 Is he respected by the men in the crew?				
Yes?	51	85.0	53	84.1
No?	7	11.7	8	12.7
Other?	2	3.3	2	3.2
80 Think back to the job on which you were injured or last saw an accident. How would you rate the foreman on his over-all ability to run a job?				
Excellent--the best in almost every respect.	14	23.3	11	17.5
Good--better than most foremen I've seen.	22	36.7	25	39.7
Just O.K.--no better or worse than most.	8	13.3	10	15.9
Poor--don't think he was as good as most roofing foremen.	13	21.7	11	17.5
Other.	3	5.0	6	9.5
81 Foreman's strong points? Foreman's weak points?				
82 How would you rate your present crew over-all as a group of men to work with?				
Excellent--couldn't imagine a better group to work with.	18	30.0	14	22.2
Good--better than most crews I've worked with or seen.	29	48.3	28	44.4
Average--no better or worse than other roofing crews.	10	16.7	18	28.6
Poor--think it is worse than most roofing crews.	3	5.0	2	3.2
Other.	0	0	1	1.6

Questionnaire Items	High Accident Group N	Percent	Low Accident Group N	Percent
83 Thinking back to your last accident or the last accident that occurred in one of your crews, how would you rate that crew over-all as a group of men to work with?				
Excellent--couldn't imagine a better group to work with.	12	20.0	9	14.3
Good-- better than most roofing crews I've worked with or seen.	26	43.3	27	42.9
Average--no better or worse than other roofing crews.	13	21.7	15	23.8
Poor--think it is worse than most roofing crews.	7	11.7	5	7.9
Other.	2	3.3	7	11.1
84 Do you think that the men you work with have any effect on your safety or is safety more an individual responsibility?				
Crew.	45	75.0	56	88.9
Individual.	14	23.3	7	11.1
Other.	1	1.7	0	0
85 In your experience, have you found that the roofing crews that are most conscious of safety are:				
Also ones that get the most work done.	11	18.3	18	28.6
Somewhat slower and less productive than other crews.	28	46.7	24	38.1
The safety consciousness of the crew really doesn't affect production one way or the other.	20	33.3	21	33.3
86 How well do the men in your crew get along with each other?				
Very well--almost no conflict or disagreement in the group.	37	61.7	30	47.6
Pretty well--less conflict and disagreement than you find in most crews.	16	26.7	20	31.7
Average--about as much conflict or disagreement as you find in any group.	6	10.0	10	15.9
Poor--there is more conflict or disagreement among the men than you have seen in other crews.	0	0	2	3.2
Other.	1	1.7	1	1.6

Questionnaire Items	High Accident Group N	Percent	Low Accident Grc N	Perce
87 Do you consider the men you now work with to be:				
An important source of pleasure and enjoyment to you both on and off the job.	24	40.0	19	30.2
Generally a source of pleasure at least while on the job.	28	46.7	35	55.6
Unimportant to me one way or the other.	5	8.3	7	11.1
Frequently a source of dissatisfaction or unhappiness during the shift.	1	1.7	1	1.6
A source of dissatisfaction or unpleasantness that affects me both on and off the job.	1	1.7	1	1.6
Other.	1	1.7	0	0
88 Would you say that the men you work with generally (not just on this job) are important to you or is one crew pretty much the same as another as far as you're concerned?				
Important.	43	71.7	50	79.4
Indifferent.	15	25.0	12	19.0
Other.	2	3.3	1	1.6

APPENDIX 3

APPENDIX III

Distribution of Subjects' Responses
to Interview Questionnaire Items

Extreme Sample
82 Subjects

Questionnaire Items	High Accident Group N	Percent	Low Accident Group N	Percent
29 Do you think it is dangerous work?				
Yes?	42	89.4	26	74.3
No?	5	10.6	8	22.9
30 How dangerous is it in your opinion? Would you say it is:				
Extremely dangerous-- more so than almost any kind of work?	11	23.4	5	14.3
More dangerous than most kinds of work?	24	51.1	15	42.9
About as dangerous as most kinds of work?	12	25.5	13	37.1
Less dangerous than most kinds of work?	0	0	1	2.9
31 What would you say are the three most dangerous operations in roofing in order?				
32 Do all roofers have about the same exposure to these operations?				
Yes?	35	74.5	27	77.1
No?	10	21.3	8	22.9
—	2	4.3	0	0
33 As you gain experience in roofing, do you find that it is more or less dangerous than you believed at first?				
More?	18	38.3	16	45.7
Less?	25	53.2	16	45.7
Same?	4	8.5	3	8.6
34 You've had only 0-1-2-3 accidents in your years as a roofer. How have you managed to avoid having more? (Most important reason only)				
I'm careful	37	78.7	30	85.7
I'm lucky	4	8.5	3	8.6
I work for a good company	1	2.1	1	2.9
The men I work with are careful	4	8.5	1	2.9
Never had accident	1	2.1		

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
35 Do you think you can continue to work in roofing indefinitely without (another) accident?				
I am certain I can.	1	2.1	1	2.9
I think it is most likely that I can.	7	14.9	10	28.6
There's no way of telling.	29	61.7	19	54.3
I think it is most likely that I can't.	6	12.8	2	5.7
I am certain that I can't.	4	8.5	1	2.9
36 This is a hard question to answer, but if you stay in roofing until you retire, what do you think your chances of having a minor/major accident are?				
Minor				
I'm sure I won't have one.	1	2.1	1	2.9
I think it is most unlikely that I will ever have one.	12	25.5	2	5.7
There's no way of telling.	15	31.9	15	42.9
I think it's most likely that I'll have at least one.	17	36.2	7	20.0
I'm sure I'll have at least one.	2	4.3	7	20.0
Major				
I'm sure I won't have one.	2	4.3	1	2.9
I think it is most unlikely that I will ever have one.	7	14.9	8	22.9
There's no way of telling.	34	72.3	22	62.9
I think it's most likely that I'll have at least one.	0	0	0	0.0
I'm sure I'll have at least one.	2	4.3	1	2.9
37 Everyone is a little bit different in the care they exercise on the job. How would you describe yourself?				
Very careful--always act in a way that avoids or minimizes risk.	15	31.8	18	51.4
Generally careful--usually act in a way that avoids or minimizes risk.	21	44.7	13	37.1
About as careful as the average roofer.	6	12.8	3	8.6
Could be more careful--could take fewer chances.	5	10.6	1	2.9
Tend to be very careless--just try to get the work done as fast as possible and don't think about risk or danger.	0	0	0	0

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
38 In the accidents or near accidents you have seen in which carelessness was the cause, what do you think made the man act as he did?				
Trying to save time or effort.	25	53.2	15	42.2
Just didn't think of the consequences.	18	38.3	15	42.9
Was trying to show off.	1	2.1	1	2.9
Pushed by Supervisor.	3	6.4	3	8.6
Careless.	0	0	1	2.9
39 How much control do you feel the roofers themselves have over what happens to them on the job?				
Almost no control.	2	4.3	1	2.9
Almost total or complete control.	28	59.6	25	71.4
Primary control but luck is a factor.	12	25.5	8	22.9
Little control, mostly a matter of luck.	5	10.6	1	2.9
40 Do you think most roofers feel like accidents are going to happen no matter what?				
Yes?	22	46.8	10	28.6
No?	25	53.2	25	71.4
41 Do you think it is possible to be maximally productive when you follow the safest working procedures?				
Yes?	30	63.8	30	85.7
No?	17	36.2	5	14.3
42 Many people think that the company that one works for has a lot to do with safety. In other words, some companies are safer to work for than others. Do you believe this?				
Yes?	40	85.1	28	80.0
No?	7	14.9	7	20.0
43 Which of the following pieces of safety equipment does your company require you to wear on the job?	0	0	0	0
44 Does your company have a formal safety or accident prevention program?				
Yes?	12	25.5	13	37.1
No?	35	74.5	21	60.0

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
45 How much emphasis does your foreman place on safety on the job?				
A great deal--he regularly and frequently makes us aware of dangerous conditions, equipment or procedures.	28	59.6	19	54.3
About average--he occasionally points out the most dangerous conditions, procedures and equipment.	9	19.1	12	34.3
Very little emphasis--he seldom or never mentions danger or safety.	10	21.3	3	8.6
46 Do you think that new men and apprentices get proper safety instruction in this company?				
Yes?	31	66.0	27	77.1
No?	16	34.0	7	20.0
47 Who do you think has primary responsibility for safety on the job?				
The roofer himself.	20	42.6	8	22.9
The foreman.	23	48.9	23	65.7
The company.	3	6.4	3	8.6
The Union.	0	0	1	2.9
Don't know.	0	0	0	0
Nobody.	1	2.1	0	0
48 How important is the safety of the roofers to the management of this company?				
Very important--they do about as much as possible to make the job safe.	21	44.7	18	51.4
They are concerned about safety, but they could do more than they are doing to make the job safe.	13	27.7	11	31.4
They are really only interested in getting the jobs done as fast and cheaply as possible.	13	27.7	5	14.3
Safety is the roofer's responsibility as far as they are concerned.	0	0	0	0
49 If you had the power to do anything you wanted in order to make roofing less dangerous, what would you do?	0	0	0	0

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
50 How do roofers learn to become safe workers? Pick the single most important source.				
Their own experience on the job.	15	31.9	12	34.3
Formal training through the apprenticeship program or other programs sponsored by the company or union.	2	4.3	8	22.9
From the foreman.	4	8.5	1	2.9
From the more experienced roofers.	26	55.3	14	40.0
51 Do you know anything about the Southern California Roofing Association?				
Yes?	18	38.3	10	28.6
No?	29	61.7	25	71.4
52 Do you feel this association has had any effect in roofing safety?				
Yes?	5	10.6	6	17.1
No?	14	29.9	5	14.3
Other	28	59.6	24	68.6
53 Have you seen or read the safety bulletins or articles of this or any other roofing contractor associations?				
Yes?	11	23.4	9	25.7
No?	8	17.0	2	5.7
Other?	28	59.6	24	68.6
54 What role does the roofing contractor's association have in emphasizing safety in apprenticeship programs?				
None	6	12.8	1	2.9
D.K.	38	80.9	34	97.1
Much	3	6.4	0	0
55 You've been a roofer for several years now. What do you like about this kind of work?	0	0	0	0
56 I guess every job has some bad features, too. What are some of the things you don't like about roofing?	0	0	0	0
57 If you had to do it all over again, would you be a roofer?				
Yes?	23	48.9	19	54.3
No?	22	46.8	16	45.7
Other?	2	4.2	0	0

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
58 If you had a son, would you want him to be a roofer?				
Yes?	8	17.0	8	22.9
No?	38	80.9	27	77.1
59 Do you think this kind of work allows you to use your abilities and the training you've had to the fullest?				
Yes?	32	68.1	26	74.3
No?	15	31.9	9	25.7
60 How hard do you have to work in order to do what is expected of you?				
Feel under pressure to work as fast as I can throughout the shift.	15	31.9	4	11.4
The pace is fast at times, but it slows down at others so it's not stressful.	29	61.7	30	85.7
The pace is generally slow, there is a lot of waiting time and it even becomes boring at times.	2	4.3	1	2.9
61 How do you feel about the pay scale and other benefits associated with roofing?				
Very satisfied--better than I could do at any other job.	7	14.9	5	14.3
Satisfied--think the pay and benefits are fair.	23	48.9	17	48.6
Rather dissatisfied--other trades and crafts are paid better for the work they do.	15	31.9	13	37.1
Very dissatisfied--actively wants to get into another line of work.	1	2.1	0	0
62 When you consider everything about roofing work (work itself, pay, conditions, danger, men, etc.) how satisfied are you with it as a career?				
Very satisfied--never consider changing.	12	25.5	8	22.9
Generally satisfied--don't think I could find anything much better.	23	48.9	21	60.0
It's a job--that's all.	9	19.1	4	11.4
Generally dissatisfied--would like to do something else but am not really looking.	0	0	1	2.9
Very dissatisfied--will quit as soon as I can.	2	4.3	1	2.9

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	Percent	Low Accident Group N	Percent
63 How secure is roofing for you as a year round job?				
I can work as much as I want-- there's plenty of work.	13	27.7	15	42.9
I'm generally sure of having work but it can be slow at times.	23	48.9	14	40.0
It's pretty uncertain; you're never sure.	3	6.4	3	8.6
It's very uncertain-- only thing you can be sure of is that you'll be out of work at least part of the year.	6	12.8	2	5.7
Other.	2	4.2	1	2.9
64 How is_______ as a company to work for, considering all things (pay, conditions, equipment, people, management, etc.)?				
Excellent-- can't imagine a better one to work for.	22	46.8	13	37.1
Good-- better than most.	16	34.0	16	45.7
Average-- no better or worse than the rest.	5	10.6	4	11.4
Poor--I've worked for better or I think it's probably worse than most.	2	4.3	1	2.9
Other.	2	2.1	1	2.9
65 How would you judge______? (the company [-ies] that subject worked for at time of his accident [s])				
Company A.				
Excellent--can't imagine a better one.	14	29.8	8	22.9
Good--better than most.	14	29.8	8	22.9
Average--no better or worse than the rest.	8	17.0	3	8.6
Poor-- think it's probably worse than most.	4	8.5	2	5.7
Other.	7	14.8	14	40.0
Company B.				
Excellent.	6	12.8	1	2.9
Good.	11	23.4	4	11.4
Average.	8	17.0	2	5.7
Poor.	5	10.6	0	0
Other.	17	36.1	28	80.0

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
65 Continued....				
Company C.				
Excellent.	3	6.4	0	0
Good.	5	10.6	0	0
Average.	10	21.3	0	0
Poor.	2	4.3	1	2.9
Other.	27	57.4	34	97.1
Company D.				
Excellent.	2	4.3	0	0
Good.	2	4.3	0	0
Average.	1	2.1	0	0
Poor.	2	4.3	0	0
Other.	40	85.1	35	100.0
Company E.				
Excellent.	2	4.3	0	0
Good.	2	4.3	0	0
Average.	2	4.3	0	0
Poor.	1	2.1	0	0
Other.	40	85.1	35	100.0
66 Do you think the top management of this company is really concerned or interested in you and the other roofers?				
Yes?	31	66.0	29	82.9
No?	14	29.8	6	17.1
Other?	2	4.2	0	0
67 Do you think there are any differences between union and non-union jobs in roofing?				
Yes?	38	80.9	33	94.3
No?	7	14.9	1	2.9
Other?	2	2.1	1	2.9
68 Do you think that overall you are better off as a member of your union than you would be as a non-union roofer?				
Yes?	40	85.1	30	85.7
No?	5	10.6	4	11.4
Other?	2	4.2	1	2.9
69 How good a job do you think the union does in representing your interests?				
Excellent.	9	19.1	8	22.9
Good job.	18	38.3	16	45.7
Just adequate.	13	27.7	7	20.0
Poor.	4	8.5	2	5.7
Other.	3	6.4	2	5.7

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	Percent	Low Accident Group N	Percent
70 Which do you think is more important to your welfare and future--the union or this company?				
Union.	31	66.0	22	62.9
Company.	11	23.4	4	11.4
Equal.	4	8.5	8	22.9
Other.	1	2.1	1	2.9
71 Do you think the interests, goals, and objectives of this company and the union are:				
The same.	5	10.6	5	14.3
Compatible.	25	53.2	22	62.9
Unrelated.	8	17.0	0	0
In conflict.	8	17.0	7	20.0
Other.	1	2.1	1	2.9
72 How is your foreman as a man to work for?				
Excellent-- the best in almost every respect.	16	34.0	13	37.1
Good--better than most foremen I've seen.	20	46.6	16	45.7
Just O. K. --no better or worse than most.	7	14.9	4	11.4
Poor--don't think he's as good as most roofing foremen.	2	4.3	1	2.9
Other.	2	4.2	1	2.9
73 Do you think your foreman lays out the work and runs the job in any orderly way?				
Yes?	38	80.9	26	74.3
No?	7	14.9	7	20.0
Other?	2	4.2	2	5.7
74 Do you think your foreman causes you and the other men in the crew to feel pressured or stressed?				
Yes?	13	27.7	10	28.6
No?	32	68.1	23	65.7
Other?	2	4.2	2	5.7
75 Do you think your foreman knows you well?				
Yes?	39	83.0	31	88.6
No?	6	12.8	3	8.6
Other?	2	4.2	1	2.9
76 Is your foreman the kind of person you can discuss your problems with?				
Yes?	35	74.5	29	82.9
No?	10	21.3	5	14.3
Other?	2	4.2	1	2.9

APPENDIX III (continued)

Questionnaire Items	High Accident Group N	High Accident Group Percent	Low Accident Group N	Low Accident Group Percent
77 Does your foreman fully recognize how hard you work and how much you do for the job?				
Yes?	40	85.1	30	85.7
No?	5	10.6	3	8.6
Other?	2	4.2	1	2.9
78 Is your foreman well liked by the men in the crew?				
Yes?	39	83.0	31	88.6
No?	6	12.8	2	5.7
Other?	2	4.2	2	5.7
79 Is he respected by the men in the crew?				
Yes?	39	83.0	30	35.7
No?	6	12.8	4	11.4
Other?	2	4.2	1	2.9
80 Think back to the job on which you were injured or last saw an accident. How would you rate the foreman on his over-all ability to run a job?				
Excellent--the best in almost every respect.	10	21.3	8	22.9
Good--better than most foremen I've seen.	17	36.2	14	40.0
Just O.K.--no better or worse than most.	6	12.8	4	11.4
Poor--don't think he was as good as most roofing foremen.	11	23.4	6	17.1
Other.	3	4.3	3	8.6
81 Foreman's strong points? Foreman's weak points?				
82 How would you rate your present crew over-all as a group of men to work with?				
Excellent--couldn't imagine a better group to work with.	14	29.8	7	20.0
Good--better than most crews I've worked with or seen.	23	48.9	17	48.6
Average--no better or worse than other roofing crews.	7	14.9	9	25.7
Poor--think it is worse than most roofing crews.	2	4.3	1	2.9
Other.	1	2.1	1	2.9

APPENDIX III (continued)

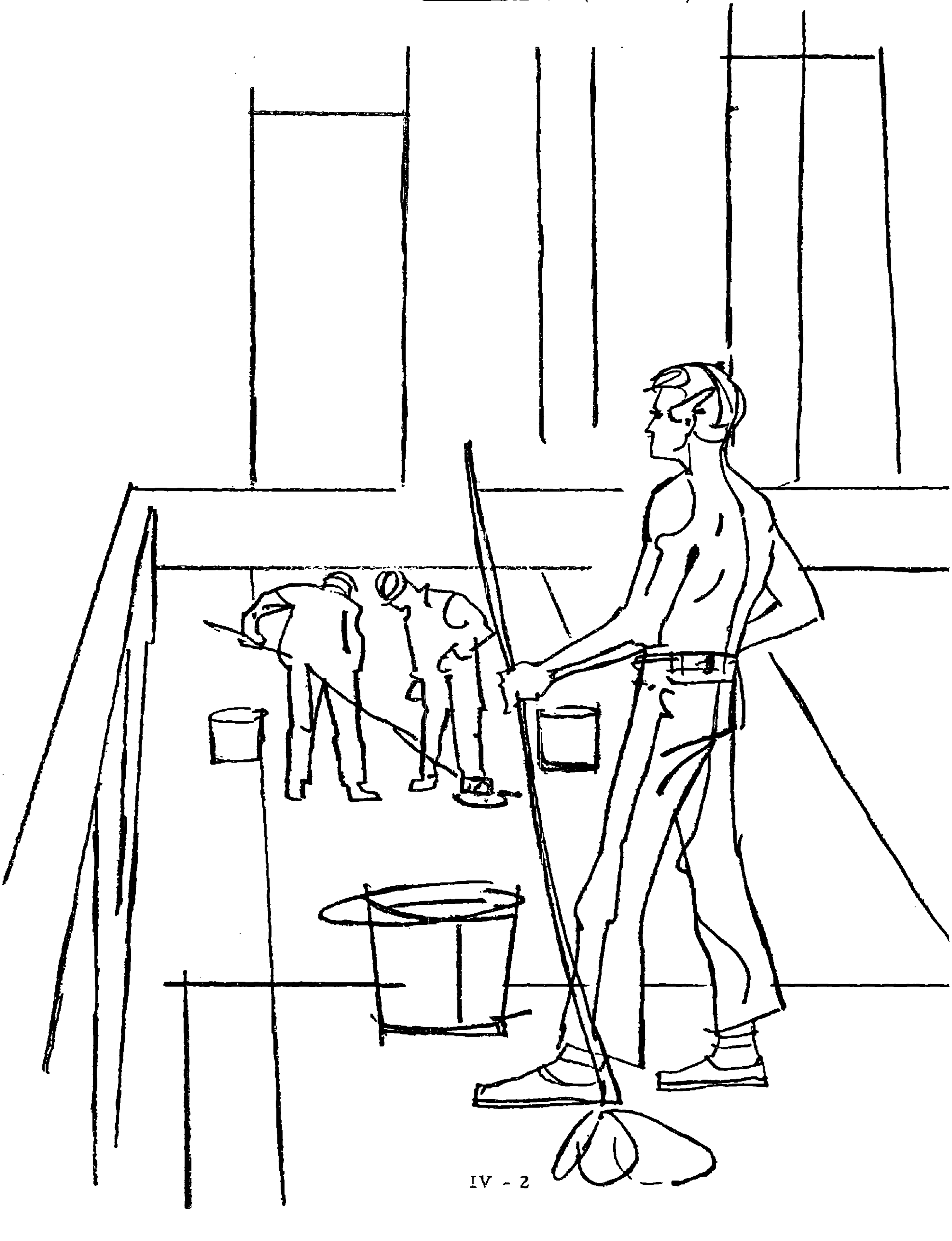
Questionnaire Items	High Accident Group N	Percent	Low Accident Group N	Percent
83 Thinking back to your last accident or the last accident that occurred in one of your crews, how would you rate that crew over-all as a group of men to work with?				
Excellent--couldn't imagine a better group to work with.	10	21.3	4	11.4
Good-- better than most roofing crews I've worked with or seen.	20	42.6	20	57.1
Average--no better or worse than other roofing crews.	9	19.1	6	17.1
Poor--think it is worse than most roofing crews.	6	12.8	2	5.7
Other.	2	4.3	2	5.7
84 Do you think that the men you work with have any effect on your safety or is safety more an individual responsibility?				
Crew.	34	72.3	32	91.4
Individual.	12	25.5	3	8.6
Other.	1	0	0	0
85 In your experience, have you found that the roofing crews that are most conscious of safety are:				
Also ones that get the most work done.	10	21.3	12	34.3
Somewhat slower and less productive than other crews.	21	44.7	15	42.9
The safety consciousness of the crew really doesn't affect production one way or the other.	15	31.9	8	22.9
Other.	1	2.1	0	0
86 How well do the men in your crew get along with each other?				
Very well--almost no conflict or disagreement in the group.	28	59.6	17	48.6
Pretty well--less conflict and disagreement than you find in most crews.	13	27.7	11	31.4
Average--about as much conflict or disagreement as you find in any group.	5	10.6	6	17.1
Poor--there is more conflict or disagreement among the men than you have seen in other crews.	1	2.1	0	2.9

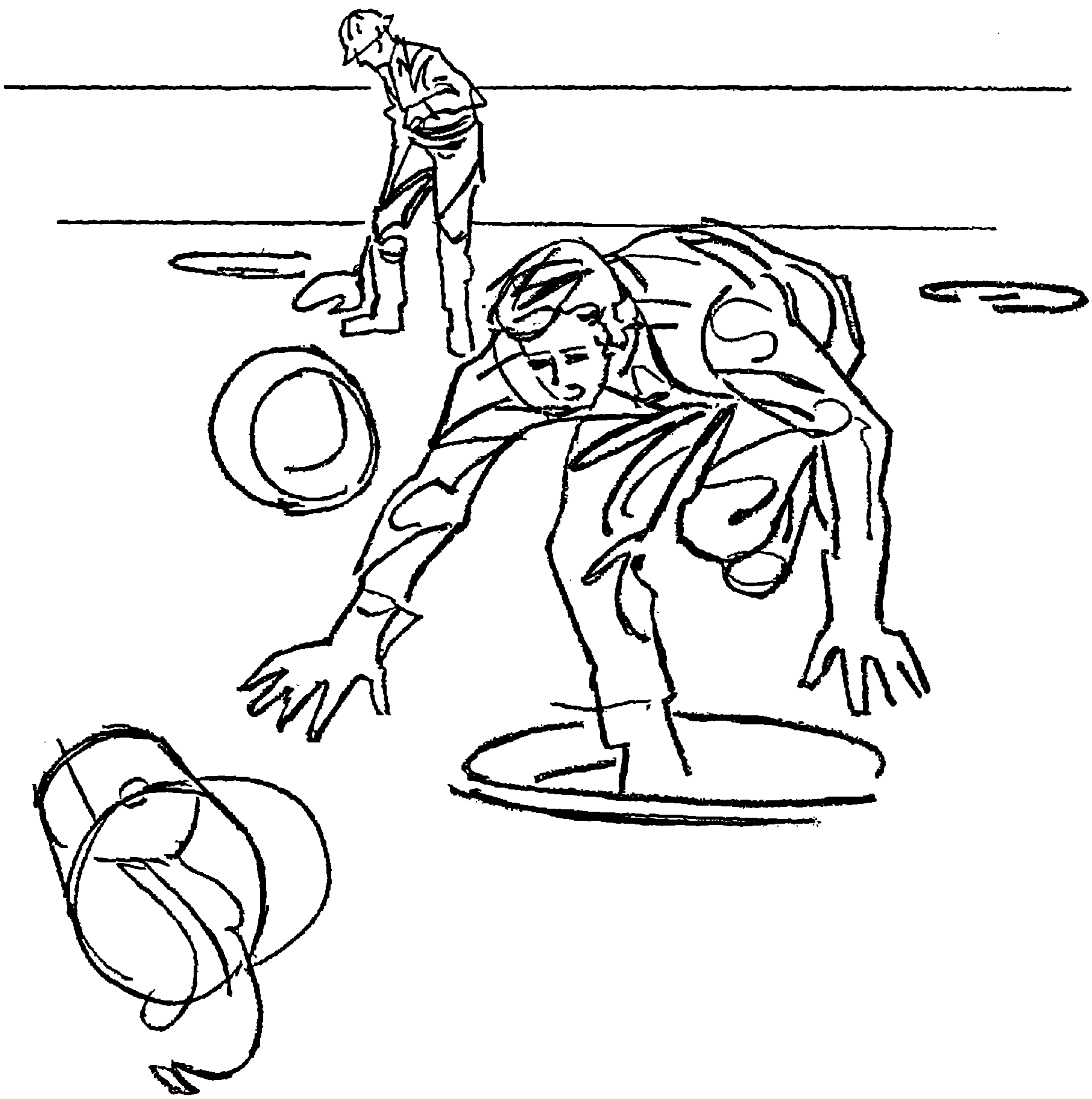
APPENDIX III (continued)

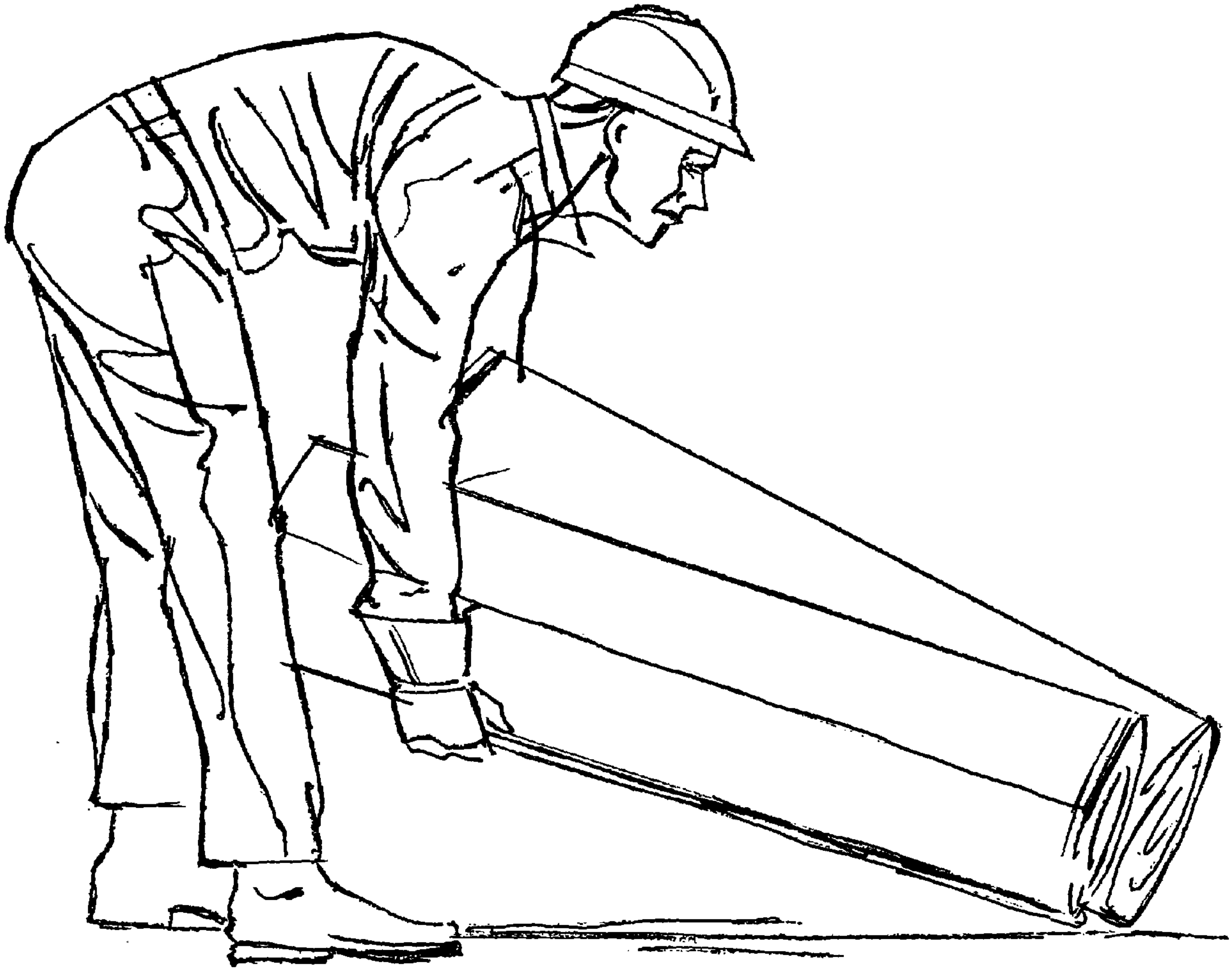
Questionnaire Items	High Accident Group N	Percent	Low Accident Group N	Percent
87 Do you consider the men you now work with to be:				
An important source of pleasure and enjoyment to you both on and off the job.	18	38.3	9	25.7
Generally a source of pleasure at least while on the job.	22	46.8	22	62.9
Unimportant to me one way or the other.	4	8.5	3	8.6
Frequently a source of dissatisfaction or unhappiness during the shift.	1	2.1	0	0
A source of dissatisfaction or unpleasantness that affects me both on and off the job.	1	2.1	0	0
Other.	0	2.1	1	2.9
88 Would you say that the men you work with generally (not just on this job) are important to you or is one crew pretty much the same as another as far as you're concerned?				
Important.	32	68.1	29	82.9
Indifferent.	13	27.7	5	14.3
Other.	2	4.2	1	2.9

APPENDIX 4

APPENDIX IV







APPENDIX 5

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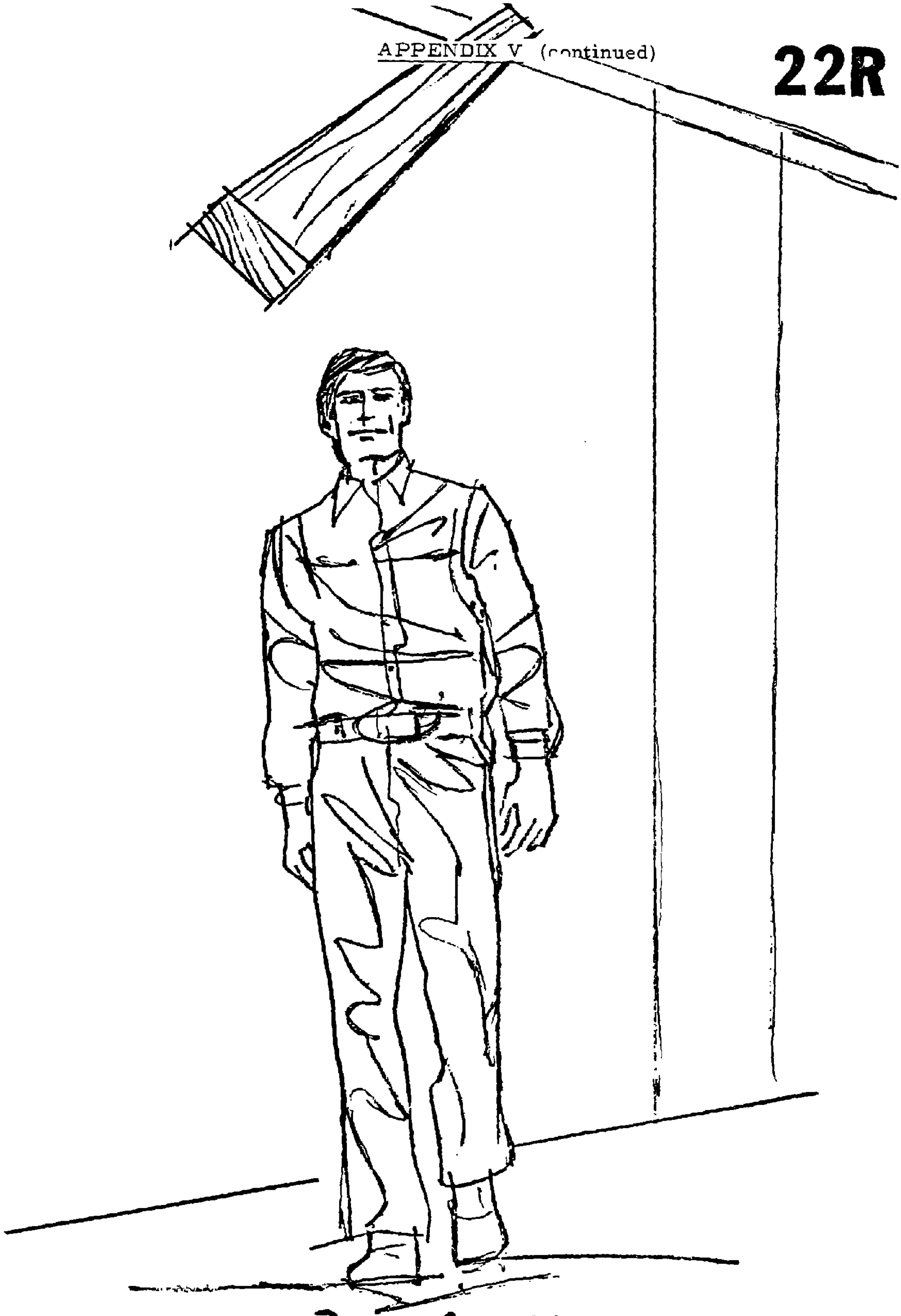

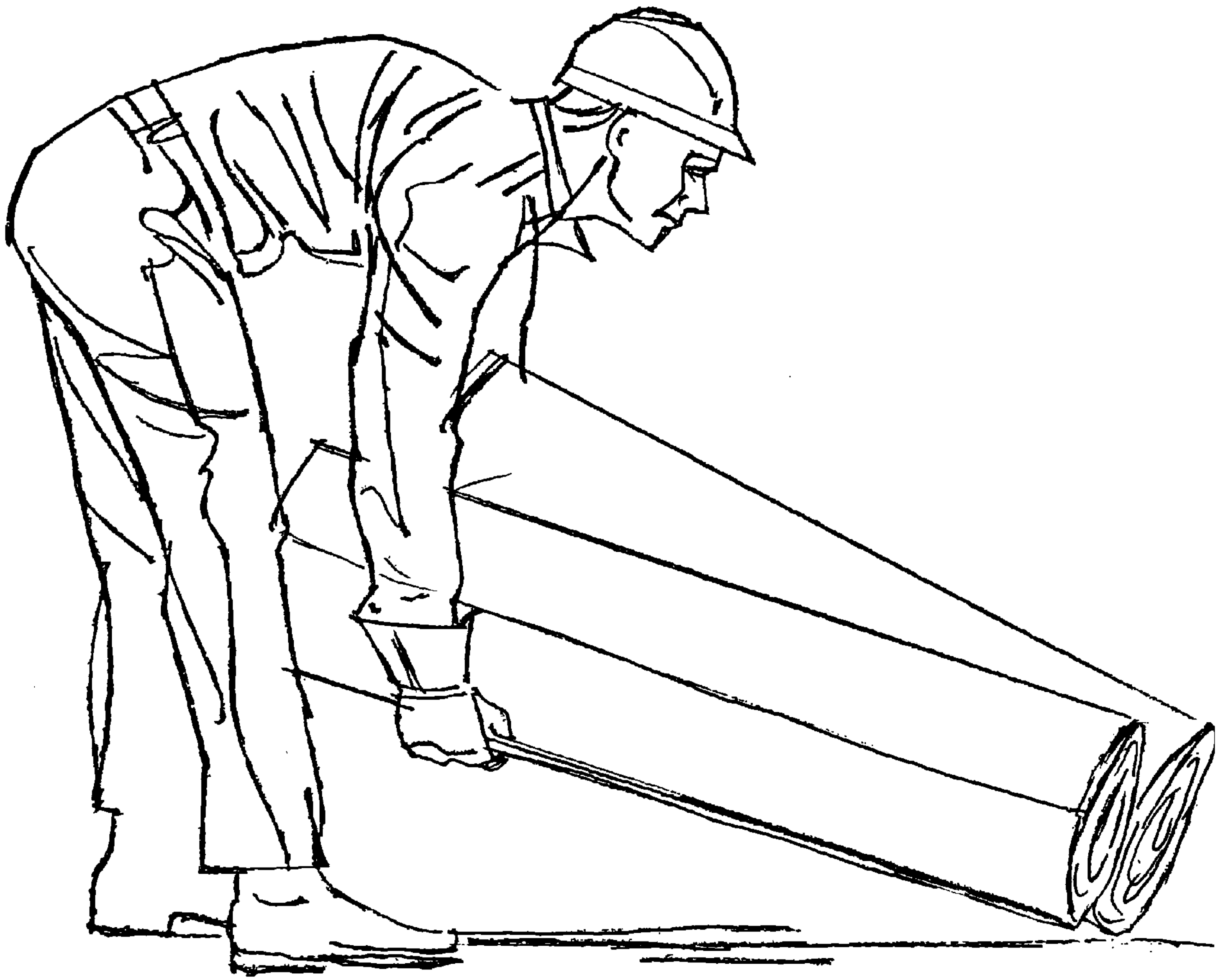

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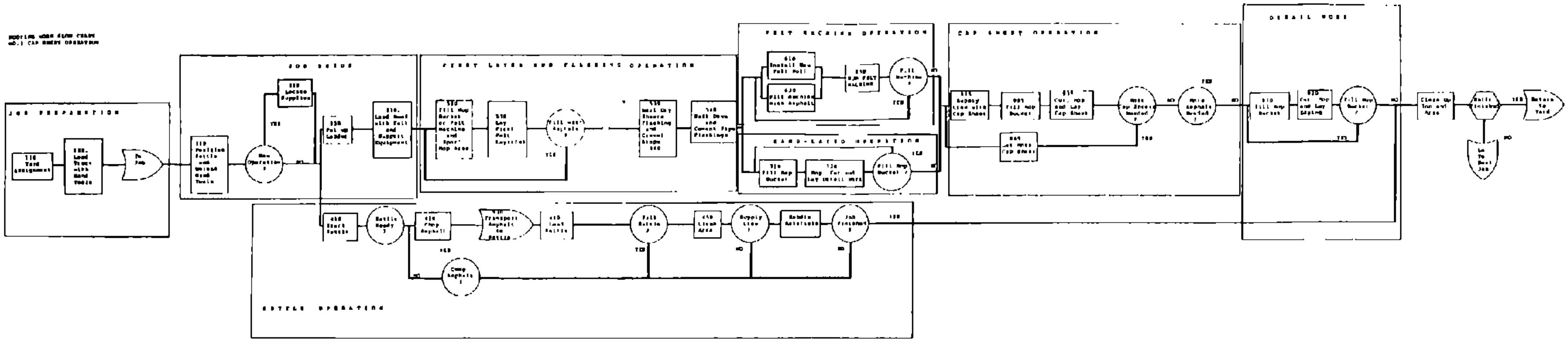
ROOFING WORK FLOW CHART
NO. 1 CAP SHEET OPERATION



ROOFING WORK FLOW CHART
NO. 2 ROCK LAYER OPERATION