CHAPTER II
DESCRIPTION OF THE OIL AND GAS WELL DRILLING INDUSTRY

The first section of this chapter briefly describes the oil and gas field industries that interact in developing an oil or gas well; the next section describes the technology and processes used by oil and gas well drilling companies; and the final section assesses the population at risk in the oil and gas well drilling industry.

This document is specifically directed toward tasks associated with oil and gas well drilling and, concomitantly, those industries performing the drilling (SIC 1381). To facilitate an understanding of the development of an oil well, an overview of all tasks necessary to complete a well is presented in the following section.

A. General Structure of the Oil and Gas Field Industry

Oil and gas field companies (SIC 138) perform tasks associated with the construction of oil or gas wells and the subsequent maintenance of a producing field. The industry is composed of companies that erect the rig and drill the hole (SIC 1381); companies that provide ancillary services such as well completion, casing, and perforating (SIC 1389); and companies that offer exploratory services (SIC 1382).

The size of the drilling rig, the number of employees, and the duration of the drilling operation depends on the depth of the well to be drilled, which may range from a few hundred feet to over 30,000 feet. Drilling times tend to increase exponentially with well depth and may vary from a week to more than 2 years.

As many as 20 different companies may perform their specialized operations at each well site. The scope of this document is limited to the tasks and operations performed in drilling a well. Figure II-1 is a flow chart showing the individual operations (underscored in the section below) required in the construction and maintenance of a producing well, starting from the geological survey.

Once a well site has been selected by a geological survey team, the site preparation will usually be subcontracted to a company specializing in earthmoving operations. This contractor will level the site, dig and dike any required reservoirs, and excavate the cellar. The "spudding-in" of the starter hole and running of conductor casing may be subcontracted to a service company, or the drilling contractor may choose to perform this task itself after it has erected the derrick. The surface casing will then be cemented in place to ensure well integrity and blowout prevention. Meanwhile, a trucking company will be transporting the drilling rig and

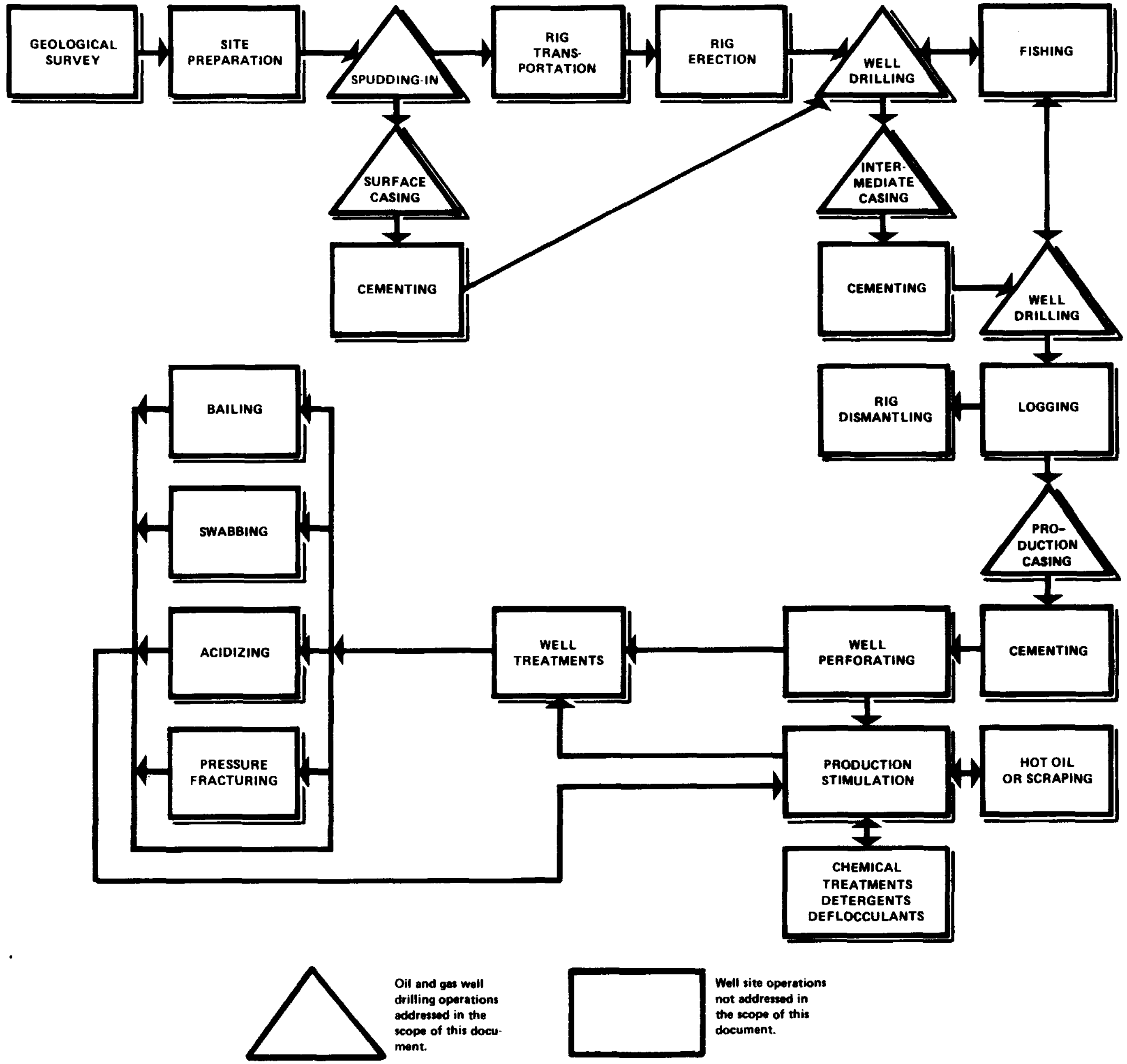


FIGURE II-1. TASKS NECESSARY TO DRILL AND MAINTAIN A PRODUCING OIL OR GAS WELL accessories to the well site for assembly and erection by the drilling contractor. As the well drilling proceeds, it is probable that intermediate protective casings will have to be run and cemented in place. If the drill string breaks and a section is lost in the well bore, then a fishing company may be contracted to remove the portion of broken drill string remaining in the well bore.

When the well depth has reached the hydrocarbon-bearing formation, a logging company may be hired to test the formation for oil and gas production potential. If the well is to be completed--that is, if the well bore has penetrated a formation that contains commercial quantities of oil and/or gas--then production casing will be run, sometimes by a contractor who specializes in this service. Usually the drilling contractor's rig remains onsite during the running and cementing of production casing. Once the casing has been cemented, frequently a company specializing in well perforating is engaged.

Many hydrocarbon-bearing formations can be stimulated to produce at faster rates than initially evidenced. Pressure fracturing or acidizing companies may be used to improve formation channelization. Bailing may be necessary to remove sand from the perforated area, or the well may have to be swabbed. Finally, once well production has been maximized, a "Christmas tree" may be added if the well is a flowing gas well, or a pump may be installed if it is an oil producer. Most new oil wells, like gas wells, will flow on their own.

Additional stimulation and well service may be required throughout the producing life of a well. Hot oil or scraping may be used to remove paraffin buildup in the casing.

The addition of detergents, deflocculants, or other chemicals may be required to maintain the flow rate. Acidizing or pressure fracturing may again be necessary.

B. Well Drilling Technology and Process Descriptions

The following process descriptions concentrate on the activities associated with oil and gas well drilling (SIC 1381). Hazardous exposures associated with these tasks are mentioned (briefly) and detailed in Chapter III.

1. Rigging-Up

Before describing the functional components of a drilling operation and their attendant hazards, it is necessary to mention rigging-up; i.e., assembling and erecting the derrick and associated gear. This phase, however, is similar to many other rigging operations with common procedures and hazards and does not require special treatment in this study. Equipment is designed for rapid assembly and economy of labor. In most cases, it is offloaded from trucks by winch and skid techniques. The substructure supporting the drill deck and derrick is either placed intact or assembled over a previously completed cellar.

In many instances, the spudding-in, or augering of the large-diameter starter hole, will have been completed earlier by a contractor using a workover rig. In this case the spud hole will be lined with conductor casing, which is likely to be cemented in place. Then the drilling rig will be assembled (rigged-up) and used to drill the hole below the conductor casing. Surface casing is then run and cemented.

Technically, the derricks in use today are, for the most part, masts in that they are not erected piece by piece. Instead, they are raised either by jackknifing or by hydraulic telescoping. On truck-mounted rigs and small workover rigs, guy lines are strung from the mast to the ground. On large jackknife masts, guy lines are not used as they are self-supporting. An emergency derrick line with escape trolley is strung from the derrick board, also called a "monkey board." The hazards of these operations are those commonly associated with construction sites and are not addressed in this document.

2. Rotary Drilling

The functional components of a rotary drilling rig have been grouped under these activities/systems:

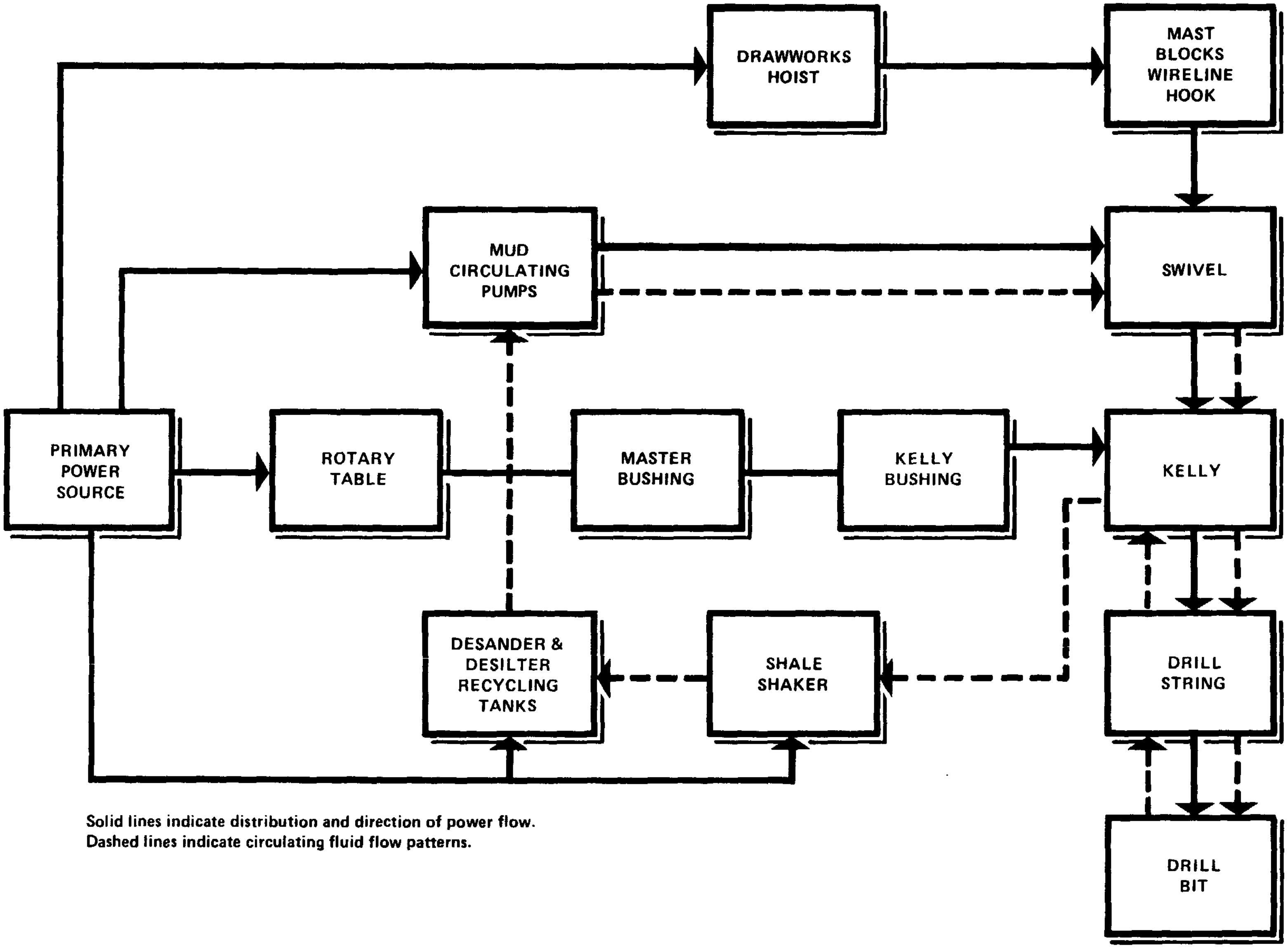
- Power generation and transmission
- Hoisting the drill string
- Rotating the drill string
- Circulating fluid systems
- Materials handling during drilling operations.

These components, described in more detail below, are shown in a functional diagram (Figure II-2) and are depicted in Figure II-3.

a. Power Generation and Transmission

The primary power source is normally one or more internal combustion engines. On larger, modern rigs, the engines are frequently located at ground level, 100 or more feet from the derrick. This is to minimize the potential of fires caused by engines igniting gases that could escape from the well bore. On smaller rigs, the engines frequently are mounted immediately next to the derrick. The most common fuel used is diesel; but gasoline, natural gas, liquefied petroleum gas, and purchased electricity are also used. Typically, several hundred horsepower (HP) will be generated and used on a drilling rig, although a larger rig may produce more than 3,000 HP.

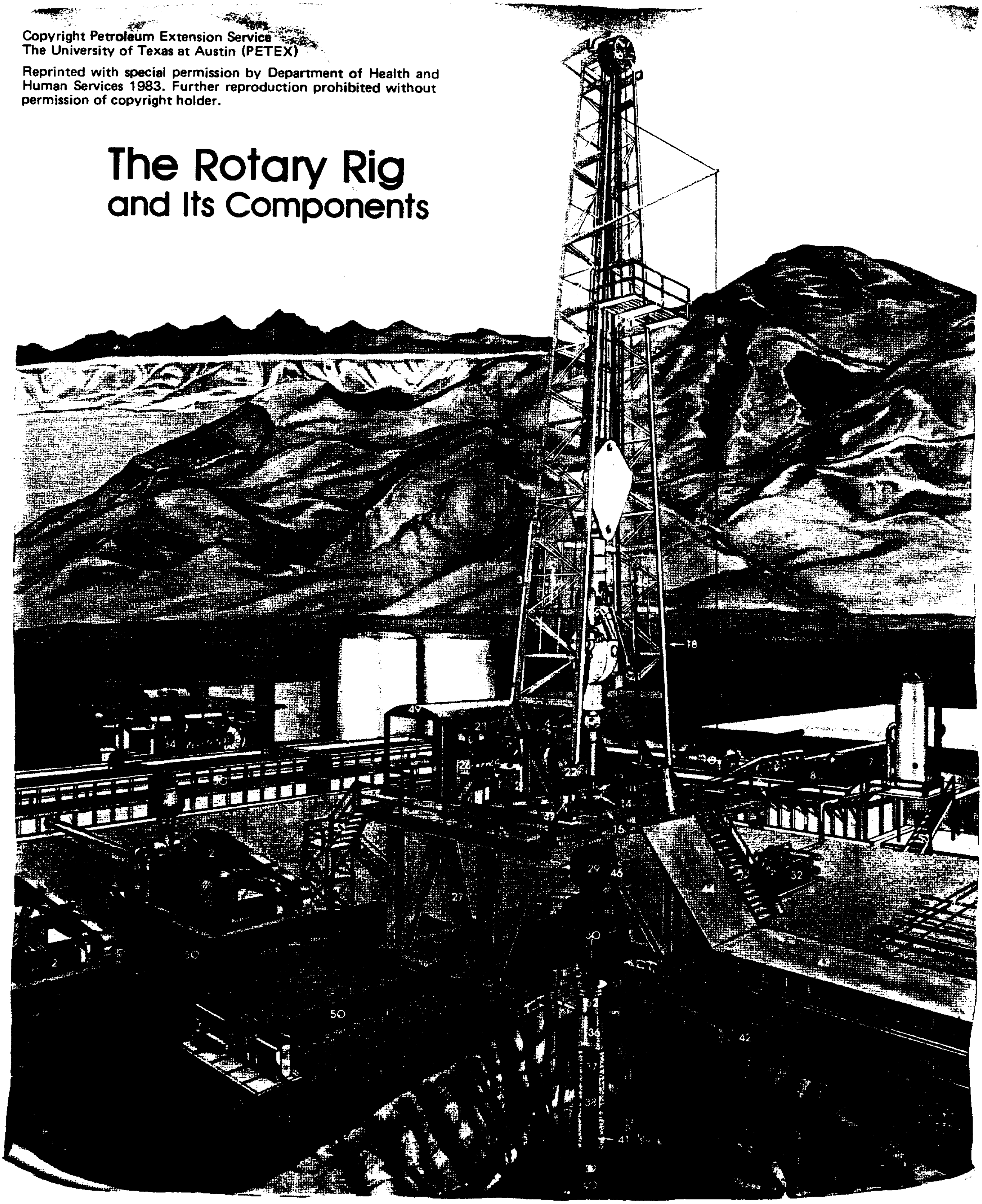
The transmission is mechanical or electric. A mechanical transmission, which is more common in older rigs, utilizes a "compound" of clutches, chains and sprockets, belts and pulleys,



Solid lines indicate distribution and direction of power flow.
Dashed lines indicate circulating fluid flow patterns.

FIGURE II-2. FUNCTIONAL AND COMPONENT DIAGRAM OF A ROTARY DRILLING RIG

The Rotary Rig
and Its Components



CIRCULATING SYSTEM
1. Mud pits
2. Mud pumps
3. Standpipe
4. Rotary hose
5. Bulk mud components storage
6. Mud return line
7. Shale shaker
8. Desilter
9. Desander
10. Degasser
11. Reserve pits

ROTATING EQUIPMENT
12. Swivel
13. Kelly
14. Kelly bushing
15. Rotary table

HOISTING SYSTEM
16. Crown block and water table
17. Monkeyboard
18. Mast
19. Traveling block
20. Hook
21. Elevators
22. Drawworks
23. Cathead
24. Brake
25. Weight indicator
26. Driller's console
27. Substructure
28. Drilling line

WELL-CONTROL EQUIPMENT
29. Annular blowout preventer
30. Ram blowout preventers
31. Accumulator unit
32. Choke manifold
33. Mud-gas separator

POWER SYSTEM
34. Power-generating plant
35. Fuel tanks

PIPE AND PIPE-HANDLING EQUIPMENT
36. Conductor pipe
37. Surface casing
38. Drill pipe
39. Drill collars
40. Drill bit
41. Annulus
42. Pipe racks
43. Catwalk
44. Pipe ramp
45. Rathole
46. Mousehole
47. Tongs
48. Tong counterweights

MISCELLANEOUS
49. Doghouse
50. Walkways
51. Cellar
52. Casinghead
53. Stairways
54. Hoisting line
55. Gin pole

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and a number of driving and driven shafts. An electric transmission is more common in newer equipment.

Most exposures to hazards associated with the power generation and transmission system occur during maintenance, fueling, and lubrication. Inadequate or nonexistent equipment guards and ineffectual (or the lack of) lockout procedures for maintenance operations during continuous drilling increase the risk of physical injury. Other hazards include high voltages, chemical injury to the eyes during fueling, fire, and explosion. The noise levels in power generation areas may be high, with the risk of hearing loss.

b. Hoisting the Drill String

The primary functions of the hoisting apparatus are to raise and lower the drill string components during tripping and drill stem lengthening operations and to support the drill string at the desired bit weight during drilling. The drawworks is essentially a rotating spool, usually located on the drill deck, controlled by a clutch and brake system operated by the driller. The wire rope drill line runs from the drawworks to the crown block at the top of the derrick, and then to the traveling block and hook, which is attached to the drill string during drilling operations. The drilling line diameter and reeving sequence of the blocks are determined by maximum drill string weight. The deadline anchor, usually located on the derrick substructure, serves as an adjustable terminal anchor point for the wire rope (Figure II-4). Typically, the dead line anchor will be adjustable to allow for the continual addition of new wire rope to the hoisting system.

Employee exposure to hazards associated with hoisting should be slight unless structural defects exist or system overloading occurs. Routine inspection of elevated hoist mechanisms involves the risk of falls. Pinched fingers and injuries from wire rope splinters are other hazards.

c. Rotating the Drill String

In addition to rotating the drill string and bit, the rotary table provides for free vertical motion of the drill as the bit penetrates into the earth. Torque is transmitted from the rotary table to the drill by the kelly, which also conveys the drilling mud that is pumped into it through a swivel connector.

The kelly is a three-, four-, six-, or eight-sided 40-foot-long conduit (i.e., longer than the 30-foot drill pipe sections) that threads into the drill pipe and is connected to the hoist traveling block by the swivel. The swivel supports the buoyed weight of the drill string while allowing the kelly to rotate and the pressurized drilling fluid to enter the drill stem. The kelly is rotated by a suitably structured kelly bushing that transfers rotational force

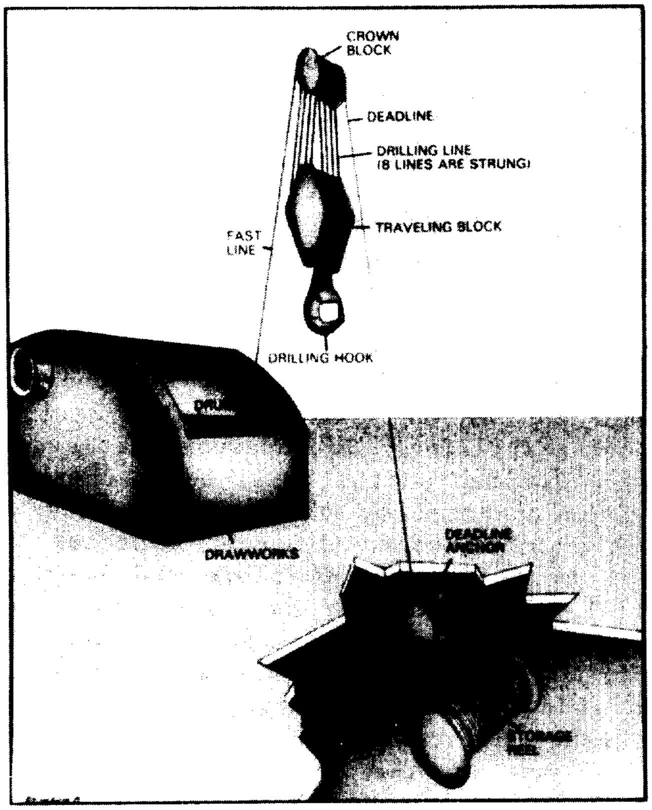


FIGURE II-4. ROTARY DRILLING RIG HOISTING SYSTEM [1]

without impeding the continuous downward movement of the kelly. During operations such as tripping, the kelly bushing must be easily removable to permit the drill pipe to be withdrawn from the well. When the kelly is hoisted and stored in the rathole during a trip, the kelly bushing is removed as an integral part of the kelly assembly. To facilitate this maneuver, the kelly bushing sits inside a three-, four-, six-, or eight-sided master bushing that is a fixed portion of the rotary table. The rotary table (and other rotating parts) may turn at rates of up to 400 rpm; however, much slower speeds are usual, perhaps in the range of 25-100 rpm. The driller operates the rotary table clutch controls and hoist controls from the same station. The power source is either an electric motor or mechanical power that is connected to the rotary table by a compounded chain drive.

A typical drill string consists of 30-foot sections of drill pipe, male and female threaded, that weigh between 14 and 18 pounds/foot (500 pounds/joint). Several heavy, thick-walled joints of pipe, called drill collars, are made up in the drill stem, just above the bit, so the bit will penetrate into the formation being drilled. A single drill collar can weigh between 2,500 and 4,000 pounds (or more) depending on its diameter.

The hazards associated with this equipment are discussed in section e., Materials Handling During Drilling Operations. However, it should be noted that employee exposure to rotating parts during drilling makes this operation one with a high potential for severe injuries, although the frequency of occurrence is low. The rotary table and kelly bushing are in nearly continuous motion and are not usually provided with any guarding mechanism. Contact with either is likely to cause slips, falls, and bruising accidents; also, there is a risk of being caught between stationary and rotating parts.

d. Circulating Fluid Systems

Drilling fluid, or "mud," is typically a mixture of water and bentonite (an absorbent, gel-forming clay) and sometimes oil or other components. It has four primary functions: cooling, lubricating, and cleaning the bit; removing the cuttings; providing hydrostatic pressure to prevent entry of formation fluids into the well bore; and reducing the risk of hazardous blowouts.

Mud pumps force the mud up a standpipe and through the flexible kelly hose to the swivel, where it enters the drill string via the kelly and eventually emerges at the bit in the well bore. Continuous pressure (up to 3,000 psi) forces the mud up the well annulus and out the mud return pipe, where it is first screened of larger cuttings at a shale shaker and then processed through a series of desanders and desilters prior to recycling (Figure II-5). Cuttings carried by the drilling fluid are taken for analysis to determine the composition of the stratum being drilled.

Hazards associated with working on or around components of circulating fluid systems are various. Mixing of the mud exposes workers to airborne respirable dust and chemical splashes. Tanks in which mud is mechanically stirred are hazardous when unguarded, or when effective lockout procedures are not followed during maintenance operations. Walking surfaces nearby may be slippery, especially in wet or icy weather. Pressure surges causing line rupture are an occasional hazard.

e. Materials Handling During Drilling Operations

On a drill rig, most of the materials handling equipment is unique to the oil field. This equipment is used in the working routines

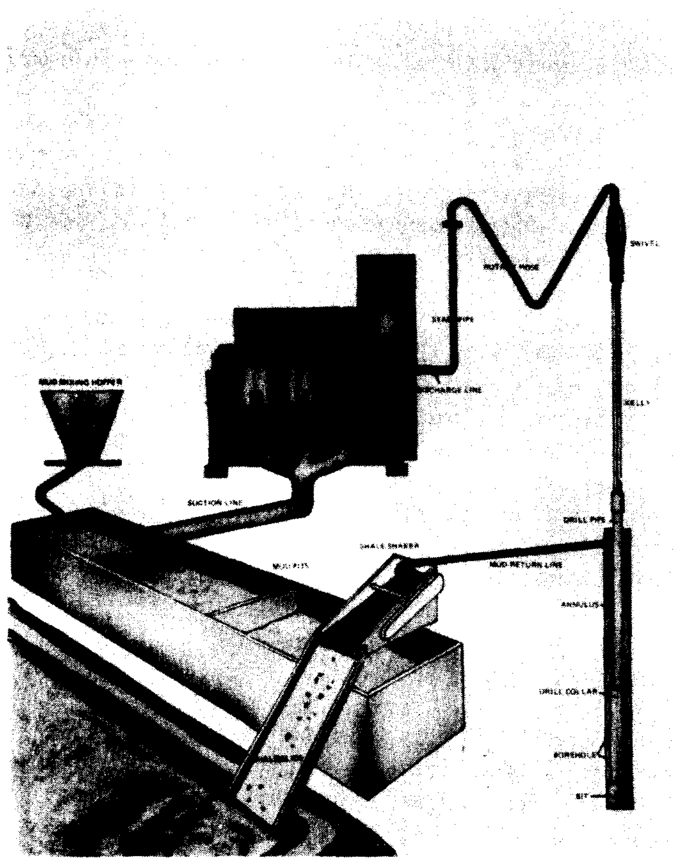


FIGURE II-5. CIRCULATING FLUID SYSTEM [1]

of raising and lowering the drill string, adding new sections of drill pipe, and tripping. This equipment and its operation are described in operational sequence in this section.

To extend the length of the drill string, a joint (30-foot section) is hoisted from horizontal pipe storage racks (located at ground level) to the drill deck. The joint is lowered into a hole in the drill deck (known as a mousehole), where it is stored until it is added to the string. This hoisting operation can be performed with a fiber rope, hands-on friction pulley (known as a cathead) that protrudes from each side of the drawworks. Most modern drilling rigs have steel cable air hoists to perform the hoisting of the drill pipe. When the kelly is at the level of the kelly bushing, the rotary table and mud circulating pumps are stopped. The driller raises the drill stem until the bottom of the kelly pipe joint connection is about 2 feet above the level of the rotary table. A set of "slips" is wedged into the space between the master bushing and the drill stem to maintain the drill pipe's position. A large pair of counterweight-suspended wrenches, called tongs, are used to "break out" the torqued kelly pipe joint connection. Once the tongs are clamped above and below the connection, mechanical force is applied to the handle of the breakout tong by a tong pull line originating from a mechanical cathead located on the drawworks. When the connection has been loosened, the joints are "spun out." Some rigs use an air-operated kelly spinner to spin out the kelly from the drill pipe, whereas others spin out the drill pipe with the rotary table after the tool joint has been "broken" with the pipe tongs. When making up a connection, some rigs use a pipe spinner to spin the joint up; then it is tightened with the pipe tongs. Many rigs use the traditional spinning chain to make up a joint of pipe; then it is tightened with the pipe tongs.

Once disengaged, the lower end of the kelly, suspended by the hoist, is pushed/pulled by the floorhands until it is centered over the pipe joint that was temporarily stored in the mousehole. The kelly is "stabbed" into the pipe joint, spun up, and tong tightened. The driller next engages the drawworks and raises the kelly and pipe joint assembly, which in turn is stabbed into the drill stem that is held by the slips. This connection is then spun up and tong tightened. The slips are removed, the mud pumps and rotary table are reactivated, and the drilling operation proceeds.

Tripping is a procedure used when well bore inspections and bit changes are necessary. The entire drill string must be removed from the hole and later returned if the drilling is to proceed. During a "round trip" (cycle of removal and replacement), the kelly is disconnected and stored in the rathole, a hole in the rig floor into which the kelly and swivel are placed during hoisting operations. Elevators, a set of clamps affixed to the bails on the swivel below the traveling block, are attached to the bell portion (tool joint) of the drill pipe and used to raise the drill string from the hole. Pipe tongs and frequently the rotary table are used to disconnect the stands (usually 90 feet of drill pipe) as one unit. The initial breaking of the pipe joint is properly performed by the automatic cathead tensioning the breakout tong. To ensure well control, drilling mud is usually added to the well bore to replace the fluid volume displaced by the drill stem and to maintain hydrostatic pressure when the drill stem is removed. The derrickman, usually using a fall-arresting derrick climber, climbs the derrick and works from the monkey board, which is usually located 90 feet above the rig floor. His task is to coordinate the placement of the triple joints between the fingers of the "finger board" for temporary storage during the trip and to disconnect the drill pipe from the elevators.

Once the bit has been removed from the hole, it is inspected for wear and replaced as necessary. "Logging" devices may be lowered into the hole on a stranded wire electric cable by a cathead power takeoff system or an independent electric winch. If the well drilling operation is to continue, the above sequence is reversed, completing the round trip.

Workers directly involved in these operations are close to moving equipment components, while performing tasks that require substantial exertion and good coordination between individuals. Transferring drill pipe from the rack to the drilling platform may result in the stockpile rolling or in the mishandling of suspended loads, with the risk of crushing injury. Handling of the tongs requires well-coordinated efforts and proper body limb placement. Mistakes in the hands-on spinning chain operations can lead to entanglement that may result in crushing, amputation, and death. Machinery is activated by an operator who depends on visual and/or audible cues; a mistake can lead to premature activation while workers are still in contact with moving parts. Mechanical failure from overloading systems can occur. Lifting and moving heavy items on wet surfaces may lead to slips, falls, and overexertion. Eyes are at risk from material falling off the drill pipe. Potential hazards in these operations can be increased if the drilling crew has not worked together very long; teamwork is necessary to carry out the operations quickly and safely.

3. Other Drilling Techniques

a. Compressed Air

Compressed air may be used instead of drilling mud when there is no risk of encountering high-pressure, permeable formations or formations containing water. It has the advantages of faster drilling and of not having to recondition the circulating mud. The drilling dust is discharged from the "blooey line" and may be blown across the working area to cause a respiratory hazard; dust particles may cause eye injuries.

b. Directional Drilling

Directional drilling occurs when a contractor intentionally drills a well that is out of plumb. Surface conditions may dictate that a drilling rig cannot be erected over the formation to be explored or, as in offshore operations, the rig may be costly enough that multiple formations should be explored from a central drilling position. Directional drilling is achieved by a number of different methods. Directional tools include downhole hydraulic turbine motors, jet deflector bits, bent subs, flexible joints, or, most common in past years, whipstocks.

c. Redrilling

The redrilling of a well takes place when well depth must be extended. (The existing formation may not be productive and the well may be extended to tap a lower formation.) In some instances the prior drilling operation may have stopped for reasons associated with annulus collapse, damaged casing, lost drilling string, or blowout.

Operationally, the drilling procedure and hazard exposure are the same as described earlier; however, techniques may have to be altered to overcome any formation or well bore irregularities.

4. Casing Operations

Lining or casing a well is a task performed to ensure the integrity of the well bore throughout the drilling and production phases. Large-diameter surface casing characteristically is used in the uppermost portion to ensure well wall integrity and for well control. The use of intermediate casings is determined by the depth that the surface casing is set and the relative pressures of shallow formations as compared to deeper formations. Production casing, which may be set by the drilling contractor, is normally required if the well is to be brought to production.

In most instances, a subcontractor is hired to install the casing. The casing contractor supplies the larger elevators and pipe tongs necessary to handle the larger-diameter casing materials. Most frequently, the manpower comprises a few direct employees of the casing contractor and the employees of the drilling contractor supervised by the subcontractor. However, there is no standard procedure governing manpower supply during casing operations. The casing operation proceeds in a manner fundamentally the same as multiple repetitions of adding new sections of pipe to the drill string. Surface and intermediate casing is larger in diameter, and is likely to result in a greater severity of materials handling or rolling stock incidents. Production casing is normally run by a casing contractor using the same rig used to drill the hole, although in some cases it may be run by a completion contractor using his own mobile rig.

Casing operations are conducted by companies that are classified by the SIC system into the oil and gas field services (1389) category. The operational procedures and equipment used are sufficiently similar to those in the actual drilling operations to yield similar accident/injury potentials. However, data on injury incidence rates for this specific portion of SIC 1389 are not available.

5. Special Hazards

In certain areas and depths, if proper precautions and control methods are not employed, two conditions may be encountered that have the potential to cause major disasters: blowouts and the escape of hydrogen sulfide.

a. Blowouts

A blowout is an uncontrolled escape of gas, oil, or formation fluids that may lead to fire, explosion, drilling rig destruction, injury, or death.

Blowouts may occur when the formation fluid pressure exceeds the hydrostatic pressure of the circulating fluid in the well annulus such as the totally unexpected encountering of unpredictable pressures and/or when mechanical controlling methods; e.g., blowout preventers (BOP's) or other pressure-control techniques, fail through misuse, misapplication, or malfunction. During a drilling operation, the mud serves as the first control method. If there is a pit level increase (or any of several other indications), then the formation pressure exceeds the hydrostatic pressure of the mud. This is called a kick. If a kick occurs, the driller should take steps to close in the well with the BOP's. After the BOP's are closed, the mud weight is increased so that it can exert a pressure equal to, or slightly higher than, the pressure of the formation.

Most wells are drilled in oil fields with predictable formation pressures. BOP's selected to be compatible with these pressures are installed as soon as the surface casing is in place. BOP's function by sealing off the well bore. A series of hydraulic (and some manual) rams activated from ground level (not on the derrick) seal and contain the formation pressures.

If the kick is not noticed in time or the techniques used to control the formation pressures are not adequate, then a blowout occurs. Since blowouts and subsequent fires involve the loss of equipment and time (as well as employee exposure to extremely hazardous conditions), the industry usually takes great care to prevent their occurrences.

b. Hydrogen Sulfide

Hydrogen sulfide is a highly toxic, colorless gas. It is a very insidious industrial hazard for two reasons: unreliability of odor as a warning, and sudden onset of incapacitation. Hydrogen sulfide has been identified by NIOSH as a leading cause of sudden workplace death [2]. At concentrations up to 30 parts per million (ppm), it has an odor of rotten eggs [2]. However, at more deadly concentrations (100 ppm), hydrogen sulfide rapidly fatigues the olfactory nerves [3-5]. A person may momentarily smell the gas but think little of it when the odor is no longer detectable. If exposure is sufficiently intense, unconsciousness and respiratory failure may occur without warning symptoms. The gas is 1.2 times denser than air, and at high concentrations will tend to accumulate in low spots. Mixed with air in concentrations of 4.3-45.5%, hydrogen sulfide is explosive [2]. It may also burn with the production of toxic sulfur dioxide.

During oil and gas well drilling operations, H_2S is first released to the atmosphere at the shale shaker area and later at the circulation fluid treatment areas. It may also be released during tripping procedures in the immediate area around the drilling operation. Typically, however, only nominal amounts of H_2S are released during normal drilling operations.

The effect of hydrogen sulfide on metals, known variously as metal fatigue, hydrogen embrittlement, and sulfide stress cracking, can cause failure of the drill string during a well control situation [3,6,7]. Such failure can result in the release of hazardous concentrations of H_2S in the drilling area. Careful selection of resistant metals and chemical treatment of drilling fluids can effectively guard against such failure.

With the exception of exploratory or "wildcat" wells, drilling operations take place in oil fields where the hydrogen sulfide locations and formation pressures likely to be encountered are known. With the demand for hydrocarbons increasing, formations historically deemed too dangerous to produce are now being developed. In some instances, there is frequent to nearly continuous employee exposure to hydrogen sulfide at concentrations from 10 ppm (OSHA 8-hour permissible exposure limit (PEL)) to life-threatening levels requiring the wearing of self-contained breathing apparatus. Innovative technologies, alarm systems, and respiratory protective equipment and programs are being employed without uniform Federal regulation.

C. Companies, Employment Figures, and Population at Risk

The companies that perform the tasks necessary to construct and maintain oil wells are grouped by the SIC system into the oil and gas field service companies (SIC 138). They are composed of companies that offer exploratory services (SIC 1382); companies that perform drilling operations (SIC 1381) such as spudding-in, air drilling, redrilling, offshore drilling, and directional drilling; and companies that perform tasks associated with well completion and stimulation (SIC 1389).

As shown in Table II-1, 764 companies were engaged in oil and gas drilling operations in 1980 [8]. The sizes of the companies, as defined by the number of drilling rigs owned, ranged from one-rig operations to companies that owned more than 20 drilling rigs. The Dun and Bradstreet Industrial Profile Data for 1980 indicates that the number of employees at each facility ranged from 1 to 7 to more than 500 employees (Table II-2). The number of workers estimated by NIOSH to be employed by drilling contractors during 1980 was 88,116 [9]. However, included in the NIOSH estimate were employees of companies engaged in water well drilling, offshore drilling, and exploratory drilling; as such, they were not part of the employee population at risk in the land-based oil and gas well drilling industry.

TABLE II-1
PROFILE OF OIL AND GAS WELL DRILLING COMPANIES IN 1980 (SIC 1381)

No. of Rigs Owned	No. of Reporting Companies
1	183
2-5	262
6-10	98
11-20	56
>20	18
Unreported	147
Total	764

Adapted from U.S. Land Drilling Contractors [8].

TABLE II-2
NUMBER OF WELL DRILLING FACILITIES AND EMPLOYEES (SIC 1381)[1]

	No. of Facilities	No. of Employees	No. of Employees at Each Facility
	2,614	7,904	1-7
	685	8,332	8-19
	390	11,456	20-49
	193	12,621	50-99
	162	23,097	100-249
	33	11,076	250-499
	14	13,630	≥500
Total	4,091[2]	88,116[3]	

[1]Dun and Bradstreet Industrial Profile, 1980, compiled by NIOSH [9].
[2]Employee counts were not available for an additional 68 facilities. Total number of reporting facilities was 4,159.
[3]Includes employees of offshore, water, and exploratory drilling companies.

1. Drilling Activities and Population at Risk

Regardless of company size, the task force employed at a well site is fairly small. A typical drilling rig employs a tool pusher to supervise the drilling operation. Depending on well site location, he may be in charge of more than one rig. The driller (shift foreman) is responsible for the immediate direction of work on the drilling rig. He operates the rig controls, supervises the changing of drill pipe and tripping operations, and directs any maintenance or repair work. His crew usually consists of one derrickman performing tasks from the upper portion of the derrick during tripping operations (the derrickman is normally the second man in charge of drilling operations; i.e., the relief driller), three rotary helpers (floormen) performing those tasks associated with the addition of pipe joints during drilling and tripping.

For large operations; e.g., deeper wells, the crew usually includes a motorman (usually most experienced rotary helper) who is in charge of the mechanics of the equipment and also acts as a floorhand during tripping procedures, and an additional rotary helper.

An electrician normally is employed on electrically powered drilling rigs. Smaller drilling rigs normally require an average of five persons per shift (not including the pusher), whereas seven or eight persons per shift are needed on a larger rotary rig.

Drilling operations are continuous (24 hours/day, 7 days/week) until the well has been completed. When a well is being drilled, the rig usually is staffed for three 8-hour shifts, although in some remote areas the operation uses two 12-hour shifts. Approximately seven employees per shift is a reasonable estimate of the number of persons at risk on a typical drilling operation. The estimate of seven employees per rig also corresponds with field observations made during site visits and data presented in the NIOSH "Safety Information Profile Oil and Gas Field Operations" [10].

The Oil and Gas Journal's "Rotary-rig Activity by States" [11] provides weekly counts, by State, of all active drilling operations. Drilling rigs are considered by the census takers to be active whenever they are drilling, tripping, or performing any task associated with making an oil or gas well. In fact, a rig is considered to be active unless it is down for repair or in storage [12]. Table II-3 contains the yearly average of active drilling rigs, by State, for the past 10 years.

The average number of active rigs and the number of workers on a shift can be used to estimate the number of workers at risk in oil and gas well drilling operations. The reason for determining the population at risk for the drilling industry is to establish an injury incidence rate for those workers exposed to the hazards attendant to drilling operations. For the purpose of comparison between industries, a "person," as defined by the BLS, works 2,000 hours during a year. In other words, for statistical comparisons, an individual who has worked

3,000 hours in a year would be counted as 1.5 person-years. A reasonable estimate of the population at risk in the land-based drilling industry can be arrived at 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 active during a year (rounded to the nearest whole number) and dividing by 2,000 (the number of hours worked by an individual in a year). The estimated population at risk in the oil and gas well drilling industry (1971-80) is shown in Table II-4. For example, during 1980, the Oil and Gas Journal reported an average of 2,605 land-based active rigs [11]. The population at risk would then be estimated as 79,869 person-years during 1980. It should be noted that this estimate of population at risk is less than that reported in the Dun and Bradstreet Industrial Profile, which includes all employees in the industry as well as those involved in offshore and exploratory drilling.

2. Trends and Projections

Economic pressures and government actions have resulted in a steady and substantial increase in oil field activity over the past decade. The average number of active drilling rigs nearly tripled between 1972 and 1980 (Figure II-6 and Table II-4), as did the number of oil field employees in SIC 138 (Figure II-7). There was an increase of approximately 692 drilling rigs during 1980--setting what was an all-time drilling record for the industry [11, 13]. The average active rig count in July 1981 set a new record of 3,681--an increase of more than 1,000 active rigs over the previous July [14]. The population at risk in drilling activities would also be expected to have increased by an estimated additional 32,990 in July 1981 resulting in a predicted population at risk of approximately 112,859 person-years. Land-based drilling operations completed 63,337 wells during 1980, an average of 24 wells drilled per rig (number of wells divided by the average number of active rigs), and almost 14,599 more than during the previous year (Table II-5).

3. Trade Associations and Unions

The International Association of Drilling Contractors (IADC) had about 1,000 member companies in 1981 and represented approximately 95% of all drilling companies. The current boom in drilling is rapidly increasing the number of IADC member companies but has not appreciably affected the percentage of representation of the trade association. The land-based drilling companies and member companies are urged by IADC to participate in intercompany, IADC-sponsored safety award programs and to avail themselves of IADC publications on safe working practices in drilling operations. A safety committee attends to accident prevention concepts and compiles a yearly analysis of drilling accidents for member companies. IADC also cosponsors a number of entry-level rotary helper schools that teach safe working practices, as well as advanced schools for derrickmen, drillers, and tool pushers.

TABLE II-3
CENSUS OF ACTIVE DRILLING RIGS

State	Average Rig Activity									
	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Alabama	10.8	12.6	12.5	13	17	14	12	13	15	8
Alaska	13.8	13.5	15.5	15	14	14	9	5	5	5
Arkansas	26.8	10.4	13.9	15	15	14	18	15	15	15
Arizona	1.0	0.0	0.4	1	1	0	1	2	1	1
California	120.2	95.6	94.1	89	89	80	72	51	46	46
Inland	104.7	85.7	86.3	81	85	77	70	49	45	40
Offshore	15.5	9.9	7.8	8	4	3	2	2	1	6
Colorado	61.1	40.2	41.1	45	38	42	45	42	35	30
Florida	4.1	5.3	6.3	6	5	9	7	9	19	11
Idaho	2.6	1.8	3.2	1	1	0	0	0	0	0
Illinois	25.4	13.1	28.4	16	22	19	7	6	14	13
Indiana	0.1	0.3	4.4	3	2	2	1	0	1	1
Kansas	120.2	66.0	75.5	67	51	57	44	28	24	29
Kentucky	1.7	0.4	3.3	2	1	1	2	1	2	2
Louisiana	427.4	347.0	338.3	292	231	227	203	205	214	194
North	54.9	34.5	39.8	45	34	31	29	23	19	16
Inland Waters	76.6	62.1	62.5	57	49	55	58	55	54	50
South	156.4	112.3	113.9	81	65	64	49	56	59	54
Offshore	139.4	138.1	122.1	109	83	77	67	71	82	74
Maryland	0.2	0.5	0.7	0	1	0	0	0	0	1
Michigan	30.7	25.1	24.0	24	24	28	24	20	17	12
Mississippi	57.6	40.2	44.5	42	32	25	29	29	37	39
Montana	49.2	32.9	30.1	27	28	27	24	19	20	17
Nebraska	14.3	9.2	9.6	9	8	9	7	5	6	5
Nevada	4.6	4.1	2.9	3	2	0	1	0	0	1
New Mexico	117.6	87.5	75.5	70	54	71	79	62	55	47
New York	7.0	8.7	7.0	6	9	8	7	1	0	1
North Dakota	83.4	56.5	39.1	24	19	17	12	10	7	9
Ohio	73.7	46.3	45.6	33	26	21	30	36	22	17

TABLE II-3
CENSUS OF ACTIVE DRILLING RIGS (Concluded)

State	Average Rig Activity									
	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Oklahoma	397.3	246.7	258.2	233	186	177	146	115	90	90
Pennsylvania	29.0	28.9	25.2	15	10	10	14	11	8	9
Rhode Island										
Offshore	2.1	4.0	4.3	1	0	0	0	0	0	0
South Dakota	1.9	1.4	2.3	3	2	1	1	1	1	1
Texas	987.7	770.2	855.0	779	653	637	508	376	338	291
Gulf Coast	210.5	141.3	197.0	175	160	142	128	109	95	79
Offshore	72.1	50.3	46.9	42	36	21	21	9	6	5
North	147.2	122.4	153.2	142	111	107	67	22	16	15
Panhandle	50.8	48.1	60.4	42	37	41	35	23	22	16
East	119.8	107.0	116.6	73	54	47	45	30	26	23
West Central	140.4	109.4	117.2	136	101	100	62	82	78	76
West	247.1	191.7	163.7	169	154	179	150	101	95	77
Utah	42.4	28.9	32.1	30	19	26	42	38	34	17
West Virginia	37.8	29.8	27.1	17	12	10	16	20	16	17
Wyoming	155.5	147.2	136.4	118	86	107	107	70	60	45
Others	3.3	2.9	2.0	2	0	7	3	3	4	2
Total[1]	2,910.3	2,177.2	2,258.8	2,001	1,658	1,660	1,471	1,194	1,107	976
Total Land-based Rigs[2]	2,604.6	1,912.8	2,015.2	1,784	1,486	1,504	1,323	1,057	964	841

[1]Total rig census figures are shown as reported in the Oil and Gas Journal [11].

[2]Total land-based rigs have been calculated by summing the offshore and inland water rig counts and subtracting this figure from the total rig count.

Adapted from the Oil and Gas Journal's "Rotary-rig Activity by States" [11].

The International Union of Operating Engineers (IUOE) has a small membership of drilling contractor employees that encompasses about 100 land-based rigs in California. The dearth of labor organization in the oil fields probably is due in part to the small employment size of many facilities and may be influenced by the frequent inaccessibility of well sites, which are not uncommonly more than 2 hours from the closest accommodations.

TABLE II-4
POPULATION AT RISK IN OIL AND GAS WELL DRILLING OPERATIONS (1971-80)
(SIC 1381)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Total Rigs[1]	841	964	1,057	1,323	1,504	1,486	1,784	2,015	1,913	2,605
Estimated Pop.[2] at Risk	25,785	29,556	32,408	40,563	46,113	45,561	54,697	61,780	58,653	79,869

[1]From the Oil and Gas Journal (Table II-3) [11].
[2]Person-years

TABLE II-5
OIL AND GAS WELL DRILLING ACTIVITY (1974-80)

	Activity by Year						
	1974	1975	1976	1977	1978	1979	1980
Total No. of Wells Completed	32,450	37,614	37,648	44,870	46,974	48,738	63,337
Total Footage (1,000 ft)	150,310	170,722	170,406	199,951	218,454	231,818	282,488
Average Well Depth (ft)	4,632	4,539	4,526	4,456	4,651	4,756	4,460
Average No. of Active Land Rotary Rigs	1,323	1,504	1,486	1,784	2,015	1,913	2,605

Compiled from the Oil and Gas Journal and Table II-3 [11, 15, 16-19].

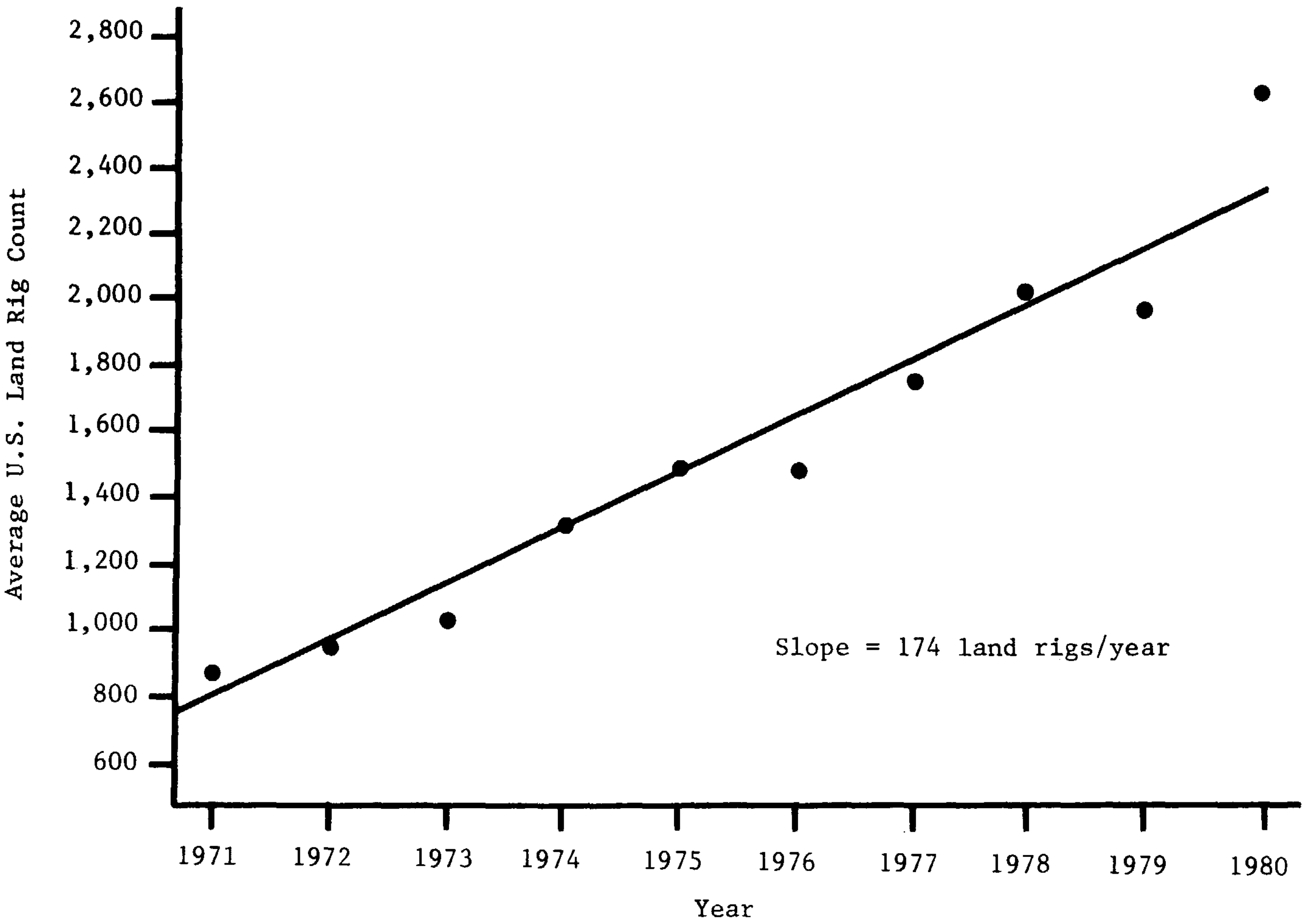
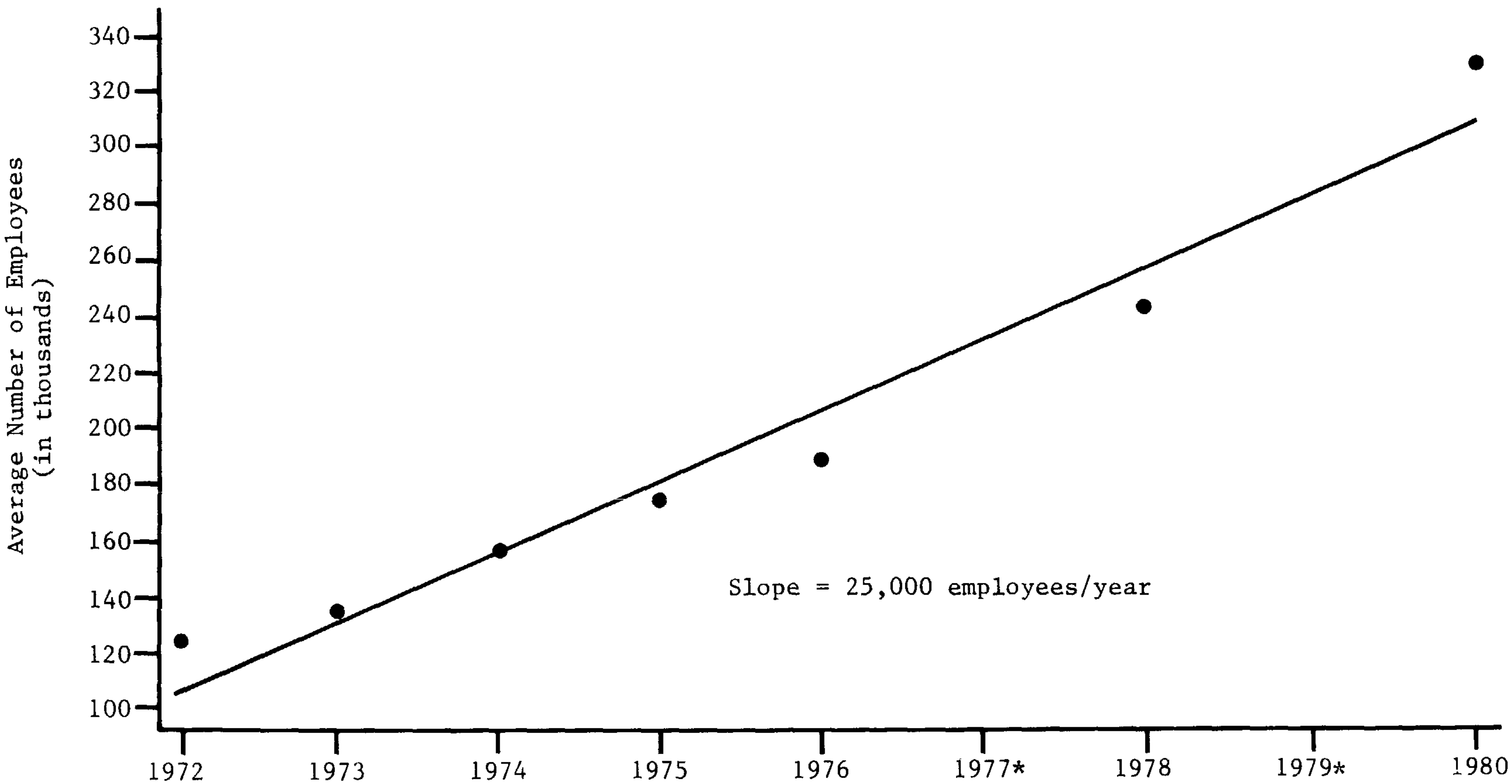


FIGURE II-6. TEN-YEAR GROWTH OF THE AVERAGE NUMBER OF ACTIVE U.S. LAND RIGS (1971-80) Compiled from the Oil and Gas Journal's "Rotary-rig Activity by States" [11] (See Table II-3).



*Data not available

FIGURE II-7. AVERAGE ANNUAL EMPLOYMENT FOR THE YEARS 1972-80 (SIC 138)
Compiled from Bureau of Labor Statistics [20-28].