CHAPTER III
DEFINITION OF THE PROBLEM--THE HAZARDS OF THE OIL AND GAS WELL DRILLING INDUSTRY

This chapter is divided into two major areas of emphasis: the development of data pertaining to the injury incidence rates of the oil and gas well drilling industry, and an identification of the tasks performed in well drilling operations that are most hazardous to the population at risk. Also included is a discussion of training and the new employee, as well as a discussion of the costs of injuries to the industry.

A. General Hazard Assessment of the Oil and Gas Field Services Industry

For the oil and gas field services industry (SIC 138), the BLS reported that between 1972 and 1980 the average yearly injury and illness incidence rate was about 19.5 cases per 100 full-time workers (Table III-1). For these same years, the average injury incidence rate for heavy construction, not including highway, was 18.3; for bituminous coal mining, about 12.1; and for the private sector manufacturers of durable goods, about 14.9 (Table III-1). Although the tasks performed by the oil and gas well field services industry are not entirely equatable to coal mining or heavy construction, they are all high-hazard industries (as evidenced by their injury statistics) and can be used for comparative purposes. The severity rate for the oil and gas field services industry (SIC 138) averaged 211.8; i.e., for every 100 employees there were 211.8 lost workdays (Table III-1). The average severity rates for heavy construction, bituminous coal mining, and the durable goods industries for the same years were 116.5, 158.4, and 82.5, respectively (Table III-1).

B. Hazard Assessment of the Drilling Industry

National injury statistics compiled by the BLS are not available for the specific four-digit classifications of the industries that comprise SIC 138; i.e., drilling, 1381; exploration, 1382; and oil field services, 1389. Consequently, three techniques using different data bases were used to estimate injury incidence rates for the drilling industry: injury statistics tabulated by the Texas Workers' Compensation State Board of Insurance (TWC), injury data developed by the International Association of Drilling Contractors (IADC), and state injury statistics compiled by the Department of Labor's Supplementary Data System (SDS). The injury incidence rates calculated in this section are not directly comparable to BLS rates since the population at risk is limited to the workers at risk at the drilling operations and does not include the entire worker population for drilling companies (i.e., support staff, clerical, and sales personnel in addition to those workers at risk in drilling operations).

TABLE III-1
AVERAGE OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES FOR SELECTED INDUSTRIES, 1972-1980

Industry	Avg. Annual Employment (Thousands)	Total Cases[1] (Thousands)	Incidence Rate[2]	Severity Rate[3]	Lost Workdays (Thousands)
All	67,245.4	5,641.0	9.7	58.9	34,481.4
Heavy Construction (Exc. Highway) (SIC 162)	511.9	92.3	18.3	116.5	597.5
Bituminous Coal (SIC 12)	210.1	24.8	12.1	158.4	344.2
Manufacturing: Durable Goods	11,673.2	1,735.8	14.9	82.5	9,666.2
Oil and Gas (SIC 138)	192.4	37.7	19.5	211.8	414.0

[1] Estimated by multiplying the number of employees by the reported incident rate and dividing by 100.
[2] Number of total recordable injuries and illnesses/100 full-time workers.
[3] Number of lost workdays/100 full-time workers.
Reported by the Bureau of Labor Statistics [20 - 28].

Note: Data for 1972 were not reported for SIC 12, and data for 1977 were not reported for SIC 138. Only data for the years reported were used to calculate averages.

1. Estimates of Injury Incidence Rates Based on Texas Workers' Compensation State Board of Insurance Data

The first method used to estimate injury incidence rates for the oil and gas well drilling industry entails the extrapolation of injury data reported by the TWC to the entire drilling industry. The types of injuries reported are injuries requiring medical treatment and/or indemnity payments.

Drilling activities in Texas are assumed to be typical and representative of all drilling activities. Texas represents a cross section of major drilling contractors and small, one-rig companies; deep and shallow wells; and large and small rigs. Drilling contractors basically operate in areas that are expected to produce hydrocarbons. The same equipment (tongs, spinning chains, kelly bushings, drill pipes, etc.) is utilized in a similar manner regardless of the well site location. There is little indication that the oil field operations or the accident statistics of Texas differ from national figures.

The injury incidence rate was estimated by extrapolating the actual number of compensable (medical/indemnity) injuries for employees of drilling companies reported in Texas to all drilling. The assumption was that if the rate of injuries in Texas for a given amount of drilling activity was representative of national drilling injury rates, and there was a reported number of drilling injuries in Texas, then a reasonable number for compensable injuries nationwide could be estimated as in Tables III-2, III-3, and III-4.

The proportion of total drilling activity attributable to Texas, as a percentage of national figures, was developed using three independent comparison factors: number of wells drilled (Table III-2), number of active rigs (Table III-3), and well footage (Table III-4). For example, Texas was determined to account for approximately 39.6% (a range of 34.7% to 41.5%) of the Nation's drilling activity based on the number of active rigs from 1973 to 1978 (Table III-3). Estimates were then made of the number of drilling employees injured nationwide based on the number of compensable claims by employees of Texas drilling contractors.

The average injury incidence rate, based on the actual number of paid medical and/or indemnity claims to employees of drilling companies in Texas, was 38.1 between 1973 and 1978 (a range of 26.5 to 49.4). Tables III-2, III-3, and III-4 present the estimated compensable injury incidence rates for the drilling industry for 1973 to 1978.

2. Estimates of Injury Incidence Rates Based on IADC Data

A second data source to be considered when evaluating injury incidence rates for the drilling industry are those developed by the IADC. Table III-5 presents the lost-time injury incidence rates developed by the IADC for oil and gas well drilling for 1975-80.

TABLE III-2
ESTIMATED NUMBER OF EMPLOYEES INJURED AND INJURY INCIDENCE RATES FOR OIL AND GAS WELL DRILLING OPERATIONS BASED ON LAND-BASED WELLS DRILLED IN TEXAS

Year	Wells Drilled in Texas[1]	Wells Drilled Nationwide[1]	Texas as a % of Nationwide[2]	Injuries in Texas[3]	Est. Injuries Nationwide[4]	Est. Population at Risk[5]	Incidence Rate[6]
1973	8,422	26,543	31.7	4,499	14,192	32,408	43.8
1974	9,645	31,954	30.2	5,533	18,321	40,563	45.2
1975	12,309	38,151	32.3	6,360	19,690	46,113	42.7
1976	12,514	40,471	30.9	6,340	20,518	45,561	45.0
1977	14,421	45,238	31.9	8,625	27,038	54,697	49.4
1978	14,747	47,413	31.1	6,820	21,929	61,780	35.5
Tot./ Avg.	72,058	229,770	31.4	38,177	121,688	281,122	43.3[7]

1 From the American Petroleum Institute Quarterly Review of Drilling Statistics [29-34].
2 Calculated by dividing the number of wells drilled in Texas by the number of wells drilled nationwide and multiplying by 100.
3 Reported by the Texas Workers' Compensation State Board of Insurance [35] (Adjusted to reflect land-based injuries).
4 Extrapolated from the percentage of drilling activity and the number of injuries in Texas.
5 Person-years (from Table II-4.)
6 Injuries per 100 person-years. Calculated by dividing the estimated number of injuries nationwide by the estimated population at risk and multiplying by 100.
7 Calculated by dividing the total estimated number of injuries nationwide by the total estimated population at risk and multiplying by 100.

TABLE III-3
ESTIMATED NUMBER OF EMPLOYEES INJURED AND INJURY INCIDENCE RATES FOR OIL AND GAS WELL DRILLING OPERATIONS BASED ON LAND-BASED ACTIVE RIGS IN TEXAS

Year	Active Rigs in Texas[1]	Active Rigs Nationwide[1]	Texas as a % of Nationwide[2]	Injuries in Texas[3]	Est. Injuries Nationwide[4]	Est. Population at Risk[5]	Incidence Rate[6]
1973	367	1,057	34.7	4,428	12,761	32,408	39.4
1974	487	1,323	36.8	5,394	14,658	40,563	36.1
1975	616	1,504	41.0	6,237	15,212	46,113	33.0
1976	617	1,486	41.5	6,099	14,696	45,561	32.3
1977	737	1,784	41.3	8,351	20,220	54,697	37.0
1978	808	2,015	40.1	6,572	16,389	61,780	26.5
Tot./ Avg.	3,632	9,169	39.6	37,081	93,936	281,122	33.4[7]

[1] From the Oil and Gas Journal (see Table II-3)[11].
[2] Calculated by dividing the number of active rigs in Texas by the number of active rigs nationwide and multiplying by 100.
[3] Reported by the Texas Workers' Compensation State Board of Insurance [35] (Adjusted to reflect land-based injuries).
[4] Extrapolated from the percentage of drilling activity and the number of injuries in Texas.
[5] Person-years (from Table II-4.)
[6] Injuries per 100 person-years. Calculated by dividing the estimated number of injuries nationwide by the estimated population at risk and multiplying by 100.
[7] Calculated by dividing the total estimated number of injuries nationwide by the total estimated population at risk and multiplying by 100.

NOTE: The injury incidence rate calculated in this table would be identical to the injury incidence rate calculated for Texas since rig count is not only used to develop the population at risk (Tables II-3, II-4) but is also the basis for the extrapolation of the estimated injuries nationwide.

TABLE III-4
ESTIMATED NUMBER OF EMPLOYEES INJURED AND INJURY INCIDENCE RATES FOR OIL AND GAS WELL DRILLING OPERATIONS BASED ON LAND-BASED WELL FOOTAGE IN TEXAS

Year	Well Footage in Texas[1] (Thousands)	Well Footage Nationwide[1] (Thousands)	Texas as a % of Nationwide[2]	Injuries in Texas[3]	Est. Injuries Nationwide[4]	Est. Population at Risk[5]	Incidence Rate[6]
1973	44,654	129,175	34.6	4,473	12,928	32,408	39.9
1974	49,677	144,990	34.3	5,480	15,977	40,563	39.4
1975	61,484	170,041	36.2	6,293	17,384	46,113	37.7
1976	63,743	176,871	36.0	6,263	17,397	45,561	38.2
1977	75,346	204,040	36.9	8,483	22,989	54,697	42.0
1978	78,516	221,401	35.5	6,743	18,994	61,780	30.7
Tot./ Avg.	373,420	1,046,518	35.7	37,735	105,669	281,122	37.6[7]

[1] From the American Petroleum Institute Quarterly Review of Drilling Statistics [29-34].
[2] Calculated by dividing the number of well footage in Texas by the number of well footage nationwide and multiplying by 100.
[3] Reported by the Texas Workers' Compensation State Board of Insurance [35] (adjusted to reflect land-based injuries).
[4] Extrapolated from the percentage of drilling activity and the number of injuries in Texas.
[5] Person-years (from Table II-4)
[6] Injuries per 100 person-years. Calculated by dividing the estimated number of injuries nationwide by the estimated population at risk and multiplying by 100.
[7] Calculated by dividing the total estimated number of injuries nationwide by the total estimated population at risk and multiplying by 100.

Accident/injury information is collected from IADC member companies participating in a yearly safety awards program [36]. The reporting format adheres to the American National Standards Institute (ANSI) Z16.1 guidelines [37]. The injuries tabulated under the ANSI guidelines by the IADC are lost-time injuries--those injuries resulting in a time loss beyond the day of the accident. The reported employee person-hour figures include those hours worked by all company employees--support staff, secretarial help, sales personnel, as well as those persons at risk in drilling operations.

Examination of Table III-5 shows that the lost-time injury incidence rate for reporting drilling contractors in 1980 was 11.6. National BLS incidence rates for oil field workers show that lost-time injuries consistently account for about 50% of the total recordable injuries in the oil field [20-28]. This means that the recordable injury incidence rate for the IADC reporting companies for 1980 should be approximately 23 (about two times the reported lost-time injury incidence rate of 11.6).

TABLE III-5
LOST-TIME INJURY INCIDENCE RATES FOR OIL AND GAS WELL DRILLING BASED ON IADC REPORTS

Year	No. of Reporting Companies	Injury Frequency[1] (per million person-hours)	Total Person-hours[1] (Thousands)	Lost-time Injuries[1]	Est. Person-years[2]	Lost-time Injury Incidence Rate[3] (per 100 person-years)
1975	57	59.1	24,337	1,439	12,169	11.8
1976	92	56.2	35,961	2,020	17,981	11.2
1977	92	59.8	41,466	2,480	20,733	12.0
1978	116	63.7	54,646	3,478	27,323	12.7
1979	113	58.1	54,181	3,147	27,091	11.6
1980	131	57.8	74,972	4,330	37,486	11.6
Tot./ Avg.	601	59.1	285,563	16,894	142,783	11.8[4]

[1] Compiled from IADC reports [38-43].
[2] Calculated by dividing total person-hours by 2,000 person-hours per person-year.
[3] Calculated by dividing the lost-time injuries by the estimated person-years and multiplying by 100.
[4] Calculated by dividing the total lost-time injuries by the total estimated person-years and multiplying by 100.

Recognizing that a portion of the IADC employment figure is not at risk in drilling operations, the injury incidence rate for those employees at risk should be higher. The reporting base for the IADC "Injury Statistics Reports" is heavily weighted toward the larger contractor (companies more likely to have active safety and employee training programs). Only five companies, 4% of the 131 contractors participating in 1980 were estimated to be small, one-rig companies.[1] The median number of rigs owned by the companies not participating in the safety awards program was reported by the IADC to be one. Approximately 83% (629 companies) of the IADC membership (approximately 760 total companies in 1980 [8]) did not contribute to the injury data base. These nonparticipating, smaller companies account for approximately 53%[2] of the worker population and are less likely to have an active safety and/or employee training program.

3. Estimates of Injury Incidence Rates Based on SDS Statistics

The third method utilizes the SDS injury data base. This data base differs from that used by the BLS to develop the incidence rates presented earlier in Table III-1. The SDS tabulates those injuries that are reported to workers' compensation carriers and subsequently to state compensation insurance boards. BLS incidence rates are based on a sample of OSHA 200 forms [44]. These forms, completed by the employer, report all work-related injuries including those that involve such circumstances as medical treatment beyond "first aid," transfer to another work assignment, and loss of time from work. It would be expected that SDS injury figures would be lower than BLS figures because injuries not resulting in medical treatment or time loss are not included in the SDS reports but are frequently recordable under the BLS criteria [44]. Of the states which report SIC 1381 injury data to SDS, a total of 17 states also reported average rig activity for the years 1976-1980. The proportion of total drilling activity based on average rig count (1976-1980) for these states, as a percentage of national figures, was 18.4% compared to 38.7% for Texas (Table II-3).

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[1] Calculated by dividing reported annual person-hours [43] by the estimated number of person-hours necessary to run a 21-person rig 365 days; i.e., 21 workers for 8 hours/day for 365 days/year = 61,320 person-hours per rig per year.

[2] The IADC reports that 74,971,823.01 person-hours [43] are included in its 1980 report. If a "person", as defined by the BLS, works 2,000 hours per year, then 37,486 (74,971,823.01 divided by 2,000) person-years are included in the 1980 report. These figures include all person-years and are not limited to the population at risk. The actual population at risk in drilling operations has been estimated to be 79,869 person-years in 1980 (Table II-4). The IADC report represents, at most, 47% of the industry population.

The SDS data were analyzed to determine the injury incidence rate for the states reporting to SDS. Table III-6 summarizes the analysis and shows the average injury incidence rate in these states to be 21.8.

4. Summary of Injury Incidence Rates for Oil and Gas Well Drilling

Because national injury incidence figures have not been compiled and reported, three data sources and three techniques have been used to estimate the injury incidence rates for oil and gas well drilling injuries. Two estimating techniques used the actual numbers of paid injury claims (medical and/or indemnity) reported to the TWC and the SDS.

The first estimating technique used actual workers' compensation injury claims for employees of oil and gas well drilling contractors that were paid in the State of Texas. The percentage of nationwide drilling activity which Texas represented was determined utilizing three technology variables. Extrapolating injury figures to all drilling activities shows that the average incidence rate of compensable injuries requiring medical treatment was 38.1 (Tables III-2, -3, -4).

The second estimating method is based on the annual safety awards competition held by the IADC. Participating companies, representing about 47% of the employment figures and 17% of the member companies in 1980, report only disabling (lost-time) injuries and compute the incidence rates based on total employment figures (population at risk plus support staff). The IADC disabling (lost-time) injury incidence rate for oil and gas well drilling averaged about 11.8 between 1975 and 1980 (Table III-5).

The third method is based on the 1976-1980 SDS injury data base which includes accident information from a 17-state sample representing only 18.4% of the drilling nationwide (Table II-3). It was estimated that the injury incidence rate in these states was 21.8 (Table III-6).

It is the conclusion of this study that regardless of which data source and estimating method are used, workers in the oil and gas well drilling industry are injured at an unacceptably high rate.

C. Fatality Statistics

The number of active oil and gas well drilling rigs in the State of Texas between 1973 and 1978 accounted for approximately 39.6% of the drilling in the United States (Table III-3). Table III-7 presents data for these years on the number of worker fatalities, reported by the TWC, in the oil and gas well drilling industry [35]. There were 148 deaths in the Texas drilling industry during these 6 years--an average of approximately 25 deaths per year. Since Texas represents approximately 39.6% of the national drilling activity, based on active rigs, an average of 63 fatalities per year of workers in the oil and gas well drilling industry may be estimated by extrapolating the average number of deaths per year in Texas to the entire industry.

TABLE III-6
ESTIMATED AVERAGE INJURY INCIDENCE RATES FOR OIL AND GAS WELL DRILLING (SIC 1381)
IN SDS REPORTING STATES BASED ON SDS INJURY STATISTICS FOR 1976-1980

State	No.Years Injuries Reported	No. Reported Injuries 1976-1980[1]	Adjusted No. Injuries 1976-1980[2]	Reported No. Active Rigs 1976-1980[3]	Est. Pop. at Risk[4] (Person-years)	Incidence Rate[5]
ALASKA	5	1236	1236	71.8	2201.4	56.1
ARIZONA	1	2	10	3.4	104.2	9.6
ARKANSAS	4	89	111	81.1	2486.5	4.5
COLORADO	5	1236	1236	225.4	6910.8	17.9
IDAHO	5	106	106	9.6	294.3	36.0
INDIANA	4	22	28	9.8	300.5	9.3
KENTUCKY	5	434	434	8.4	257.5	168.5
MARYLAND	5	8	8	2.4	73.6	10.9
MICHIGAN	5	836	836	127.8	3918.3	21.3
MISSISSIPPI	1	258	1290	216.3	6631.8	19.5
MONTANA	5	2280	2280	167.2	5126.4	44.5
NEBRASKA	5	359	359	50.1	1536.1	23.4
N.MEXICO	3	698	1163	404.6	12405.0	9.4
NEW YORK	3	106	177	37.7	1155.9	15.3
OHIO	2	806	2015	224.6	6886.2	29.3
S.DAKOTA	4	34	43	10.6	325.0	13.2
UTAH	5	743	743	152.4	4672.6	15.9
TOT./AVG.		9253	12075	1803.2	55286.1	21.8[6]

[1] Reported by the Bureau of Labor Statistics, Supplementary Data System [45].
[2] Adjusted to reflect total injuries for states reporting for less than five years.
[3] Total rig activity for SDS reporting states [11] (Table II-3).
[4] Calculated by multiplying the number of employees per rig (7) by the number of shifts per day (3) by the number of hours per shift (8) by the number of days per year (365) by the average number of rigs and dividing the result by 2,000 (the number of hours worked by an individual in a year).
[5] Injuries per 100 person-years. Calculated by dividing adjusted injuries for SIC 1381 by the estimated population at risk, multiplied by 100.
[6] Calculated by dividing total adjusted injuries for SIC 1381 by the total estimated population at risk, multiplied by 100.

Thirty-seven fatalities were reported by the oil and gas well drilling companies participating in the IADC safety awards program for 1980 [43]. If the participating companies in the 1980 IADC report represent about 47% of the employment figures for drilling activities and 37 deaths were reported, then 79 deaths can be estimated for the entire drilling industry.

TABLE III-7
FATALITIES THAT OCCURRED IN TEXAS OIL AND GAS WELL DRILLING OPERATIONS EXTRAPOLATED TO THE ENTIRE OIL AND GAS WELL DRILLING INDUSTRY

Year	Active Rigs in Texas[1]	Active Rigs Nationwide[1]	Texas as a % of Nationwide[2]	Fatalities in Texas[3]	Est. Fatalities Nationwide[4]
1973	367	1,057	34.7	27	78
1974	487	1,323	36.8	26	71
1975	616	1,504	41.0	17	41
1976	617	1,486	41.5	20	48
1977	737	1,784	41.3	32	77
1978	808	2,015	40.1	26	65
Avg.	605	1,528	39.6	25	63

[1] From the Oil and Gas Journal [11].
[2] Calculated by dividing the active rigs in Texas by the active rigs nationwide and multiplying by 100.
[3] Reported by the Texas Workers' Compensation State Board of Insurance [35] (Adjusted to reflect only land-based fatalities).
[4] Estimated by extrapolating the percentage of total active rigs in Texas and the reported fatalities [35] to the entire industry.

D. Hazardous Tasks Performed in Well Drilling Operations

An analysis of detailed accident and injury reports was performed to determine causative factors in drilling accidents. The accidents included in the analysis tended to be representative of the more serious events--detailed summaries of minor injuries/accidents are not commonly available. However, the comparison of accident causative factors with accident analysis developed by IADC in its reports, as well as the SDS analysis of accident types, led to the conclusion that the analysis is representative of accidents that occur during drilling operations.

The analysis of 738 accident and injury reports indicated that approximately 82% of the reported injuries and fatalities were directly attributable to drilling activities such as tripping, adding drill pipe, and torquing the drill string (Table III-8). The remaining injuries (18%) were associated with tasks performed in many industries such as using handtools, 4.3%; performing pump inspection and maintenance, 1.9%; and other, 8.5%.

TABLE III-8
DRILLING OPERATIONS AND INJURY DISTRIBUTION

	Drilling Activities	Hand-tools	Falls from Ladders	Falls on Stairway	Mud Tank Tasks	Pump Inspection and Maintenance	Burns	Other
No. of Reported Injuries	603	32	2	12	5	14	7	63
Percentage of Total	81.7	4.3	0.3	1.6	0.7	1.9	1.0	8.5

Compiled from 738 accident reports of OSHA investigations, company accident reports, workers' compensation reports, and published case histories (Tables III-9 and III-10) [10, 46-49].

After further refinement of the 603 fatality and injury reports (Table III-9) attributable specifically to well drilling activities, the major activities (tasks, tools, and equipment) contributing to oil and gas well drilling accidents were found to be as follows:

- o Handling of drill pipes, collars, and casings resulted in 22.2% of the accidents and 16% of the reported fatalities.
- o Tong operations resulted in 15.3% of the accidents and 10% of the reported fatalities.
- o Derrick operations resulted in 8.3% of the accidents and 31% of the reported fatalities.
- o Cables and chains were involved in 8.0% of the accidents and 6% of the reported fatalities.
- o Elevator operations resulted in 6.3% of the accidents and 4% of the reported fatalities.

Table III-9 presents a detailed analysis of accident reports specific to drilling activities, and Table III-10 presents an analysis of accidents that occurred while tasks typical of other industries were being performed. Case histories representative of these accidents are presented in Appendix A.

The IADC, in its "Charlie Report for 1980", classifies total injuries associated with rig activity or equipment (Table III-11) [43]. In 1977 through 1979 the IADC also reported major categories (Table III-12) [40-42], which are similar to those used by the SDS for reporting state injury data; e.g., caught in or between, struck by or against, falls of personnel, overexertion, falling objects, flying objects, and temperature extremes. Further examination of Table III-11 shows that approximately 48% of the

TABLE III-9
TYPES AND CAUSES OF ACCIDENTS SUSTAINED DURING TASKS
UNIQUE TO WELL DRILLING OPERATIONS[1]

Tool/equipment Associated with Accident	Type of Accident								
	Struck by/ against	Caught in/ between	Overexer- tion(lift)	Foreign Substance in Eye	Fall to Working Surface	Fall to Below	Nonclas- sifiable	TOTAL(%)	Fatal
Tongs	53	35	3				1	92(15.3)	10
Drill pipes, collars, casing	51	62	13	2	3		3	134(22.2)	17
Elevators	12	21	1			4		38 (6.3)	4
Slips	3	9	11					23 (3.8)	
Catheads,catlines	4	5	1					10 (1.6)	
Kelly	4	3	3					10 (1.6)	
Spinning chains		5	1				1	7 (1.2)	2
Cables, Chains, Ropes, Lines	23	8	5	1	3	3	5	48 (8.0)	6
Traveling blocks	14	2						16 (2.7)	4
Rotary table	4	4			2			10 (1.6)	2
Hose, Pipe, Flow line	16	5	2	1	1		2	27 (4.5)	6

[1] Seven hundred thirty-eight accident reports have been compiled from OSHA investigations, company accident reports, workers' compensation reports, and published case histories [10, 46-49]; 603 of the accident reports relate directly to well drilling activities (Table III-8) and are analyzed in this table. An analysis of the remaining 135 accident reports is presented in Table III-10.

TABLE III-9
TYPES AND CAUSES OF ACCIDENTS SUSTAINED DURING TASKS
UNIQUE TO WELL DRILLING OPERATIONS (Continued)

Tool/equipment Associated with Accident	Type of Accident							TOTAL(%)	Fatal
	Struck by/ against	Caught in/ between	Overexer-tion(lift)	Foreign Substance in Eye	Fall to Working Surface	Fall to Below	Nonclas-sifiable		
Pipe rack					4			4 (0.7)	
Swivel	3	1						4 (0.7)	1
Snubs	3	2	3		1			9 (1.5)	
Jets	2							2 (0.3)	
Boards	3							3 (0.5)	
Drill bits	2							2 (0.3)	
Brakes	4							4 (0.7)	1
BOP	9	5	2	1	1	3	1	22 (3.6)	6
Derrick		1			7	41	1	50 (8.3)	33
Rig floor						5		5 (0.8)	1
Substructure						3		3 (0.5)	1
Mousehole, Rathole	2				2		3	7 (1.2)	

TABLE III-9
TYPES AND CAUSES OF ACCIDENTS SUSTAINED DURING TASKS
UNIQUE TO WELL DRILLING OPERATIONS (Concluded)

Tool/equipment Associated with Accident	Type of Accident: Struck by/ against	Caught in/ between	Overexer- tion(lift)	Foreign Substance in Eye	Fall to Working Surface	Fall to Below	Nonclas- sifiable	TOTAL(%)	Fatal
Vee-door						2		2 (0.3)	
Cellar						4		4 (0.7)	1
Ladder into Cellar						2		2 (0.3)	
Valve cap on mud tank	3							3 (0.5)	2
Drawworks	1	1						2 (0.3)	2
Rigging	4							4 (0.7)	
Welding, Cutting				1			1	2 (0.3)	
Reserve pit						1		1 (0.2)	1
Motor vehicle							3	3 (0.5)	3
Other		7	10	7	7		19	50 (8.3)	2
TOTAL	220	176	55	13	31	68	40	603	105
(%)	(36.5)	(29.2)	(9.1)	(2.2)	(5.1)	(11.3)	(6.6)	(100.0)	(17.4)

TABLE III-10
TYPES AND CAUSES OF ACCIDENTS SUSTAINED DURING TASKS
NOT UNIQUE TO WELL DRILLING OPERATIONS[1]

Accident Types	Handtools	Ladders	Stairways	Mud Tank	Pump	Burns	Other	Total(%)	Fatal
Foreign substances in the Eye	3						10	13 (9.6)	
Fall to working surface	2		8	3	2		6	21(15.6)	
Fall to below		1	4		7		3	15(11.1)	1
Struck by/against	25						14	39(28.9)	
Caught in/between	2				4		8	14(10.4)	
Contact with temperature extremes						5		5 (3.7)	
Overexertion				1			4	5 (3.7)	
Puncture							3	3 (2.2)	
Heat exposure						1	2	3 (2.2)	
Electrocution				1		1	3	5 (3.7)	4
Motor vehicle							3	3 (2.2)	
Nonclassifiable		1			1		7	9 (6.7)	1
TOTALS	32	2	12	5	14	7	63	135	6
(%)	(23.7)	(1.5)	(8.9)	(3.7)	(10.4)	(5.2)	(46.6)	(100.0)	(4.4)

[1] Seven hundred thirty-eight accident reports have been compiled from OSHA investigations, company accident reports, workers' compensation reports, and published case histories [10, 46-49]; 135 of the accident reports concerned activities not unique to well drilling activities (Table III-8) and are analyzed in this table. An analysis of the remaining 603 accident reports is presented in Table III-9.

reported accidents involved equipment and/or machinery that is directly associated with tripping and drill string lengthening procedures; e.g., tongs, 13.0%; cables, chains, and ropes, 8.4%; slips, 3.2%; pipe, 16.8%; elevators, 4.5%; and rotary tables, 1.8%. Similar results reported by the Union of Soviet Socialist Republics (USSR) researchers show that more than 50% of the accidents involved adding drill pipe to the string [50, 51].

This study suggests that the specific handling of drill pipes, collars, and casings was responsible for more injuries than any other task (22% of the accidents), and that tongs were involved in more accidents (15%) than any other type of equipment or tool (Table III-9). Two studies of offshore drilling accidents also reported that tongs were the most hazardous piece of equipment [52, 53]. Falls of personnel accounted for almost 15% of the injuries, and overexertion caused an additional 6% of the injuries reported during 1980 by the IADC (Table III-11) [43]. Falls were determined by this study to be responsible for 16% of the injuries (Table III-9).

TABLE III-11
INJURIES ASSOCIATED WITH RIG ACTIVITY OR EQUIPMENT, 1980

Rig Activity or Equipment	Reported Disabling Injuries	(%)
Tongs	427	13.03
Pipe	552	16.84
Cables, Chains, Ropes	276	8.42
Hose	48	1.46
Cathead	19	.58
Elevator	148	4.52
Hand Tools	155	4.73
Air Tugger	13	.40
Vehicles	30	.92
Motors or Generators	41	1.25
Fans	2	.06
Clutches or Brakes	19	.58
Slips	106	3.23
Falling Objects	147	4.48
Cranes	16	.49
Belts or Pulleys	42	1.28
Personnel Falls	490	14.95
Overexertion	182	5.55
Rotary Tables	60	1.83
Temperature Extremes	25	.76
Harmful Substances	74	2.26
Other	406	12.38
TOTAL	3278	100.00

Adapted from the International Association of Drilling Contractors' "Charlie Report for 1980" [43].

The percentage distribution of accident types, as reported by both the IADC and SDS for the 3-year period, 1977-1979, is highly correlated (Table III-12).

TABLE III-12
TYPE OF ACCIDENT OR EXPOSURE FOR OIL AND GAS WELL DRILLING ACTIVITIES (1977-79)

Type of Accident or Exposure	IADC[1]		SDS[2] SIC 138		SDS[2] SIC 1381	
	Number	Percent	Number	Percent	Number	Percent
Struck by or against	1,913	22.4	5,118	20.7	1,078	19.7
Falls of personnel	1,725	20.2	3,592	14.6	829	15.2
Caught in or Between	1,694	19.9	4,162	16.9	975	17.9
Overexertion	920	10.8	2,841	11.5	602	11.0
Falling objects	602	7.1	2,925	11.9	660	12.1
Flying objects	273	3.2	645	2.6	221	4.1
Temperature extremes	265	3.1	748	3.0	169	3.1
All others	1,130	13.3	4,648	18.8	927	16.9
TOTAL	8,552	100.0	24,679	100.0	5,461	100.0

[1] Compiled from reports of the International Association of Drilling Contractors (IADC) [40-42].
[2] Reported by the Bureau of Labor Statistics, Supplementary Data System (SDS) [45].

E. How Injuries Occur in Drilling Operations

Inherent in all tasks is the potential that an accident will occur, although the accident potential may be greater for some tasks than for others. Accidents, in turn, may result in injuries, some more severe than others. Injury severity is reflected by the nature of the injury (amputation, fracture, laceration) and by the amount of time the injured employee is unable to work.

A hazard has been defined as "a thing or condition that might operate against success or safety: a possible source of peril, danger, duress, or difficulty" [54]. In this report, which takes an operational approach to the concept of hazard, those tasks which are more likely to result in severe injuries to workers are considered the more hazardous tasks.

Injuries that result from hazards unique to oil and gas well drilling operations can be broadly classified into two major categories: those injuries incurred from task-specific accidents and those injuries incurred during more catastrophic events such as blowouts, derrick collapse, and hydrogen sulfide exposures.

1. Task-Specific Accidents

The first major category of accidents is representative of incidents that occur during task-specific operations. Accident case histories, typical to these operations, are presented in Appendix A. This major category has been further subdivided into accidents that occur during drilling operations, derrick tasks, and materials handling activities.

a. Drilling operations have been further categorized by the tools or equipment used in performing the task, such as:

(1) Slips

Slips are the toothed wedges that are positioned between the drill pipe and the master bushing/rotary table to suspend the drill string in the well bore when it is not supported by the hoist. Most of the accidents attributable to slip operations occur in relationship to materials handling; strained backs and shoulders are common. Furthermore, the working surface may be wet and slippery, contributing to muscle strains, as well as to accidents such as falls and dropping the slips onto the feet. Lack of communication between the driller and the employees engaged in the slip operations and lack of coordination between employees engaged in the task contribute to accident potentials in slip handling.

(2) Tongs

Tongs are the large, counterweight-suspended wrenches used to "break out" the torqued couplings on the drill pipe. Both sets of tongs have safety lines; when breakout force is put on the tongs, employees should step back from the outside radius of the tongs in the event a tong slips or a safety line slips or breaks. In these instances, employees positioned in the path of travel can suffer serious injury.

Another likely accident can occur when the driller actuates the wrong tong lever and an unsecured tong swings across the rig floor at an uncontrolled velocity. Sometimes the wrong lever is pulled because the levers are not placed in such a manner as to make them readily distinguishable, and sometimes because the driller is distracted or fatigued.

A common accident attributable to tongs can occur when an employee has his hand or finger in the wrong place as he attempts to swing and latch the tong onto the drill pipe resulting in crushing injuries and amputations of the fingers.

(3) Elevators

Elevators are a set of clamps affixed to the bails on the swivel below the traveling block. They are used to clamp each side of a drill pipe (the pipe is belled in this area) and hold the pipe as it is pulled from the well bore.

A number of accidents and associated injuries can occur during the latching and unlatching tasks--fingers and hands can get caught and crushed in the elevator latch mechanisms. The more severe injuries involve improper attachment of the pipe to the elevator. If the pipe is overhead when the latching mechanism fails, then the pipe may fall on employees working on the drill floor.

(4) Catlines

Catlines are used on drilling rigs to hoist material. The revolving cathead on the drawworks powers the friction pulley system. An employee wraps a rope, usually 1-1/4 inches in diameter, around the cathead and tensions the line. The tighter the rope and the more wraps around the cathead, the faster the material is hoisted.

Accidents that occur during catline operations may injure the employee doing the rigging as well as injure the operator. Minimal hoisting control causes sudden and erratic load movements, which may result in hand and foot injuries.

(5) Working surfaces

The rig floor is the working surface for most tasks performed in well drilling operations. This surface is frequently wet from circulating fluid and/or water used to wash it down. Prevailing weather may further increase the slipperiness of the surface.

Employees must lift, push, and pull heavy items as a routine part of their assignments. Slippery working surfaces can increase the likelihood of back injuries and other overexertion injuries. Slips and falls may result in sprains, strains, contusions, and lacerations. Exposed moving parts (rotary table and kelly bushing) may compound the injury potential and severity.

Additionally, the rathole (although usually an elevated tube) and mousehole, used to temporarily store the kelly bar and drill pipe, may be uncovered when not in use. Stepping into a floor hole can result in fractures and sprains.

The cellar is a pit in the ground below the derrick structure. Hydrogen sulfide, if released, and water may accumulate in this low area. Ladder access into the cellar is a potential accident source, as is lack of proper guarding.

b. Derrick Operations

The derrickman on a well drilling operation performs his tasks from various elevated work platforms in the mast. He is exposed to falls when not utilizing fall protection equipment while climbing the derrick ladder, while working with the pipe stands, and while moving from the ladder to his platform station. The derrickman is also exposed to crushing injuries from shifting stands of pipe and elevator latching tasks.

Adequate and continuous fall protection is a prerequisite for the safety of employees working on a derrick. Conditions beyond the control of the derrickman (wind, vibration, pipe movement) make even momentary unprotected exposures hazardous.

c. Materials Handling

The most common type of accident that occurs in materials handling operations is the "caught between" situation; e.g., when a load is being handled and a finger or toe gets caught between two objects. Rolling stock (drill pipe and collars) can shift and/or fall from a pipe rack or truckbed. Employees must be alert to the hazards attendant to pipe handling and racking.

Vertical and near-vertical storage of drill pipe on the inclined ramp requires adequate slippage protection and employee procedural training for safe handling.

Improper rigging of loads can result in load shifts and objects falling on those below. Materials handling is a support activity, so safe materials handling procedures frequently are not given the necessary emphasis.

2. Catastrophic Events

Catastrophic accidents involve the destruction of the drilling rig and/or injuries to multiple employees. Blowouts, derrick collapse, and hydrogen sulfide accidents are included in this category. Even though these accidents frequently may involve loss of life as well as the major destruction of equipment, the actual number of casualties

represent only a small percentage of the total well drilling occupational injury incidence and severity rates [3, 55].

Although not a common occurrence, derrick or mast collapse most frequently happens during rigging-up and rigging-down procedures. The greatest strains are exerted on the mast components during these operations. Derrick frames subjected to abuse during movement may be damaged and wrecked. Inspection of the derrick structure is important for the detection of weld weakness, oxidation, and bent members [6, 7]. Weight indicators and recorders allow the driller to stay within mast load tolerances; consequently, they must be maintained and inspected. Manufacturers' rig capacities and guying requirements should always be followed.

F. Costs of Injuries

Workers' compensation insurance carriers, representing oil and gas well drilling companies in 15 States and accounting for approximately 81%[1] of the total number of active rigs, made actual compensation payments (medical and indemnity) averaging $28,840,230 per year between 1971 and 1978 (Table III-13). Since data were not available from every state for the entire time span, a very conservative estimate of the medical/indemnity expenditure per employee at risk in the drilling industry between 1971 and 1978 is approximately $686 per employee (average number of employees between 1971 and 1978 was 42,058 (Table II-4); this figure divided into the total reported dollars per year spent on medical and indemnity for employees of drilling companies-- $28,840,230 (Table III-13)--is $685.73) [35, 56]. Compensation payments for injured employees accounted for 8.6% of the corporate payroll in these states--a range of 26.2% of the total payroll in Louisiana to 3.8% in Indiana (Table III-13). Additional indirect costs of employee injuries (e.g., new employee training, administration, and overhead) are estimated by the National Safety Council to be more than four times the actual medical/ indemnity payments, or approximately $115,000,000 per year for the oil and gas well drilling industry during the 8-year period (1971-78) (Table III-13) [57].

For the states indicated in Table III-13 (representing approximately 80% of the total footage drilled) (Tables III-4 and III-13), the average incurred workers' compensation loss per foot of well drilled was $0.21.

G. Training and the New Employee

Traditionally, training of oil field employees has been by on-the-job exposure under the guidance of an experienced hand and the supervision of a fully qualified driller; years were required for advancement from floorhand to driller. In the past it was unusual for a young person to be a driller,

[1]Number of active land-based rigs for reporting years (Table II-3) as a percentage of total land based active rigs.

TABLE III-13
WORKERS' COMPENSATION LOSSES INCURRED BY THE
OIL AND GAS WELL DRILLING INDUSTRY, 1971-78

State	Years Reported	Average Compensation Losses[1] ($/year)	Average Payroll[1] ($/year)	Payroll Paid in Compensation Losses (%)	Average Well Footage Drilled[2] (ft./year)	Compensation Losses per Foot[3] ($)
Alabama	1973-77	329,985	5,004,462	6.6	1,123,655	0.29
Alaska	1972-77	1,203,597	18,152,949	6.6	446,814	2.69
Arkansas	1973-77	416,865	5,692,735	7.3	1,963,036	0.21
Colorado	1973-76	1,083,862	13,718,224	7.9	5,823,623	0.19
Illinois	1972-77	608,125	7,019,205	8.7	2,564,963	0.24
Indiana	1973-77	46,891	1,240,933	3.8	856,158	0.05
Kansas	1972-77	1,544,177	22,037,448	7.0	10,743,261	0.14
Louisiana	1973-77	3,139,169	11,997,301	26.2	16,477,052	0.19
Michigan	1972-77	1,203,170	8,762,933	13.7	2,241,429	0.54
Mississippi	1972-76	755,648	14,131,438	5.3	3,905,173	0.19
Montana	1971-77	536,564	7,176,740	7.5	2,383,769	0.23
New Mexico	1973-77	1,755,866	20,647,992	8.5	6,709,484	0.26
Oklahoma	1973-77	6,698,880	70,225,608	9.5	20,826,149	0.32
Texas	1971-78	9,105,563	140,258,688	6.5	62,236,657	0.15
Utah	1973-76	411,868	9,674,385	4.3	1,533,450	0.27
Total		28,840,230	355,741,041		139,834,673	
Average		1,922,682	23,716,069	8.6	9,322,312	0.21[4]

[1] Compiled from reports by the National Council of Compensation Insurance [56] and the Texas Workers' Compensation State Board of Insurance [35] (Adjusted to reflect land-based compensation losses and payroll).

[2] Compiled from the American Petroleum Institute Quarterly Review of Drilling Statistics [29-34] (for years 1973-78).

[3] Calculated by dividing average incurred compensation loss by average well footage drilled for reporting states.

[4] This statistical analysis incorporates a weighting factor that attributes greater representation to 1,000,000 feet drilled than to 100,000 feet drilled.

but with the present level of drilling activity it has become a necessity [58]. Skilled hands are now at a premium and technical development may lag behind job advancement. Insufficient crew training and lack of experienced hands have been targeted by industry experts as the "greatest problem facing the industry today" [59, 60].

A 1979 study of Canadian oil field accidents, conducted for the Alberta Division of Occupational Safety and Health, concludes:

> The data suggests that accidents will be reduced when people who work on well sites are selected properly, oriented well, trained completely, retrained constantly, motivated always, and retained to become career oil field staff.
>
> Selecting properly from a more qualified pool of applicants will begin to occur when escalation of activity in the industry decreases, or levels out, or when better retention of workers reduces the need for constant replacements. At the present time manpower needs are so urgent that normal selection procedures are often by-passed.
>
> Orientation would be improved by industry cooperating with educational institutions in providing information and courses to prospective employees about opportunities in the oil fields. Recruitment should include exposure to packaged audio visual orientation material that would take the surprise out of first days on the job.
>
> Training must compensate for lack of experience when new men, because of necessity, are promoted rapidly. The industry will be challenged to research best methods and to implement excellent programs.
>
> Remaining aware of danger, as familiarity kills caution, requires constant retraining in a variety of ways in order to retain interest. This constitutes another developmental thrust for training institutions and personnel.
>
> Motivation to work safely and to stay with the industry must come from the companies. The opportunity to be employed year around, developing pride in working for a good company, experiencing satisfaction with job conditions, knowing that the work is meaningful and in being rewarded generously should lessen the movement of workers through the industry. It will assist in raising public opinions about oil field work to the status of a respected career. This should reduce the number of workers who say they are in it for the money only.
>
> Government cooperation with company management in addressing the high priority strategic failure paths identified in this

study should help to reduce the number of severity and accidents in the Alberta oil fields [61].

A disproportionately high percentage of injuries are sustained by new employees. The IADC determined that 61% of the reported drilling injuries for 1979 happened to persons employed for 6 months or less (Table III-14). An analysis of more than 738 accident reports compiled from OSHA investigations, company accident reports, workers' compensation reports, and published case histories [10, 46-49] of injuries sustained by employees during well drilling operations showed that about 72% of the injured workers had been employed for less than 6 months (Table III-15). Furthermore, 45% of the injured employees actually had been employed for 1 month or less. Other researchers have noted similar relationships between length of employment and injury incidence rates. For example, a Canadian study of well drilling accidents showed that 58% of those injured in 1977 had been employed for less than 6 months [62]. Recent studies of accidents that occurred during offshore drilling operations have reported that 76.5% of those injured were employed for less than 1 year, and 54.8% of the injuries occurred to employees with less than 6 months' experience [52, 53]. A study reporting on worker turnover and safety found that the new workers were the most vulnerable to accidents [63]. These studies did not determine what proportion of the work force was made up of new employees or whether the tasks assigned to new employees posed a greater exposure to hazards. It should be noted that in the drilling industry the new employee traditionally advances from the position of a rotary helper to a derrickman and eventually to the position of driller. The tasks performed by a rotary helper (e.g., handling and torquing drill pipe during drilling and tripping, tongs, catlines, and slips) have been demonstrated by this study to be precisely those most frequently associated with worker injuries; therefore, employees new to these drilling tasks should be trained in proper operational procedures. Similar task/injury relationships were reported in studies of offshore drilling operations [52, 53, 64], as well as in a Canadian study of drilling accidents [62].

Some drilling contractors have implemented extensive training programs by using courses developed by the American Petroleum Institute (API), the Petroleum Extension Service of the University of Texas (over 200 audio-visual programs), and the IADC, as well as their own multimedia introductions to drilling and its hazards. A month-long school for drilling rig rotary helpers in South Texas reports that for approximately 500 persons who graduated after 1975, only three serious disabling accidents have been recorded and two of these were snakebite incidents [65]. Louisiana initiated a similar 8-week training course in 1980 [66]. This trend is unlikely to immediately affect the many small firms in the industry, since new employees may be hired at the well sites without the benefit of preliminary training and orientation.

However, one major drilling contractor recently implemented a mobile training unit to teach safety to crews drilling in remote locations. Although these crews still exhibit the highest turnover rate, they have gone

TABLE III-14
INJURY BREAKDOWN BY LENGTH OF EMPLOYMENT

	Length of Employment (Months)			
	6 and under	7-11	12-23	24 and over
No. of Disabling Injuries	2,925	552	578	738
Percent of Total	61	12	12	15

Compiled from the 1979 IADC "Charlie Report" [42].

TABLE III-15
REPORTED ACCIDENTS AND LENGTH OF EMPLOYMENT[1]

	Length of Employment (Months)				
	1	2-3	3-6	6-12	12 and over
No. of Reported Accidents	234	97	46	56	89
Percent of Total	45	18	9	11	17

[1]Seven hundred thirty-eight accident reports have been compiled from OSHA investigations, company accident reports, workers' compensation reports, and published case histories; 216 did not include length of employment and are therefore not included in this table [10, 46-49].

from the highest to the lowest lost-time accident rates for the reporting company [67].

H. Conclusion

Although national injury statistics are not available for the oil and gas well drilling industry (SIC 1381), three techniques, using different data bases, were used to estimate the injury incidence rates for the drilling industry. The data bases and estimating techniques report different types

of injuries (lost-time, compensable, SDS recordable) and, as such, are not entirely equatable. However, regardless of the type of injury or the estimating technique, the magnitude of the problem, occupational safety during oil and gas well drilling operations, is extensive. Workers were injured at the following average estimated incidence rates:

- Compensable injury incidence rate (TWC): 38.1
- Disabling lost-time injury incidence rate: 11.8.
- Estimated injury incidence rate for 17 SDS states: 21.8

The evidence further indicates that a substantial percentage of the well drilling industry's injuries occur while tasks associated with tripping, torquing, and joint spinning are being performed. Handling drill pipe and chains, operating tongs, and working from and climbing the derrick contribute substantially to drilling injuries. Materials handling, lifting, and falling (to a level below and to the working surface) contribute further to the industry's high injury incidence and severity rates.

Individual companies that submit their injury data to the IADC report varied lost-time injury frequency rates (per million person-hours)--ranging from 0 to more than 200 [38-43]. The diversity of reported injury rates could be indicative of a variable corporate approach to worker safety. The high injury incidence and severity rates found in the oil and gas well drilling industry and the uniqueness of the processes and technologies used in these drilling operations indicate the need for the development of comprehensive safety recommendations including the need for employee training and safety awareness.