

SAFETY ANALYSIS OF  
HIGH RISK ACTIVITIES  
WITHIN THE ROOFING INDUSTRY

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## 16. Abstracts

This report describes a study to identify high risk tasks within the roofing occupation. In this study, an analysis of injury data from BLS Workmen's Compensation Statistics from 1977 to 1980 was performed. Additionally, injury statistics for over 1000 roofer and slater injury reports from the NBS report "Roofing Accident Data Base" and a supplemental NIOSH report "Accident Descriptions in the Roofing Industry" were reviewed and extensively analyzed. The analysis of these injury statistics resulted in the identification of the four highest risk accident categories within the roofing occupation. A further analysis of this data determined hazardous tasks within each high risk category. The report contains numerous statistical tables which categorize each of the four high risk injury-types in detail, including estimated medical and indemnity costs associated with each category. Recommendations for reducing the risk of injury from each of the four high risk categories are given. Also included are proposed areas for further research.

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## INTRODUCTION

The construction industry is one of the few industries where the working environment is subject to continuous change. Each task performed during the construction activity has the potential to change this environment. This continual change can result in the exposure to many different hazards as the construction progresses, thus adding to the difficulty of implementing an effective safety program. A review of fatality rates compiled by the National Safety Council revealed that over the past 11 years, the construction industry has the highest fatality rate among the following industries: transport and public utilities, manufacturing, service, and trade industries (Figure 1). A review of incidence rates compiled by the Bureau of Labor Statistics (BLS) for the last 10 years also revealed that the construction industry has the highest incidence rate when compared with other major industries (Figure 2). As illustrated with these statistics, the construction industry typically has been and continues to be one of the most hazardous industries and thus, should continue to receive priority in terms of safety research efforts.

In an effort to improve the safety of the construction industry, the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR) has developed a construction safety research plan. This plan was developed to prioritize research areas within the construction industry and define where DSR will concentrate its future resources for construction safety research. One of the priority areas identified by this research plan as having a high risk of injury was the occupational classification of "roofers and slaters". This conclusion was based on the following facts:

1. Statistics in the construction research plan indicate that the incidence rate for the occupational classification "roofers and slaters" is 1.5 times greater than the average rate for the construction industry whose overall incidence rate is already one of the highest, over 15 per 100 workers (Figure 2).
2. Due to the labor intensiveness of the roofing occupation, it is assumed that roofing injuries would be amenable to prevention through the identification of high risk tasks and subsequent improvement in work practices.
3. The existence of comprehensive roofing injury data (as provided by previous NIOSH research) from which a task analysis could be performed.

Therefore, the purpose of this study was to identify high risk activities or tasks of roofers and slaters, and suggest appropriate countermeasures to reduce the risk of injury from performing these tasks. Also included are recommendations for further research needs. The study consisted of three phases:

- Phase I    A preliminary review of available injury statistics to identify the high risk accident categories within the roofing occupation.

Phase II A comprehensive analysis of the high risk accident categories to determine hazardous tasks within each category, including injury cost estimates.

Phase III The development of suggested countermeasures to reduce the risk of injury from these high risk categories and the identification of further research needs for further reducing the risks associated with these high risk tasks.

## PHASE I

### Background

In 1978, the construction industry employed 75,120 roofers and slaters or 1.7% of the industry's workforce. Most of the roofers and slaters are employed in Standard Industrial Classifications (SICs) 15 and 17 (Building Construction and Special Trades, respectively). Therefore, only injuries to roofers and slaters in these two SICs were considered in this study.

In 1978, the Building Construction industry (SIC 15) employed 4,490 roofers and slaters or 0.3% of the Building Construction workforce, and the Special Trades (SIC 17) employed 70,600 roofers and slaters or 3.1% of the Special Trades workforce [1].

The roofing trade involves the performance of a variety of different tasks which adds to the difficulty in developing an effective safety program. Roofers and slaters are primarily concerned with covering roofs and exterior walls of structures with slate, asphalt, wood, and related materials. The Dictionary of Occupational Titles [2] describes the duties of the roofer (hereinafter, implying both occupations of roofers and slaters) as follows:

866.381-010 ROOFER (const.) - Covers roofs with roofing materials, other than sheet metal, such as composition shingles or sheets, wood shingles, or asphalt and gravel, to waterproof roofs: cuts roofing paper to size, using knife, and nails or staples it to roof in overlapping strips to form base for roofing materials. Aligns roofing material with edge of roof, and overlaps successive layers, gaging distance of overlap with chalkline, gage on shingling hatchet, or by lines on shingles. Fastens composition shingles or sheets to roof, with asphalt, cement, or nails. Punches holes in slate, tile, terra cotta, or wooden shingles, using punch and hammer. Cuts strips of flashing and fits them into angles formed by walls, vents, and intersecting roof surfaces. When applying asphalt or tar and gravel to roofs, mops or pours hot asphalt or tar onto roof base. Applies alternate layers of hot asphalt or tar and roofing paper until roof covering is as specified. Applies gravel or pebbles over top layer, using rake or stiff-bristled broom. May construct and attach prefabricated roof sections to rafters [CARPENTER (const.)]. May attach shingles to exterior walls and apply roofing paper and tar to shower pans, decks, and promenades to waterproof surfaces.

Therefore, the types of activities described above were considered in the task analysis of the roofing occupation.

A review of the literature revealed previous research efforts by NIOSH in identifying hazards associated with roofing. One such effort was the "Behavioral Analysis of Workers and Job Hazards in the Roofing Industry" [3]. This report developed an industrial engineering oriented analysis of roofing tasks for hot roofing activities, a psychological evaluation of the characteristics of personality, attitude, and adjustment of roofing workers, and the measurement and analysis of certain behavioral or functional performance capacities of roofers. One significant finding of this study was that new workers and younger workers incur an injury rate much higher than experienced roofers. Other NIOSH research in this area includes "The Supervisory Effects of Worker Safety in the Roofing Industry" [4]. This study found that a positive attitude and commitment to safety on the part of top management resulted in a lower number of injuries at the roofing site. Also noted was that in the companies surveyed, less than one-third of the companies had a quantified safety goal. A third NIOSH publication on roofing included the development of a "Health and Safety Guide for the Commercial Roofing Industry" [5]. This guide identified roofing hazards and possible preventive measures.

Another valuable source of information is the "Best's Loss Control Engineering Manual" [6]. This manual lists the following exposures under workmen's compensation for roofing activities:

Exposures: Physically demanding work; lifting and carrying heavy roofing materials; constantly changing and unfamiliar job sites; inexperienced help. Working at heights; using ladders, scaffolds and hoists. Hot composition work; operating kettles or tanks; filling and transporting buckets of molten asphalt or tar; mopping "hot stuff". Poor housekeeping; spills. Environmental exposures of wind and heat. Contact with irritating or toxic materials; fumes or vapors from chimneys, ventilation outlets, adhesives, asphalt, tar pitch or other solvents. Exposed nails on reroofing jobs. Working near power lines or electrical installations.

As this description illustrates, there are numerous potential hazards to which workers in the roofing occupation are exposed, including contact with hot substances, falls, overexertions, and irritating or toxic fumes and vapors. This study will only consider the safety aspects of the roofing occupation, and will not investigate the health aspects such as exposure to toxic fumes.

#### Preliminary Data Analysis

Workmen's compensation claims reported to the BLS Supplemental Data System from 1977 to 1980 were reviewed for roofer and slater injuries within the construction industry. The major injury types experienced are given in Table 1. To supplement the injury statistics from the Supplemental Data System (SDS) data base, a series of roofing injury case studies was obtained from the

National Bureau of Standard's (NBS) report "Roofing Accident Data Base" [7]. This report and a supplemental NIOSH study "Accident Descriptions in the Roofing Industry" [8] provide a description and analysis of roofing injuries from over 1,000 insurance claims from 178 companies in 28 states during 1974.

As can be seen from Table 1, Contact with hot substances, Falls from elevations, Struck by, and Overexertions. To further illustrate the potential hazardousness of the roofing occupation, costs associated with insurance payments for various injuries sustained by roofers were reviewed. This analysis was based on data from the Employer's Insurance of Wausau [9]. This insurance data lists total costs and associated major loss causes for roofing cases (based on a study of 1,349 injuries costing a total of \$1,857,815). The major loss causes are as follows:

1. Falling from elevations accounted for 34 percent of the injury cost.
2. Handling barrels, kegs, hand trucks, rolls, containers and other materials accounted for 14 percent of the injury cost. The back was involved in over one-half of these costs.
3. Contact with hot substances produced 12 percent of the injury cost.

Comparing the major loss causes from the insurance data and the injury-type statistics from the BLS data provided some interesting similarities between the two data bases. The same high risk injury types identified from BLS data were also associated with high costs as shown by the insurance data. Analysis of BLS injury data revealed that 18.2% of the roofer and slater injuries were "Falls from elevations" such as, falls from scaffolds, ladders, into shafts, etc., and also falls to lower levels. The category "Falls from elevations" accounted for 34% of the injury cost. "Overexertion" accounted for 18.4% of the injuries while about 14% of the injury costs were due to overexertions through manual materials handling. "Contact with hot substances" accounted for 19.1% of the injuries and 12% of the injury cost. Although insurance cost data for the "Struck by" cases were not available, this category of injuries ranked fourth in the BLS data analysis accounting for 13.8% of the total injuries and thus, will be considered for further analysis in this study.

The four injury categories at highest risk identified through SDS and insurance data were subjected to further analysis by source of injury, part of body injured, and nature of injury for SICs 15 and 17. The results are listed in Tables 2 and 3. In the category "Contact with hot substances", the major source of injury was asphalt oil, and the most common parts of body injured were the hand, upper extremities, or multiple parts. The back or multiple parts were the most commonly injured body part in the "Fall to lower level" category and most of these injuries, about 55%, were fractures or sprains/strains. A bundle or container was the common source of injury for the "Overexertion by lifting" category. The back was the most commonly injured part of the body and the leading nature of injury was a sprain/

strain. In the "Struck by, NEC" (not elsewhere classified) category, the common sources of injury were a knife or metal item, NEC. Over 47% of the injuries were to the finger or hand and the leading natures of injury were cuts/lacerations and contusions.

Upon identifying these four "high risk" injury categories from the BLS data, each was subjected to a more thorough and comprehensive analysis, using the 1000 accident reports from the NIOSH study "Accident Descriptions in the Roofing Industry" [8].

## PHASE 2

### Detailed Data Analyses

This section is divided into two tasks: Task 1 is a separate comprehensive analysis of the four high risk injury categories identified in Phase 1; Task 2 develops an estimated cost per injury for each of the four high risk injury categories.

The detailed analysis was based on roofer insurance claims, SDS indemnity costs and the roofing work flow charts and task descriptions contained in Appendix A. Injury costs were estimated using SDS indemnity data in order to demonstrate which type(s) of injuries are the most costly. These cost estimates can provide a basis for illustrating the relative cost effectiveness of implementing task and equipment changes.

### Task 1 - Comprehensive Analysis of High Risk Accident Categories

The four specific high risk accident categories identified in the preliminary data analysis were subjected to further analysis by identifying the specific events which led to the injury. Each of these will be discussed separately.

#### Contact with Hot Substances

Contact with hot substances accounted for 19.1% of the injuries in the SDS data. The review of the insurance data (hereinafter, implying the data from Reference 8) revealed that contact with hot substances accounted for 16.5% or 166 of the reported cases. In these reported cases, the workers sustaining burns were as follows:

<u>OCCUPATION</u>	<u>NUMBER OF INJURIES</u>	<u>%</u>
Journeyman	51	30.7
Helper	41	24.7
Apprentice	30	18.1
Kettlemen	24	14.5
Foremen	11	6.6
Laborer	5	3.0
Other	4	2.4
<u>TOTAL</u>	<u>166</u>	<u>100.0</u>

The equipment in use or being tended to at the time of the burn injury was as follows:

EQUIPMENT	NUMBER OF INJURIES	%
Can/Bucket	82	49.4
Kettle	46	27.7
Mop	9	5.4
Lugger	7	4.2
Supply Pipe	6	3.6
Felt Layer	4	2.4
Other	12	7.3
TOTAL	166	100.0

From the above table, it was shown that the vast majority (77.1%) of burns occurred from a can, bucket, or kettle. Therefore, further investigation of burn injuries was limited to the can, bucket and kettle.

#### Can/Bucket

Hot asphalt splashing from the can or bucket accounted for 49.4% (82/166) of the burn injuries. The worker's activity at the time of injury were as follows:

ACTIVITY	NUMBER OF INJURIES	%
Carrying	49	59.8
Pouring	11	13.4
Filling	10	12.2
Lifting - Stuck	6	7.3
Other	6	7.3
TOTAL	82	100.0

It was further observed from the accident reports that in 14 of the 49 injuries involving carrying the can or bucket, the accident resulted when the bucket struck an object.

Following is a review of the body parts injured as a result of spills or splashing of hot substances from a can or bucket:

PART OF BODY	NUMBER OF INJURIES	%
Hand	40	48.8
Arm	20	24.4
Foot	7	8.5
Hand/Arm	5	6.1
Leg	3	3.7
Other	7	8.5
TOTAL	82	100.0

As seen, the hand, arm, and hand/arm were burned in 79.3% of the injuries. A breakdown of these injuries for usage of personal protective equipment and activity at the time of injury follows:

	TOTAL	YES	PPE		CARRYING	POURING	ACTIVITY		
			NO	UNKNOWN			FILLING	STUCK	OTHER
Hand	40	19	18	3	29	3	5	3	-
Arm	20	2	7	11	11	4	3	1	1
Hand/Arm	5	2	2	1	2	2	-	1	-

In 9 of the 29 cases where the worker was carrying a can/bucket and burned the hand, the accident resulted when the bucket or can struck an object. Also, in 3 of 20 cases where the worker burned his arm, the can or bucket struck an object. Again the can/bucket struck an object in 1 of the 5 accidents that resulted in burns to the hand/arm.

The lost time per injury was also reported. The time lost for hand and arm injuries and the effect of PPE is given in the following table:

	NO. OF CASES	NO. OF LOST TIME CASES	TOTAL DAYS LOST	AVERAGE DAYS LOST PER INJ.	OVERALL AVERAGE
					DAYS LOST PER INJURY
Hand	40	20	244	12.2	6.1
with PPE	19	10	157	15.7	8.3
without PPE	18	9	83	9.2	4.6
unknown	3	1	4	4.0	1.3
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Arm	20	10	187	18.7	9.4
with PPE	11	4	152	38.0	13.8
without PPE	2	1	12	12.0	6.0
unknown	7	5	23	4.6	3.3
<hr/>					
Hand/Arm	5	5	60	12.0	12.0
with PPE	2	2	40	20.0	20.0
without PPE	2	2	15	7.5	7.5
unknown	1	1	5	5.0	5.0

A review of the above table reveals the following comparisons:

1) Hand Burns While Carrying a Bucket - PPE was in use in about half the cases reviewed. When there was a lost time injury the person averaged 15.7 days off when gloves were used and 9.2 days off when gloves were not used. The overall average of lost time was 8.5 days with gloves and 4.6 days without gloves. From these figures it was concluded that the use of gloves as personal protective equipment (PPE) is not effective in reducing the extent of the injury.

2) Arm Burns While Carrying a Bucket - Due to the large percentage of unknown PPE usage at the time of the injury, it is not possible to determine the effectiveness of the PPE in use. However, it should be noted that there was an average of 9.4 days lost per injury, which is 3.3 days greater than the average lost time for hand injuries.

3) Hand/Arm Burns While Carrying a Bucket - The hand/arm burn appears to be the most severe injury since all the reported cases reviewed involved lost time. The average lost time was 12.0 days, which is greater than the average lost time for hand or arm injuries. However, due to the limited number of cases, no other conclusions could be drawn on this type of injury.

Roofing work flow charts and related task descriptions for the hot roofing operations are presented in Appendix A. The hot roofing charts and related task descriptions were obtained from the report "Behavioral Analysis and Job Hazards in the Roofing Industry" [3]. The following activities were associated with transporting hot asphalt in a bucket in the cap sheet and rock cover operations given in Appendix A:

1. Cap sheet operation

The transporting or carrying hot asphalt in a bucket occurs in the following activities:

- a) First layer and flashing operation  
520 fill mop bucket or felt machine and 'spot' map area.
- b) Felt machine operations  
620 fill machine with asphalt
- c) Hand-layed operations  
710 fill mop bucket
- d) Cap sheet operation  
995 fill mop bucket
- e) Detail work  
810 fill mop bucket

2. Rock cover operation

The transport or carrying hot asphalt in a bucket occur in the following activities:

- a) First layer and flashing operations  
520 fill mop bucket or felt machine and 'spot' mop area
- b) Felt machine operations  
620 fill machine with asphalt
- c) Hand-layed operations  
710 fill mop bucket
- d) Detail work  
810 fill mop bucket

- e) Rocking operations
  - 910 fill asphalt spreader
  - 995 fill mop bucket

The following hazards are associated with the above activities in transporting hot asphalt by buckets.

- 1) Typical Asphalt Transport Injuries: Slips and falls on roof, often involving burns and serious falls through roof openings.

Worker's Task: Travel from roof working area to supply pipe which feeds roof level with asphalt from kettle with an empty bucket.

- 2) Typical Asphalt Fill Injuries: Getting hand into asphalt fill stream, or splashes from handling containers.

Worker's Task: Fill mop bucket, spreader bucket, or five-gallon bucket. Time requirements vary, depending on asphalt transport method (pipe or hoist) and container size.

- 3) Typical Bucket Carrying Injuries: Splashes of asphalt out of bucket associated with tripping, slips or falls.

Worker's Task: Travel from filling spot to work with full container.

The above descriptions indicate the types of tasks roofers perform while working with hot substances and thus, will provide the basis for the development of countermeasures to reduce burn injuries.

#### Kettle Operations

The worker was tending the kettle in 27.7% (46/166) of the burn injuries. The activities of the worker tending the kettle at the time of the injury were as follows:

<u>ACTIVITY</u>	<u>NUMBER OF INJURIES</u>	<u>%</u>
Filling	32	69.6
Working on Pipe	6	13.1
Moving	3	6.5
Tending	3	6.5
Turning Valve	2	4.3
<b>TOTAL</b>	<b>46</b>	<b>100.0</b>

As revealed from the above table, filling the kettle resulted in about 70% of the injuries, followed by working on the pipes used to pump hot asphalt (13%). The body parts injured in kettle operations were as follows:

PART OF BODY	NUMBER OF INJURIES	%
Arm	10	21.7
Face	10	21.7
Hand	9	19.6
Hand/arm	4	8.7
Face/eye	4	8.7
Face/body part	4	8.7
Other	5	10.9
TOTAL	46	100.0

As seen from the the above table, the hand and arm were involved in 50% of the injuries and the face and/or other parts of the body in 39% of the injuries. A breakdown of the personal protective equipment usage was as follows:

PART OF BODY	PPE USED	PPE NOT USED	UNKNOWN
Hand	1	3	5
Arm	3	3	4
Hand/arm	1	0	3
Face	0	8	2
Face/eye	0	4	0
Face/other body of body	0	2	2
TOTAL	5	20	16

Due to the limited number of injuries and the large percentage of unknowns, no conclusions on the effectiveness of PPE during kettle operations could be drawn.

A review of lost time by body part is given in the following table for kettle operations:

PART OF BODY	NO. OF CASES	NO. OF LOST TIME CASES	TOTAL DAYS LOST	AVE. LOST TIME	OVERALL AVE PER INJURY
All cases	46	21	286	13.6	6.2
Arm	10	5	43	8.6	4.3
Hand	9	3	50	16.7	5.6
Hand/arm	4	1	6	6.0	1.5
Face	10	4	8	2.0	0.8
Face/eye	4	0	0	0.0	0.0
Face/other body parts	4	4	78	19.5	19.5
Other	5	4	101	25.3	20.2

As revealed, the most severe injury is burning multiple parts of the body, which had an average of 19.5 days off per injury. However, there were only four injuries in this category. Injuries to the hand and arm resulted in lost work days in about half of the cases reviewed. The average time off was 6.2 days for all cases as compared to 8.6 days per arm burn case and 16.7 days per hand burn when there was lost time. Injuries from transporting hot asphalt resulted in more severe injuries to the hand and arm as compared to hand and arm injuries in kettle operations.

The following activities are associated with filling the kettle in the sheet and rock cover operation flow charts (Appendix A):

1. Load Kettle

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

Worker's Activity: Placing asphalt chunks into kettle.

Typical Injuries: Hand burns on hot surface.

Worker's Activity: Closing kettle lid.

Falls from Elevations

The second category of injuries was "Falls from elevations". This category accounted for 18.2% of the injuries in the SDS data. The review of insurance data revealed that falls accounted for 8.8% or 88 of the reported cases. No explanation could be determined for the difference between the two data bases. The following table compares the types of falls in the SDS data to the insurance data:

FALLS FROM ELEVATIONS	PERCENTAGE OF CASES	
	SDS	INSURANCE
From scaffold	1.7	0.7
From ladders	4.5	2.3
From vehicles	1.4	1.1
Into shafts, etc.	0.8	1.1
To lower level NEC	9.2	2.8
Other	0.6	0.8
TOTAL	18.2	8.8

The main areas in both data sources are falls from ladders and falls to lower level, NEC. These areas account for 75% of the falls in the SDS data and 58% of the falls in the insurance data. Using the insurance data, the specific workers sustaining falls are as follows:

OCCUPATION	NUMBER OF INJURIES	%
Journeyman	39	44.3
Helper	14	15.9
Foremen	13	14.8
Apprentice	6	6.8
Laborers	6	6.8
Other	10	11.3
TOTAL	88	100.0

Falls from ladders and falls to lower levels, NEC are the leading sources of injury. Therefore, this analysis will be limited to these two areas.

Falls from Ladders

There were 23 falls from ladders in the insurance cases reviewed. The breakdown of falls by the occupations are as follows:

OCCUPATION	NUMBER OF INJURIES	%
Journeyman	7	30.4
Foremen	5	21.7
Apprentices	4	17.4
Laborer	4	17.4
Helper	1	4.4
Other	2	8.7
<b>TOTAL</b>	<b>23</b>	<b>100.0</b>

The workers' activity at the time of the injury was as follows:

ACTIVITY	NUMBER OF INJURIES	%	CARRYING ITEM	%
Climbing ladder	14	60.9	5	83.3
Descending ladder	7	30.4	1	16.7
Working from ladder	2	8.7	-	-
<b>TOTAL</b>	<b>23</b>	<b>100.0</b>	<b>6</b>	<b>100.0</b>

As revealed from the above table, 61% (14/23) of the fall injuries occurred when the worker was climbing the ladder. Also, in about a fourth of the accidents the worker was carrying an item.

The following events, which contributed to the accident occurred when the worker was on the ladder:

EVENT	NUMBER OF CASES	%
Worker slipped on ladder	10	45.5
Base of ladder slipped	8	36.4
Ladder collapsed	3	13.6
Wind blew ladder	1	4.5
<b>TOTAL</b>	<b>22</b>	<b>100.0</b>

As revealed, injuries resulted in 10 cases when the worker slipped off the ladder and in 8 cases when the base of the ladder slipped. In four cases, the worker slipped as he was carrying an item. This leads to the conclusion that the number of falls from ladders could be reduced by securing the ladder and by limiting the amount of material which must be manually transported by ladder.

Given below is a summary of the distance the worker fell and the lost days for the ladder accidents:

DISTANCE FELL	NUMBER OF CASES	NO. OF LOST TIME CASES	LOST DAYS	LOST DAYS PER CASE	AVERAGE LOST DAYS
All Cases	23	15	959	63.9	41.7
0'-5'	4	1	156	156.0	39.0
6'-9'	8	6	93	15.5	11.6
10'-15'	3	2	285	142.5	95.0
16'-20'	4	3	253	84.3	63.3
21'	2	2	159	79.5	79.5
Unknown	2	1	13	13.0	6.5

As seen from the above table, the average lost time for falls from a ladder was 41.7 days, with about 65% of the falls resulting in lost time.

#### Fall to Lower Level, NEC

There were 28 cases where the worker fell to lower level, NEC or fell off the edge of the roof. A breakdown of workers involved in these injuries are as follows:

OCCUPATION	NUMBER OF INJURIES	%
Journeyman	11	39.3
Helper	7	25.0
Foremen	4	14.3
Apprentice	1	3.6
Laborer	1	3.6
Other	4	14.2
TOTAL	28	100.0

The slope of the roof and worker's activity at the time of the injury are given in the following table:

SLOPE	NO.	WALKING	STANDING	KNEELING	CLIMBING	MATERIALS	
						HANDLING	UNK.
Flat	7	1	3	1	0	2	0
2/12	2	2	0	0	0	0	0
3/12	3	2	0	1	0	0	0
4/12	4	3	1	0	0	0	0
5/12	7	2	0	3	1	1	0
6/12	1	0	0	0	0	1	0
6/12	2	0	0	1	1	0	0
Unknown	2	0	1	0	0	0	1
TOTAL	28	10	5	6	2	4	1

As shown, 9 of the 28 accidents occurred when the worker was on a roof with a slope of 2/12 or less. In 10 cases the worker was walking (either forward or backward) when he fell off the edge of the roof. Compared below is the slope of the roof to the event that led to the worker's fall:

SLOPE	NO. OF CASES	SURFACES SLIPPED	WORKER SLIPPED	LOST BALANCE	WAS BUMPED	UNKNOWN
Flat	7	2	1	2	0	2
2/12	2	0	0	2	0	0
3/12	3	0	2	0	1	0
4/12	4	0	3	1	0	0
5/12	7	0	4	3	0	0
5/12	1	0	1	0	0	0
6/12	2	1	1	0	0	0
Unknown	2	0	0	1	0	1
TOTAL	28	3	12	9	1	3

As expected, when the roof became steeper, the worker tends to slip or lose his balance more often.

Lastly, the lost time to the distance the worker fell was compared. This comparison is given in the following table:

DISTANCE FELL	NO. OF CASES	NO. LOST TIME CASES	LOST DAYS	DAYS PER LOST TIME CASE	AVERAGE LOST TIME PER CASE
All Cases	28	26	1567	60.3	56.0
0'-5'	1	1	90	90.0	90.0
6'-9'	1	1	6	6.0	6.0
10'-15'	18	16	849	53.1	47.2
16'-20'	3	3	235	78.3	78.3
20'	4	4	297	74.3	74.3
Unknown	1	1	90	90.0	90.0

The average lost time for falls from the edge of the roof is 56 days. Of the 28 cases reviewed, 26 resulted in lost time. Falls from 10' to 15' had an average lost time of 47 days and falls greater than 15' had a lost time of about 75 days. Also, it was noticed that 20 of the 28 falls (71%) were at heights of 15' or less.

#### Struck By

The third category of injuries analyzed were "Struck by" which contained two subcategories: "Struck by falling object" and "Struck by, NEC". The Struck by accident type accounted for 13.8% of the total roofer injuries within the SDS system. Struck by falling objects accounted for 4.9% of the injuries while Struck by, NEC accounted for 8.9% of the injuries.

#### Struck by Falling Objects

A review of the insurance claims revealed that Struck by falling objects accounted for 6.7% of the total cases considered. The percentage of injuries by occupation are as follows:

OCCUPATION	NUMBER OF CASES	%
Journeyman	24	35.8
Helper	13	19.4
Apprentice	12	17.9
Foreman	6	9.0
Truck Driver	5	7.5
Other	7	10.4
<b>TOTAL</b>	<b>67</b>	<b>100.0</b>

The item which the worker was handling before the injury occurred are illustrated as follows:

OBJECT	NUMBER OF CASES	%
Asphalt/Shingles	13	19.4
Felt Rolls	7	10.4
Keg/Barrel	6	9.0
Bucket/Can	6	9.0
Misc.(Tools, Ladder, etc.)	35	52.2
<b>TOTAL</b>	<b>67</b>	<b>100.0</b>

Eighty-four percent of these injuries occurred on the ground compared to the roof. The part of body involved in these incidents is given below:

PART OF BODY	NUMBER OF CASES*	%
Foot/Toes	24	34.3
Hand/Finger	16	22.9
Trunk	8	11.4
Head	7	10.0
Arm	7	10.0
Leg	7	10.0
Eye	1	1.4
<b>TOTAL</b>	<b>70</b>	<b>100.0</b>

\*2 cases with multiple injuries.

The foot/toes and hand/fingers are involved in over 57% of the Struck By falling object cases. For the 24 cases in which foot or toes were injured, the personal protective equipment worn was as follows:

PPE USAGE	NUMBER OF CASES	%
No Steel Toes	16	66.7
Hard Steel Toes	5	20.8
Do not know	3	12.5
<b>TOTAL</b>	<b>24</b>	<b>100.0</b>

Thus, in two-thirds of the cases involving foot/toe injuries, steel toes were not worn.

In further analyzing these cases, it was determined that in 60% of the cases (n=40) the employee was performing some type of manual materials handling task such as loading and unloading material or equipment. The circumstances most commonly involved in these cases was the worker either "dropped the object," it "slipped or falls," or the worker "lost his grip." These handling activities are recapped as follows:

ACTIVITY	NUMBER OF CASES	%
Dropped	16	40.0
Fell	13	32.5
Slipped	5	12.5
Lost Grip	4	10.5
Other	2	5.0
<b>TOTAL</b>	<b>40</b>	<b>100.0</b>

For comparison, the severity of these types of injuries to the others being analyzed is as follows:

NO. OF CASES	NO. OF LOST TIME CASES	TOTAL DAYS LOST	AVERAGE PER LOST TIME INJ.	OVERALL AVERAGE DAYS LOST FOR ALL CASES
67	27	165	6.1	2.5

Struck by, NEC

Struck by, NEC accounted for 8.9% of the total roofer injuries in the SDS system. The leading source of injury was the knife, which accounted for 20% of the Struck by injuries or 1.8% of the total roofer injuries. In the insurance claims reviewed, there were 32 injuries resulting from knife cuts or 3.2% of the claims. The table given below reports the worker classifications sustaining knife cuts.

OCCUPATION	NUMBER OF CASES	%
Journeyman	15	46.9
Apprentice	6	18.8
Helper	4	12.5
Foremen	1	3.1
Kettleman	1	3.1
Other	5	15.6
<b>TOTAL</b>	<b>32</b>	<b>100.0</b>

The part of body injured is given in the following table:

PART OF BODY	NUMBER OF CASES	%
Hand/Finger/Wrist	20	62.5
Arm	4	12.5
Hand/Arm	1	3.1
Leg	7	21.9
<b>TOTAL</b>	<b>32</b>	<b>100.0</b>

As noted from the above table, the hand was injured in over 65% of the cases. The leg accounted for 22% of the cuts sustained with a knife. The use of PPE was reviewed for the injuries to the hand and the results are given in the following table:

PPE	NUMBER OF INJURIES	%
Gloves used	9	45
Gloves not used	6	30
Unknown	5	25
<b>TOTAL</b>	<b>20</b>	<b>100</b>

There were 3 reported lost time injuries and all 3 were to the hand. In 2 cases gloves were not used and in the third it is unknown if gloves were used. The average lost time per was 6.7 days per lost time case or 1 day per case when the hand was cut.

A review of the object being cut at the time of injury revealed the following information:

OBJECT BEING CUT	NUMBER OF CASES	%
Insulation	5	15.6
Felt paper	5	15.6
Reaching for knife	4	12.5
Other	7	21.9
Unknown	11	34.4
<b>TOTAL</b>	<b>32</b>	<b>100.0</b>

As noted from the above table, over 30% of the injuries occurred when the worker was cutting insulation or felt paper.

#### Overexertion by Lifting

The final injury category analyzed was overexertion by lifting. Although this category was originally restricted to lifting, due to the number of overexertion injuries which occur during tasks such as pushing, pulling, carrying, etc., this analysis was expanded to include all overexertions through manual materials handling tasks.

As a group, overexertions accounted for 19.1% of all insurance cases as compared to 18.4% in the SDS cases. Lifting is still the most common task involved in these types of injuries, accounting for 8.5% of all injuries sustained (insurance data). The breakdown of overexertion injuries by occupation from the insurance data is as follows:

OCCUPATION	NUMBER OF CASES	%
Journeyman	77	39.9
Apprentice	32	16.6
Helper	31	16.1
Foreman	14	7.3
Truck Driver	11	5.7
Laborer	7	3.6
All Other	21	10.8
<b>TOTAL</b>	<b>193</b>	<b>100.0</b>

The manual materials handling tasks which were being performed at the time of injury are as follows:

TASK	NUMBER OF CASES	%
Lifting/Lowering	86	44.6
Pull	20	10.4
Push	18	9.3
Carry	15	7.8
Slipping	30	15.5
Other	24	12.4
TOTALS	193	100.0

As expected, lifting/lowering was involved in the majority of cases (44.6%). Pushing and pulling were next, with an almost equal number attributed to each of these tasks. Carrying objects also appeared in a significant number of the injury reports (7.8%). The other category includes activities such as throwing objects or slipping while walking in which an overexertion injury resulted. The type of overexertion injury resulting was either a strain (75%) sprain (22%) or hernia (39%). The following table shows the part of body injured:

PART OF BODY	NUMBER OF CASES	%
Back/Trunk	127	64.6
Lower Extremities	34	17.2
Upper Extremities	18	9.1
Stomach	14	7.1
Other	5	2.5
TOTAL	198	100.0

\*Five cases had multiple injuries

The part of body involved most often was the back/trunk (64.1%) the lower extremities (ankle, knee, leg, foot), 17.2% and upper extremities (arm, hand, finger, wrist, elbow) 9.1%. In most of the cases, an injury to the back was classified as a strain, an injury to the stomach or groin was classified as a hernia, and an injury to an extremity was classified as a sprain. The lost time for overexertion injuries are as follows:

NO. OF CASES	NO. OF LOST TIME CASES	TOTAL DAYS LOST	AVERAGE PER LOST TIME INJ.	OVERALL AVERAGE PER INJURY
192	109	2195	20.1	11.4

The average lost time cases were 20.1 days/case. In reviewing this data, it was noticed that there were huge fluctuations in the number of days lost resulting from these overexertion injuries. Many workers either lost no time or returned within 1 or 2 days. However, others were off as much as 60 days or more.

## Task 2 - Determination of Estimated Injury Costs

The next step in this phase of the analyses was to determine the estimated injury costs for each injury category. These injury cost estimates were based on the SDS data for both indemnity and medical costs. An estimate of the number of injuries by accident type within the roofing industry was obtained by the following formula:

### Estimated injuries and Cost

$$ENI = EM \times CI \times RF \times AT\%$$

where;

ENI = Estimated Number of Injuries

EM = Roofer employment: 75120 [1]

CI = Construction incidence rate: 15/100 (SDS Data)

RF = Roofer's risk factor;: 1.5 (SDS Data)

AT% = Accident-type percentage (From Table 1)

An example calculation to determine the estimated number of injuries for the category "Contact with hot substances" is given below:

Contact with hot substances

$$ENI = 75120 \times .15 \times 1.5 \times .191$$

$$ENI = 3228$$

Using the above formula, the estimated number of injuries for the four accident types studied are as follows:

<u>INJURY TYPE</u>	<u>ESTIMATED NUMBER OF INJURIES</u>
Contact with hot substances	3230
Falls from elevation	
from ladders	760
lower level, NEC	1550
	2250
Struck by	
falling object	830
NEC	1500
	2300
Overexertion	
lifting	1740

In order to estimate an injury cost for each of the four categories, indemnity compensation payments (the monetary awards provided to the injured employee for the time lost, disfigurement or disability) were obtained from the SDS data over a four-year period (1977-1980). Only a

select number of states in the SDS system provide this information. An average indemnity payment per injury-type that occurred in the construction industry was established by summing the total cost incurred over the four-year period and dividing by the number of cases.

The medical cost varied widely within the states because some states require a 3 day waiting period before payment as opposed to other states which require 5 to 7 days. The medical costs were about 35% of the indemnity costs for the 3 day period and 50 to 75% of the indemnity costs for the 5 to 7 day period. Therefore the total injury costs (indemnity and medical) would be estimated at 1.5 times the indemnity costs. The average indemnity and medical costs per injury case for the accident types studied are given in the following table.

ACCIDENT-TYPE	INDEMNITY COST	INJURY COST
Contact with hot substances	\$1450	\$2175
Falls from elevation		
from ladders	4150	6225
lower level, NEC	4850	7275
Struck by		
falling object	2500	3750
NEC	2250	3375
Overexertion		
lifting	3100	4650

The annual cost of injuries by accident type is obtained by multiplying the number of injuries by their average total injury cost. The results are given in the following table:

ACCIDENT TYPE	INJURY COST
Contact with hot substances	\$6,900,000
Falls from elevation	
from ladders	4,670,000
lower level, NEC	10,910,000
Struck by	
falling object	3,000,000
NEC	5,060,000
Overexertion	
lifting	8,140,000

### PHASE III

After identifying activities and tasks which were associated with increased injury risks for roofers, the next step was to develop recommended countermeasures to reduce these risks (Task 1), and/or to identify areas where further research is needed in order to adequately develop recommended countermeasures to reduce the risk of injury to roofers (Task 2).

## Task 1 - Proposed Countermeasures for Reducing Risks

### Contact with Hot Substances

The activities with the highest risk identified in this category were burns to the hand/arm while carrying or handling cans or buckets or while tending a kettle. Thus, to abate these types of hazards, the following countermeasures are recommended:

1. Until improved equipment designs for kettles and cans/buckets can be developed implemented (see proposed research areas), workers should be instructed on safe procedures for loading and handling asphalt in kettles and buckets to reduce the risk of being burned while handling hot substances. Two good references for identifying safe handling procedures are the Health and Safety Guide for the Commercial Roofing Industry [5] and Safe Storage and Handling of Hot Asphalt [11]. As recommended by the NIOSH Health and Safety Guide for Commercial Roofing [5], half-lids should be installed on cans and buckets to reduce splashing during carrying and pouring tasks.
2. From this analysis, it was concluded that the use of gloves as personal protective equipment were not effective in reducing either the frequency or severity of burn injuries for reported cases. Therefore, gloves should not be considered as an adequate countermeasure for reducing burn injuries associated with these types of tasks.

### Falls from Elevations

The most hazardous activities in this category were falls from ladders and falls to lower levels, NEC. In using ladders, the tasks most commonly associated with injuries were simply ascending and descending the ladder and transporting materials or equipment while ascending or descending the ladder. In the falls to lower level, NEC category, workers either fell off the edge of the roof or slipped or lost their balance while on the roofing surface. Thus, to abate these types of hazards, the following countermeasures are recommended:

1. Workers should be instructed in the safe use of ladders. Information pertaining to the safe usage of ladders is available in the American National Standards Institute (ANSI) standards A14.1 and A14.2 and OSHA standards 1910.25 and 1910.26. Some of the important areas to be considered include:
  - a. Always secure the ladder properly and be certain that it rests on a solid base
  - b. Always be certain that ladders are positioned at the proper angles before they are used; a good rule of thumb to follow is to place the foot of the ladder one-fourth of its working length horizontally from the vertical line under its support
  - c. Ladders should extend 3 feet above the point where a worker steps onto the roof
  - d. Minimize the size and quantity of load (such as materials, tools, etc.) that must be carried while ascending and descending ladders

- e. Where possible, utilize mechanical lifting devices such as hoists and pulleys to transport materials and equipment from the ground to the roof and vica versa.
2. While on the roof, workers must practice good housekeeping procedures to insure that the roofing surface is free from materials and equipment which could cause workers to fall.
3. Shoes with slip resistant soles, i.e., ones with good coefficient of friction characteristics, should be worn [13,14,15].
4. To reduce falls off the edge of the roof, compliance with OSHA standard 1926.500 G(1) - warning ropes - should be strictly enforced.

### Struck By

The struck by injury is composed of two major accident types, struck by falling object and struck by, NEC. The type of work activity usually involved in the struck by falling object category was the manual handling of materials or equipment. The most frequent scenario in these incidents was that the object(s) either fell, slipped, were dropped, or the worker lost his grip. The part of body injured most frequently were the feet/toes and hands/fingers. When the feet/toes were involved, PPE, i.e., steel-toed shoes, were not worn in two-thirds of the cases. In the struck by, NEC category, the use of knives accounted for the majority of injuries sustained, especially when cutting insulation or felt paper.

The following are suggested countermeasures to help reduce injuries in the struck by category:

1. To reduce the number and severity of injuries to the feet and toes, it is recommended that steel-toed shoes be worn by all workers [16]. Because steel-toed shoes which incorporate the steel protection as an integral part of the shoe itself can be uncomfortable to wear for roofers who must squat and bend frequently, the metatarsal guard which fits over the shoe may be a more comfortable and practical alternative. Also, the shoes must provide adequate ventilation due to the temperature extremes encountered during roofing, and have slip resistant soles to provide desirable coefficient resistant characteristics.
2. To reduce the chance of dropping or losing the grip during manual handling activities, materials and equipment which incorporate handles should be used where possible. Mechanical lifting devices to transport heavy equipment and materials should be utilized where possible. Also, employees should seek help whenever they must handle material or equipment which is heavy or bulky.
3. Employers should provide training to increase the overall awareness of employees to utilize safe working techniques. These could be in the form of improved housekeeping procedures, the wearing of appropriate personal protective equipment, and the use of mechanical lifting aids to help move materials and equipment where possible.

4. To reduce the struck by injuries associated with the use of knives, employers should develop and emphasize the use of safe work practices when using knives. The use of gloves was not shown to significantly decrease the frequency or severity of injury when using knives.

#### Overexertions

As with other occupations which involve manual materials handling, it is generally difficult to determine any specific causal factors which increase the risk of sustaining an overexertion injury while performing these tasks. This is due to the wide differences in individual abilities to perform manual materials handling tasks. Due to the large variety of sizes and weights of material and equipment which is handled by roofers, this is especially true in roofing. Some general guidelines which may be useful in reducing overexertion injuries during manual materials handling tasks are outlined as follows:

1. Utilize mechanical lifting aids such as pulleys, etc., where possible.
2. Seek help when handling large and/or bulky loads.
3. Practice good housekeeping procedures to help reduce slipping and tripping hazards.
4. Provide training to workers to utilize "safe" lifting techniques and to recognize when a load is too heavy or bulky to be handled alone.
5. Utilize basic ergonomic techniques to aid in designing jobs which reduce biomechanical stresses to workers' arms, wrists, and backs [17,18]. Another good reference is the NIOSH Work Practices Guide for Manual Lifting [10]. Examples of these techniques include:
  - a. reduce the weight of the load being lifted
  - b. reduce the distance between the worker and the load
  - c. remove all obstacles between the worker and the load
  - d. reduce the frequency of the lift
  - e. provide good couplings at the hand interface, i.e., handles and provide slip resistant soles on shoes

#### Task 2 - Identification of Future Research Needs

Specific research needs have been identified within the four accident types studied. These research needs are tailored to specific events that lead to the injury. Only by performing further research in these specific areas can one fully understand the problem and develop appropriate safety countermeasures.

#### Contact with Hot Substances

Contact with hot substances account for 19% of the roofer injuries at an annual loss of approximately \$7 million. The detailed analysis revealed that there are two main sources of burn injuries: transporting hot asphalt in a can or bucket and filling the kettle. Three specific research topics have been identified:

1. Gloves - As revealed in the analysis, gloves appear to be ineffective PPE in reducing the extent of the burn injury when the injury was reported. The time off per lost time injury was greater when gloves were used as compared to when gloves were not used. This tends to confirm that the gloves used must soak in hot asphalt, thus increasing the exposure to hazardous agent. However, the effectiveness of the gloves in reducing the number of minor burns is unknown. Therefore, a research project to investigate improved glove designs needs to be performed. Some important parameters to consider in this research include the following:
  - a. the types of gloves currently being used in the field
  - b. determine the design requirements needed in the field
  - c. consider the comfort in the design requirement
  - d. identify a more effective glove material
  - e. evaluate and field test the gloves
  
2. Bucket - Hot asphalt splashing from the bucket was the leading source of burn injuries (50%). Most of the injuries occurred (60%) when the worker was carrying the bucket. Therefore, further research to develop an improved design for a bucket is needed. The project should investigate the following:
  - a. the types of buckets used in the field and why
  - b. determine design requirements
  - c. design a splash resistant bucket
  - d. evaluate and field test the bucket
  
3. Kettle operations - About 28% of the burns to roofers occur from the kettle. The leading source of the burn is the splashing of the asphalt when the kettle is filled with new asphalt (70%). Therefore, a research project needs to be undertaken that would design a method of loading the kettle which would prevent the splashing of the hot asphalt either through improved work practices and/or improved equipment designs, and perform a field test to determine the effectiveness in reducing splashes.

#### Falls from elevations

Falls from elevation account for about 18% of the roofer accidents. The two leading sources are falls from ladders and to lower level, NEC (off edge of roof) at a cost of \$4,700,000 and \$10,700,000 respectively.

#### Falls from ladders

Falls from ladders accounted for about 5% of the roofer accidents. A review of the injury cases revealed that most of the falls were related to the ladder being improperly set-up or the worker trying to climb the ladder while he is carrying something. Therefore, a document that illustrates the usage of ladders in the roofing industry and describes proper safety procedures should be produced. The basic data on safe ladder usage is generally available. However, the proposed document should stress ladder safety and target recommendations specifically to the roofing occupation.

Falls to lower level (Off edge of roofs)

Falls off of the roof account for about 9% of the injuries in the roofing industry. In the review of the insurance claims, falls from roofs only accounted for about 3% of the claims. Due to the limited number of claims and recent OSHA rulemaking (warning ropes), no immediate action need be taken, other than to encourage compliance with the current OSHA standard 1926.500 G(1) - warning ropes.

Struck by

To supplement the recommendation for all roofers to wear safety shoes, roofing trade associations should try to work with shoe manufacturers to design a steel reinforced shoe which is both comfortable to wear while performing roofing tasks while being effective in reducing injuries to the feet/toes.

Also, an effort should be made to encourage both material manufacturers and equipment manufacturers to incorporate handles into their products to aid in the handling of these items. These handle designs should also incorporate sound ergonomic principles to more effectively reduce biomechanical stresses during manual materials handling tasks.

The knife was the leading source of injury for the struck by, NEC, injuries. Generally, these injuries are not a severe injury. There were only 3 lost time injuries out of the 32 cases reviewed. Therefore, it is recommended that a paper be written describing safe knife handling procedures for roofing activities.

#### Overexertions

Many of the material or equipment handled by roofers is heavy and/or bulky, such as 100 pound kegs of asphalt and 80 pound bundles of shingles. Due to the combined effect of the weight and bulkiness of the items handled, many times a good grip is difficult to obtain, and thus, the potential for being struck by an object due to dropping or losing the grip is increased.

Basic research into determining the causal factors associated with overexertion injuries should continue. This includes efforts by the federal government, universities, private industry and organized labor. Some specific areas germane to roofing activities are as follows:

1. Continue to perform research into determining optimum designs for manual materials handling equipment such as tote containers and push carts and dollies. Examples would include containers with handles properly positioned to minimize stresses to workers arms, wrists, shoulders, legs, and back.
2. As with the struck by category, an effort should be made to encourage both material manufacturers and equipment manufacturers to incorporate handles into their products to aid in the handling of these items. These handle designs should also incorporate sound ergonomics principles to more effectively reduce biomechanical stresses during manual materials handling tasks.

3. Develop a short training program in the principles of ergonomic job design targeted specifically for the roofing occupations to train workers to identify jobs and tasks which are potentially hazardous in terms of overexertion injuries.

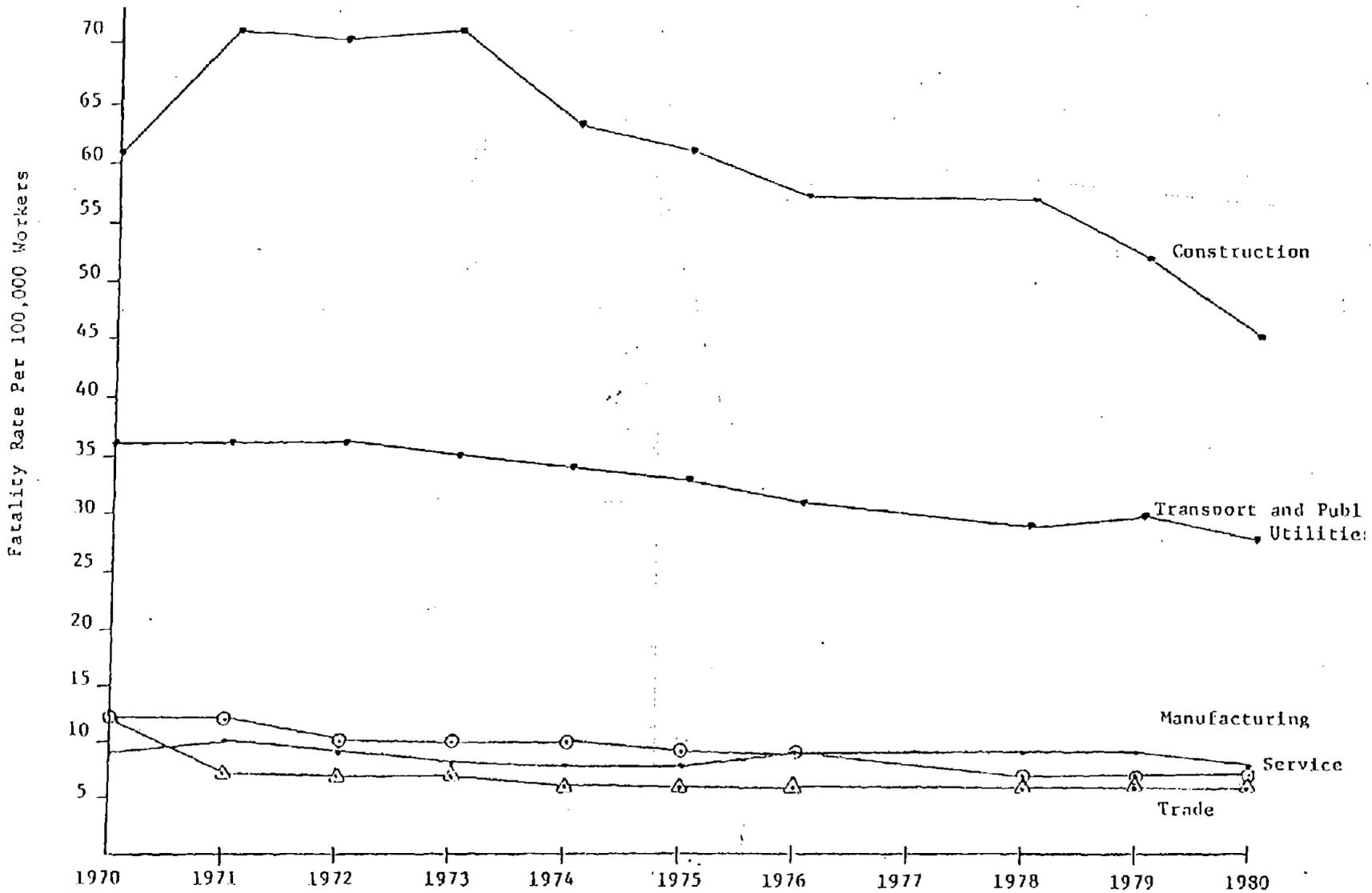
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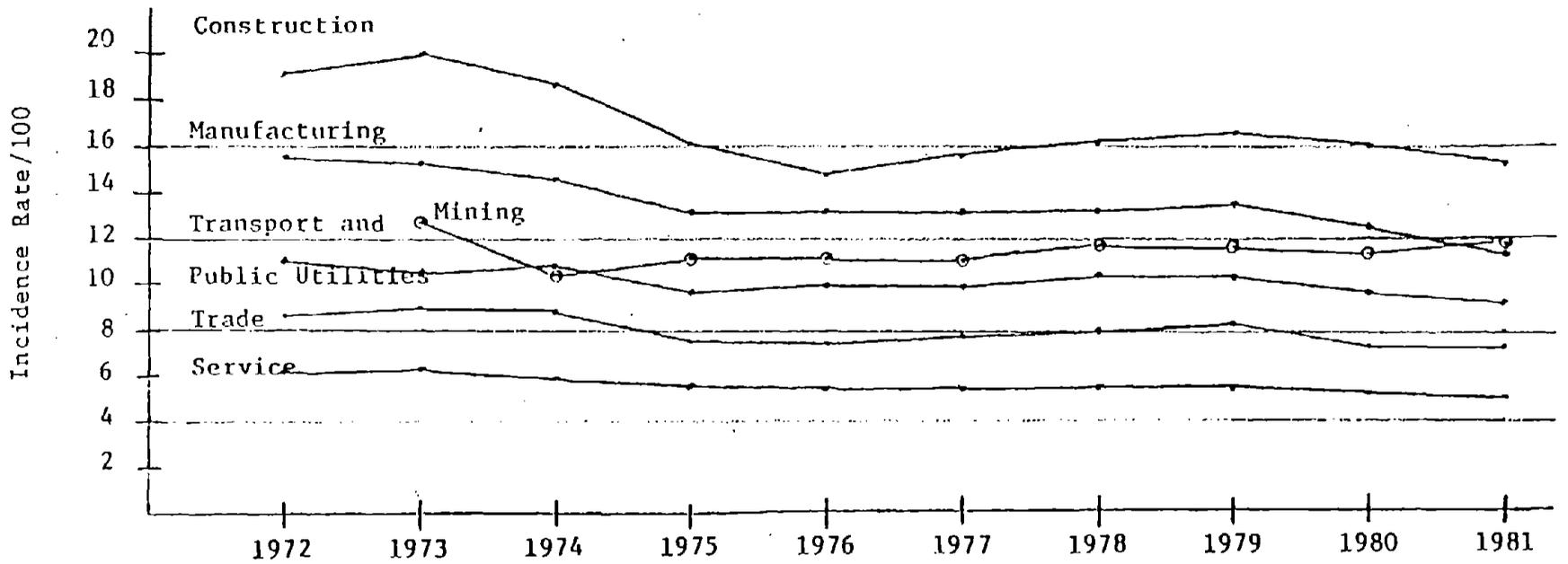


Figure 2 Incidence Rates as Reported by BLS - General Industries

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Table 1 - Roofer and Slater Injury Types

<u>INJURY CATEGORY</u>	<u>PERCENT OF INJURIES</u>
Contact with hot substance	19.1
Falls from elevations	
from ladders	4.5
from scaffolds	1.7
from vehicles	1.4
into shafts, etc.	0.8
fall to Lower Level, NEC	9.2
other types of Falls	0.6
	18.2
Struck by	
falling object	4.9
struck by, NEC	8.9
	13.8
Overexertion	
by lifting object	10.3
throwing object	2.7
pushing/pulling	1.6
overexertion NEC	3.8
	18.4
Struck against	
stationary object	6.6
All Other Injury Types	<u>23.9</u>
	100.0

Table 2 - Roofers and Slaters - Accident Types

Accident-Type	SIC 15					SIC 17					COMBINED AVERAGE
	1977	1978	1979	1980	AVG	1977	1978	1979	1980	AVG.	
<u>Percentage of Total Accidents</u>											
Struck Against Stationary Object	7.4	7.1	7.3	6.8	6.9	5.1	7.0	6.9	7.1	6.5	6.5
Struck by Falling Object	2.8	2.5	6.3	3.7	4.1	5.0	5.3	5.1	4.6	4.9	4.9
NEC	11.1	10.4	8.6	7.9	8.6	8.5	9.2	8.2	8.2	8.3	8.3
Fall From Elevation From Ladder	5.6	7.9	10.6	3.7	8.2	3.4	4.6	4.6	4.0	4.3	4.5
NEC	13.0	16.3	19.9	16.3	18.0	9.1	9.0	8.9	7.5	8.8	9.2
Overexertion in lifting objects	14.8	8.8	7.0	8.9	8.7	10.0	7.6	9.9	11.8	10.3	10.3
Contact with Temperature Extremes Hot objects	8.3	10.4	11.9	18.9	12.1	20.2	19.6	20.0	18.3	19.4	19.1

W  
E

Table 3 - Roofers and Slaters - Building Construction  
Type By Source, Part of Body, Nature of Injury

Accident Type	%	Source	%	Part of Body	%	Nature	%
Fall to Lower Level, NEC	18.0	Ground	77.1	Multiple Parts	22.5	Fracture	41.4
		Roof	5.7	Back	12.1	Sprain/Strain	18.5
		Floor	5.7	Ankle	11.5		
		Other	11.5	Other	53.9	Other	40.1
			<u>100.0</u>		<u>100.0</u>		<u>100.0</u>
Contact with Hot Objects	12.1	Asphalt Oil	83.7	Multiple Parts	28.8	Burn/Scald	99.1
		Flame/Fume/ smoke	6.3	Hand	18.0		
		Other	10.0	Upper extremities	13.5		
			<u>100.0</u>	Other	39.7	Other	0.9
					<u>100.0</u>		<u>100.0</u>
Overexertion/Lifting	8.7	Bundle	30.3	Back	75.0	Sprain/Strain	88.2
		Container, N	13.2	Abdomen	7.9	Dislocation	5.2
		Other	56.5	Other	17.1	Other	6.6
			<u>100.0</u>		<u>100.0</u>		<u>100.0</u>
Struck by, NEC	8.6	Knife	19.0	Finger	35.4	Cut/Laceration	72.2
		Metal Item, NEC	10.1	Hand	17.7	Contusion	11.4
		Other	70.9	Other	46.9	Other	16.4
			<u>100.0</u>		<u>100.0</u>		<u>100.0</u>

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Table 4 - Roofer and Slater - Special Trades  
Type By Source, Part of Body, Nature of Injury

Accident Type	%	Source	%	Part of Body	%	Nature	%
Contact with Hot Objects	19.4	Asphalt Oil	81.8	Hand	25.8	Burn/Scald	99.3
		Coal/Oil NEC	9.1	Multiple Parts	22.1	Other	<u>0.7</u>
		Other	<u>9.1</u>	Upper Extremities	13.8		
				Other	<u>38.3</u>		
					100.0	100.0	100.0
Overexertion/Lifting	10.3	Reel/Roll	16.2	Back	68.6	Strain/Sprain	86.0
		Bundle	13.1	Abdomen	8.0	Other	14.0
		Container NEC	10.4	Other	<u>23.4</u>		
		Other	<u>60.3</u>				
			100.0	100.0	100.0		
Fall to Lower Level	8.8	Ground	69.2	Multiple Parts	22.2	Fracture	33.5
		Work Area	7.8	Back	13.6	Sprain/Strain	21.3
		Other	23.0	Foot (not toes)	9.4	Contusion	11.8
				Other	<u>54.8</u>	Other	<u>33.4</u>
			100.0	100.0	100.0		
Struck by, NEC	8.3	Knife	20.7	Finger	32.8	Cut/Laceration	62.6
		Metal Item, NEC	9.1	Hand	14.9	Contusion	14.6
		Other	<u>70.2</u>	Other	<u>52.3</u>	Fracture	7.5
			100.0	100.0	100.0		

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Appendix A  
Roofing Work Flow Charts and Task Descriptions

## 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.)

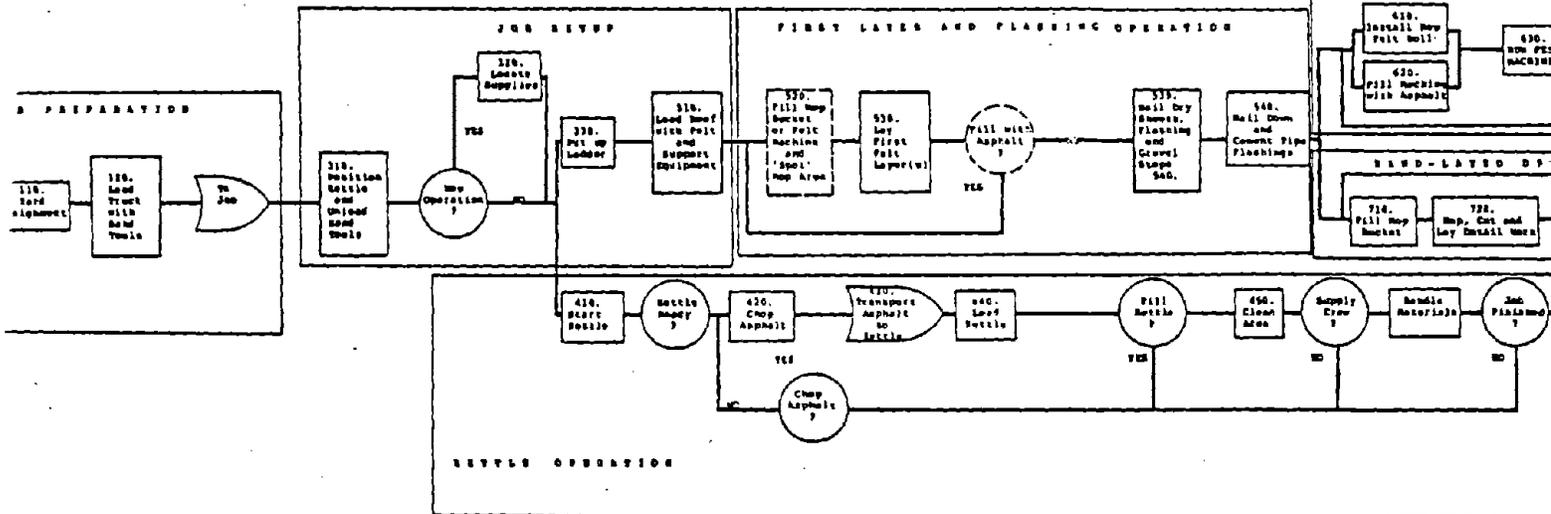
The box numbers on the flow charts correspond to the numbered operation descriptions that follow the flow chart. The two flow charts do not cover all the various types of roofing operations, but are sufficiently representative of operations to permit a basic understanding of the work content and basic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

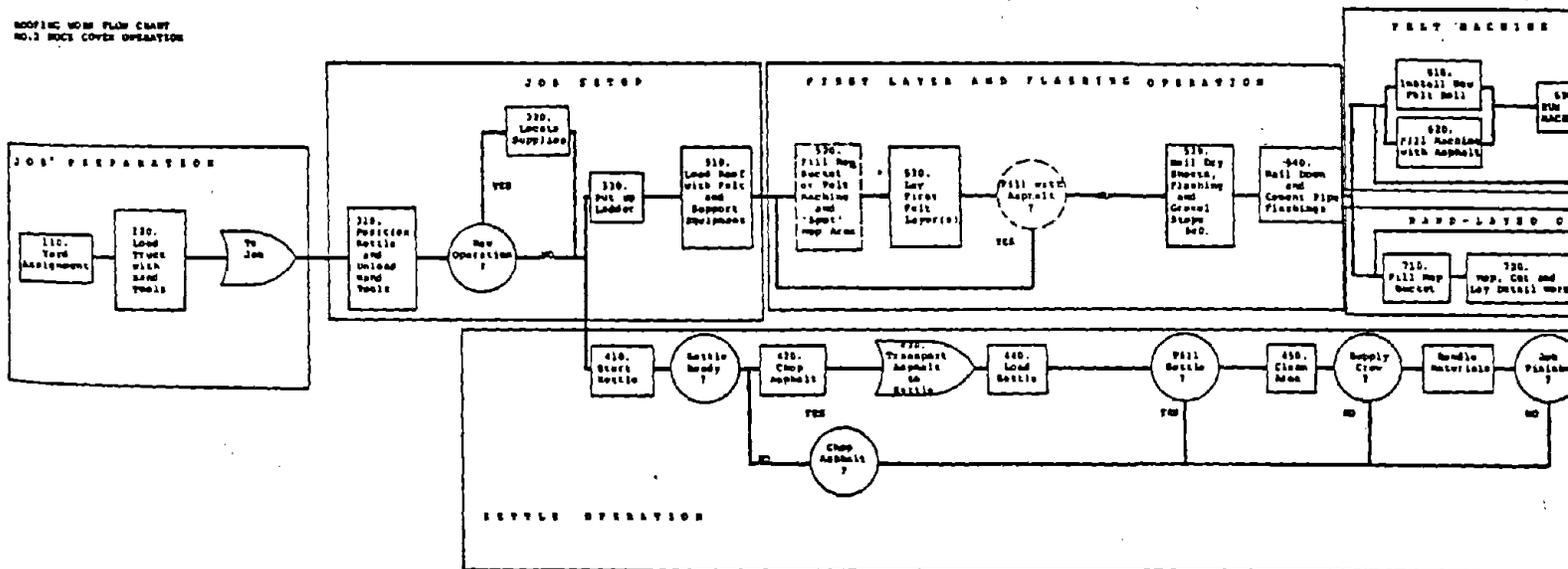
Such an analysis would help resolve the risk exposure increase-versus-decrease controversy about perimeter guard rails on the roof. For example, if most roofers are falling through roof openings and only rarely off the roof perimeter, then installing guard rails might increase rather than decrease the 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.

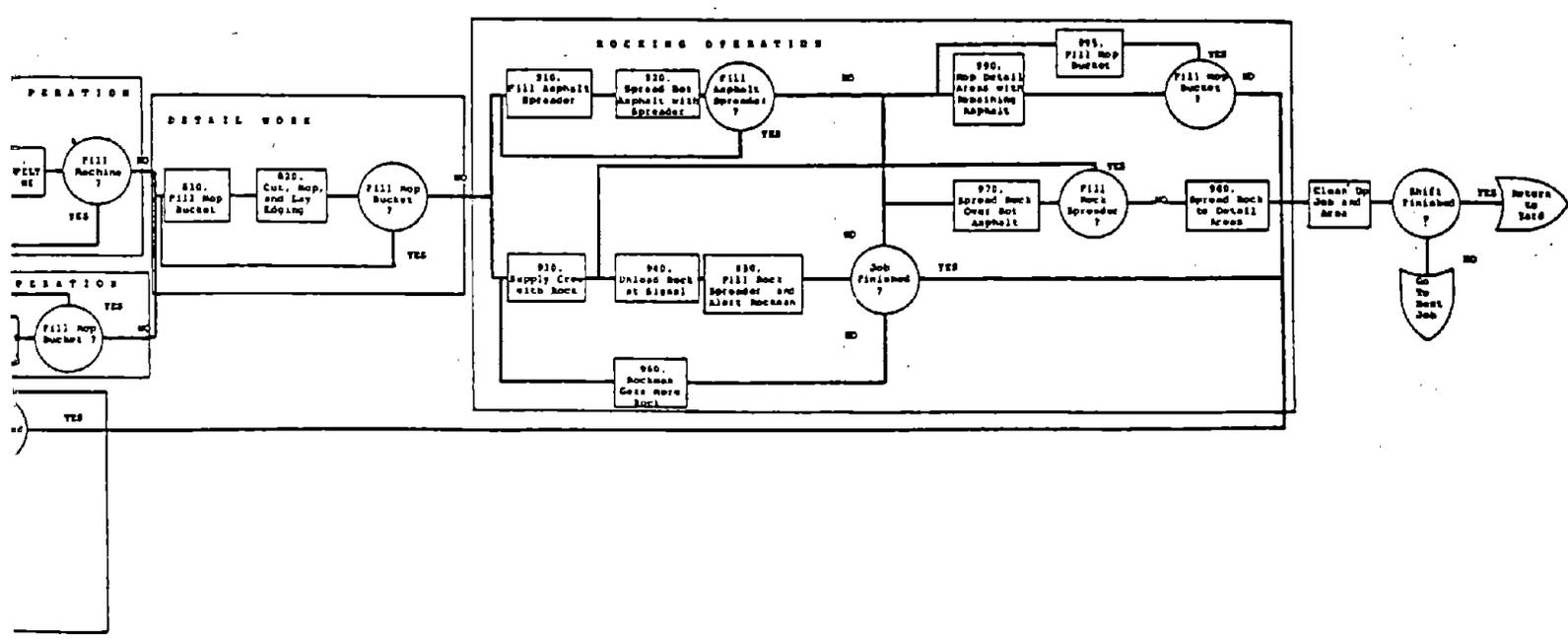
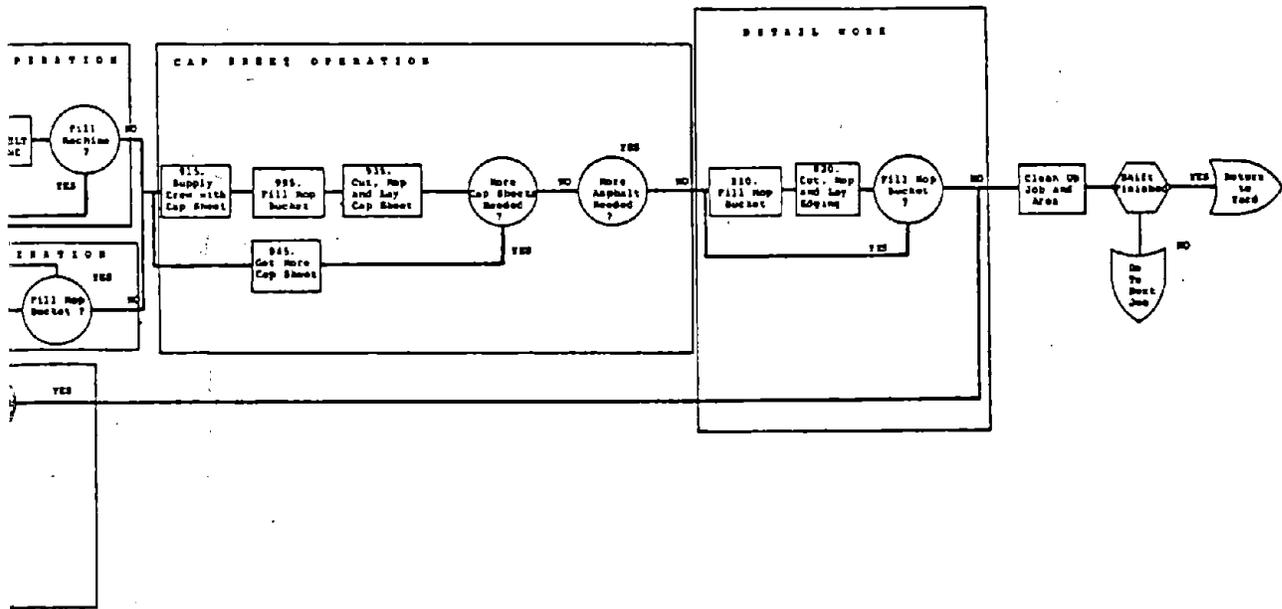
Hopefully, subsequent safety research efforts will extend what has been stated in the accompanying flow charts and the explanation that follow the charts:

NO MORE FLOW CHART  
CAP SHEET OPERATION



ROOFING WORK FLOW CHART  
NO.2 ROOF COVER OPERATION





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. Kettleman 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.