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Remote operated pipe handling, changes in personnel safety, working environment and health

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Résumé

The report analyses and reports trends in development in relation to health, environment and safety for employees on drilling floor, drilling rig and pipe deck on pipe installations on Norwegian continental shelf. The main approach is to view changes caused by the introduction of remote controlled pipe handling on the installations.

Subject words: Pipe handling, personnel safety, and working environment

Thanks to contributors.

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Terje Lie, project leader

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Summary

During the last 20 years pipe handling in drilling operations offshore has changed substantially on the Norwegian shelf, both with regards to equipment and work-operations. The Norwegian Petroleum Directorate (NPD) imposed regulations in 1981 requiring that remote controlled pipe handling equipment should be used for racking, making up/breaking out and suspension in the rotary table of drill pipes. In 1992 the regulations were extended to include drill collars and casing, and they required that transport of pipes from the storage area to the drill floor should be remote-controlled.

The aim of the present study was to investigate the effects of the transition from manual to remote controlled pipe handling on health, safety and working environment.

Regarding safety effects, two databases were used for analysis of injury trends in drilling. Both were based on injuries reported on a standard form as required by the Norwegian National Insurance (RTV). The Rogaland Research database ”Injuries in drilling” covers the years 1980 to 1990 and The NPD ”PIP3” database covers 1991 to 1997. Both linear regression and chi-square analysis were used for evaluating changes in injury rates.

Reliable and comprehensive data sources on health and working environment were unavailable, but NPD’s ”MOAS” database contains data on the relative incidence of different types of work related illness. We also had access to reports and other material from the operators on the Norwegian shelf. Finally we interviewed experienced employees: Tool pushers, and HSE personnel.

Main results from the analysis of injury frequencies show that the introduction of remote controlled pipe handling equipment has reduced injury incidences significantly. The 1981 regulations appear to have made the largest impact. It was also concluded that the transition to remote controlled equipment has had a positive impact on health and working environment in drilling.

Preface

The Norwegian Oil Industry Association and Norwegian Ship owner's Association has commissioned the project 'Remote controlled pipe handling, personnel safety, working environment and health'. The project is part of a larger study of the conditions related to remote operated pipe handling in connection with drilling on Norwegian continental shelf.

1 Introduction

The aim of this part of the project was initially to map out and analyse trends in relation to employees safety, working environment and health during work on drilling floor, drilling rig and pipe deck. The main focus will be on consequences caused by remote controlled pipe handling.

The specific aims are:

1. To investigate the impact remote controlled pipe handling on drilling floor, drilling rig and pipe deck has had on the employee's safety, working environment and health.
2. Prepare status of strains the involved employee's are exposed to during pipe handling operation in these areas.
3. Prepare a survey of which operation of work, devices and practise in need of critical attention, as well as those less critical.
4. Relate the results to "Regulations relating to drilling and well activities and geological data collection in the petroleum activities".
5. Prepare document basis for further development of regulations and practise of dispensations in this matter.

The Norwegian Petroleum Directorate's regulations relating to drilling and well activities and geological data collection in the petroleum activities have the following requirements:

Remote operated systems are to be installed for:

a) Racking, making up/breaking out and suspension of drill pipes in the rotary table

b) Transportation of drill pipes, drill collars, casing etc. between storage area and drilling floor.

(summary from § 28)

Parts of this were not put into practise in the drilling regulations until 1981, then further expanded in new drilling regulations in 1992. The requirements were further reinforced during the last amendments made in February 1998.

The original requirements on remote operated pipe handling came as a result of an increase in number of reports on personnel injuries related to pipe handling on the drilling floor, towards the end of the 1970's. (ref. Skjæveland 1980). Some of the more modern rigs had towards the 1970's obtained some equipment, which eased the manual labour during pipe handling (i.e. "spinner tong", "spring slips", "stabbing arm" and a forerunner to the "iron roughneck" seen today). The equipment vendors worked on new developments and the process of mechanisation had just begun. It is dear that the

NPD's regulation of 1981 has accelerated this process of mechanisation and lead to considerable changes to rigs that are now operating on Norwegian continental shelf.

In addition to the personal injuries, more work related problems were uncovered during the 1980's. The noise level was too high and therefore caused hearing injuries for drilling personnel. The rigs had a noise level well above the occupational hygiene marginal values. Heavy lifting and unfavourable working positions caused repetitive strain injuries. One employee got soiled and came in direct contact with drill fluids, oil, chemicals and gasses/steam from the drilling fluid/well. Statistics from NPD also indicates that the personnel frequently working with pipe handling, i.e. drilling floor crew/assistants often report work-related injuries. These groups of employees are amongst those who send most reports, following mechanics/welders (NPD 1998).

Employees have now been removed from a number of manual pipe handling operations that are physical demanding and hazardous and reduced some of the contact with drill fluids/chemicals. The rigs on the other hand, have become heavier, more expensive and further complicated to maintain without noticeable improvements in pipe handling. Most pipe handling operations takes equally or longer time than before (exceptions are: equipment such as retractable blocks and top-drive machines, which has lead to some reduction in time).

Most will agree the development has been positive which can be seen in the high standard on new equipment. Previous studies from RF show i.e. how the rate of personal injuries has decreased during operations where mechanical pipe handling equipment has been in use, compared to operations where it has been left out (Grytnes etc. 1990, Fidtje etc. 1993). Manual operations must still be carried out in the same areas, although there has been an increase in steering by remote control. A number of employees believe these areas has become more dangerous to work in due to less space, less measurable and a lot of heavy remote controlled equipment. NPD describes the injuries on the movable installations in their Annual Report: "The injuries most often occur in connection with wrong handling of equipment on drilling floor and when the injured places him/herself in a unsuitable position in relation to equipment and material in movement" (NPD 1998, p. 85).

On the other hand, questions are being raised about the extent of the remote control, particularly in the demand for upgrading existing rigs and pace set for this upgrading. The Norwegian Petroleum Directorate gives several dispensations today, different to the requirements set in the regulations (Stavnes & Anzjøn 1998).

The report consists of four main parts: injuries and personnel safety, work related illness and conclusion.

2 Injuries

2.1 Introduction

The subject for this section of the report is whether the introduction of the remote controlled equipment for pipe handling in drilling has had an effect on personnel injuries. NPD have set requirements for introduction of pipe handling equipment, mainly in drilling regualtions of 1981 and 1992. The description and the implications the directions are discussed here.

Trends has been drawn up which points out the number of injuries per year, level of seriousness, equipment involved, injuries in various areas on the rig and various professions. A detailed description of injuries associated with remote controlled pipe handling equipment will be given. Trends have been prepared by collecting data from two databases: RF's 'Injuries in drilling' covering 1980 to 1990 and The Norwegian Petroleum Directorate's new database "PIP3" where data from 1991 to 1997 have been stored to be used for this report. Reports from NPD and RF have been used as foundation together with information from the equipment vendor.

Data from 1980 to 1990 will roughly be described due to focus on the development in personnel injuries in earlier studies. The main focus will be on the development of personnel injuries in drilling from 1991 to 1997.

2.1.1 The Norwegian Petroleum Directorate's regulations on pipe handling

The Norwegian Petroleum Directorate has introduced two regulations on the use of remote controlled equipment for pipe handling in drilling, the first in 1981 and the second in 1992. The sections on remote controlled pipe handling equipment will be covered here.

2.1.1.1 NPD's drilling regulation of 1981

§2.2.2. Drilling rigs are to be equipped with remote controlled fixed hydraulic/pneumatic driven equipment for racking of drill pipes.

§ 2.3.5. Suspensions in the rotary table of drill pipes as well as making up and breaking out drill pipes to be executed by remote controlled hydraulic/pneumatic driven equipment.

2.1.1.2 NPD's drilling regulation of 1992

§ 5 pkt) 4 bb) § 28 ref. Installation of remote controlled systems for:

bba) racking, making up/breaking out and suspension of drill pipes, drill collars and casing in the rotary table.

bbb) transport of drill pipes, drill collars, casing etc. from storage to the rig floor.

§ 28 Workstations in connection to drilling and well activities are to be arranged in a way to ensure the safety of personnel and operations. Critical or distinctive working conditions are to be analysed to simplify the process, reduce risk of wear and tear on personnel and to safely secure the execution of work.

Guidance to § 28

The regulation requires work places to be arranged so that the safety of personnel and operations are secured. This will call for action to be taken to reduce injuries from falling objects, repetitive strain injuries due to heavy and difficult working operations and various types of crush injuries when handling drilling equipment.

According to today's technology this means there will be more remote controlled systems installed for:

a) racking, making up/breaking out and suspension of drill pipes, drill collars and casing in the rotary table.

b) Transport of drill pipes, drill collars, casing etc. form storage to the drilling floor.

2.1.1.3 Implications by NPD's regulations

The regulation of 1981 meant in practice that it was required to have a remote controlled iron roughneck, remote controlled vertical pipe handling system on drilling floor, remote controlled slips and remote controlled power elevator. The regulations did not affect pipe handling of pipe deck, but did however explicitly refer to drill pipes and not casing or drill collars. For the drilling personnel the regulations of 1981 created less use of manual rig tongs for making up/breaking out pipes and less manual pulling and steering of drill pipes while these were hanging in winches (i.e. when stabbing). Heavy lifting whilst pulling slips were reduced. The reception of pipes was still manually handled, using an air winch to pull the catwalk up to the drilling floor.

The regulation of 1992 expanded the existing rules of pipe handling equipment on the drilling floor to include casing and drill collars.

Remote controlled pipe-handling equipment were still a requirement on the drilling floor. In practice this meant a regulation of tubular loading units from pipe deck to drilling floor as well as equipment for moving pipes from storage to pipe deck to tubular loading unit. It was essential to have a receiver system on the drilling floor, to grab pipes coming from the tubular loading unit and lift these to a vertical position.

NPD's intentions on fully remote controlled pipe handling has not been completed to included all pipe dimensions, neither for drill collars, casing nor drill pipes (Munch-Sørgaard, 1999). According to NPD's drilling regulation of 1998 the requirement went on to include pipe dimensions up to 20". In addition to what is mentioned above, handling of subs, thread protectors, drilling crowns, appliance of doping, stabilizers and lifting nipples are still being handled manually.

2.1.2 Hypothesis

NPD's drilling regulation of 1981 is expected to have improved the safety in working conditions first and foremost for the roughnecks and the derrick men. These professions reduced the use of manual rig tongs when making up and breaking out drill pipes (possibly casing when it could be handled by equipment) and manual pipe handling in the tower and on the drilling floor. We expect a relatively large reduction in number of injuries on the drilling floor and drilling rig, some fewer than on pipe deck/main deck.

We expect to find a reduction in number of injuries, both on pipe deck and drilling floor in the period following 1992, considering a pipe handling system on pipe deck is to reduce a number of manual labours with pipes. The extent of physical contact with pipes on pipe deck will additionally be reduced due to the removal of manual receiver in v-door, as well as a reduction of manual handling of drill collars and casing. Manual handling has not been removed on a whole due to some limitations where i.e. the remote controlled equipment is unable to handle all pipe dimensions. It is also partly because the remote controlled equipment occasionally is out of function and leaving one to switch to manual operations.

2.2 Method

2.2.1 Data Basis

The data basis for the analysis is based on two databases, (RF's "Injuries in Drilling") covering 1980 to 1990 and (NPD's "Personnel injuries in The Oil and Gas Industry", PIP3) covering 1991 to 1997. The following information on injuries was gathered from both databases for this project:

- Injuries occurring on Norwegian continental shelf
- All injuries on drilling rig, drilling floor and on pipe deck/main deck. It is difficult to separate injuries on pipe deck and main deck because the RTV-form used during this period does not have an applicable box solely for "pipe deck". The outcome has been ticks made in the box "main deck" although the form indicates that it is likely the injury occurred on pipe deck. In most cases it is impossible to point out where the injury occurred. This is the case in caused by stumbling or misstep without reporting what caused it. Injuries on pipe deck and main deck (where drilling personnel is involved) are therefore joined together in one category.
- Injuries on fixed and movable installations, but not drilling ships
- The same rigs examined in Munch-Sørgaard (1999) is also examined in this report in addition to Ekofisk 2/4-X.

The two bases vary in construction on a number of points although we were able to merge the following:

- Data of injury
- Experience in position

- Type of installation
- Installation
- Company and operator
- Profession
- Used equipment
- Injured by (equipment/construction)
- Injured body part
- Type of injury (wound injury, amputation, fracture, soft tissue injury, internal injuries
- Incidence (what caused the injury?)

Additional data fields in the database PIP3 from 1991 to 1997, covers information related to consequences of the injury whereas two fields describing equipment involved at the time of the injury.

2.2.2 Mapping of Equipment

Detailed information on equipment from 1980 to 1990 is to be found in RF's database "Injuries in Drilling". During these years NPD's regulations of 1981 were eventually followed up, resulting in remote controlled pipe handling equipment to be found on most rigs on Norwegian continental shelf (4 fixed installations did not have such equipment towards the end of 1990). Meanwhile, only a few rigs had pipe-handling equipment on pipe deck.

We have information on equipment supplied by equipment vendors with the exception of the larger vendors for the years 1991 to 1997. A "before and after" category for 1991 to 1997 will be most adequate. This will be based on status of equipment in 1990 as described in RF's database "Injuries in Drilling" and 1997 as described in Munch-Sørgaard (1999). The Munch-Sørgaard Report includes status on equipment for 50 rigs, where 21 are movable. The report covers status towards the end of 1998, but the information used covers the years 1995 to 1998. Towards the end of 1998 the status of remote controlled pipe handling for most of the examined rigs (p. 21) were as follows:

- Drill collars, drill pipes and casing <20" are transported to catwalk and rotary table as well as being racked with remote controlled pipe handling equipment
- Screwing is remote controlled for drill pipes, drill collars, casing <20"
- Stabbing is remote controlled for drill pipes and casing <20"
- Remote operated slips are remote controlled for drill pipes and casing <14"
- Pup-joints get stabbed, slips in position and screwed with remote controlled equipment

- A number of pipes/types of equipment are manually handled. This includes i.e. bits, mud motor, MWD tools, stabilizers, centralizers, perforating equipment, fishing equipment, completion equipment and core sample equipment.

On the basis of this one can view the introduction of remote controlled pipe handling equipment, as a gradual process were NPD's regulations are yet to be accomplished. Munch-Sørgaard's report otherwise claims that some of the regulations will be impossible to accomplish.

The information received by RF from the equipment vendors, is in our opinion not consistent enough to be used as a substantive statistically comparison of the injury sequence before/after installation of various types of remote controlled pipe handling equipment for rigs now installed with such equipment. This is due to the fact that a large number of the rigs with such equipment are new constructions, or had such equipment when they began drilling on Norwegian continental shelf and even upgraded rigs installed equipment in different order. We therefore base this report on Munch-Sørgaard's report (1999).

2.2.3 Method of Analysis

The data of injuries from the database will be used in two ways within this report:

1. As a control for degree of activity. There is no available information on working hours for the period during 1980 and 1990 so this will therefore be number of injuries per 1.000 days of operation. For the period 1991 to 1997 injuries will be calculated as injuries per million working hours in drilling as reported to NPD. Ratios such as these will be used as trend analysis where we wish to work on a survey of the development over time. For this purpose statistic methods will be used as regression analysis.

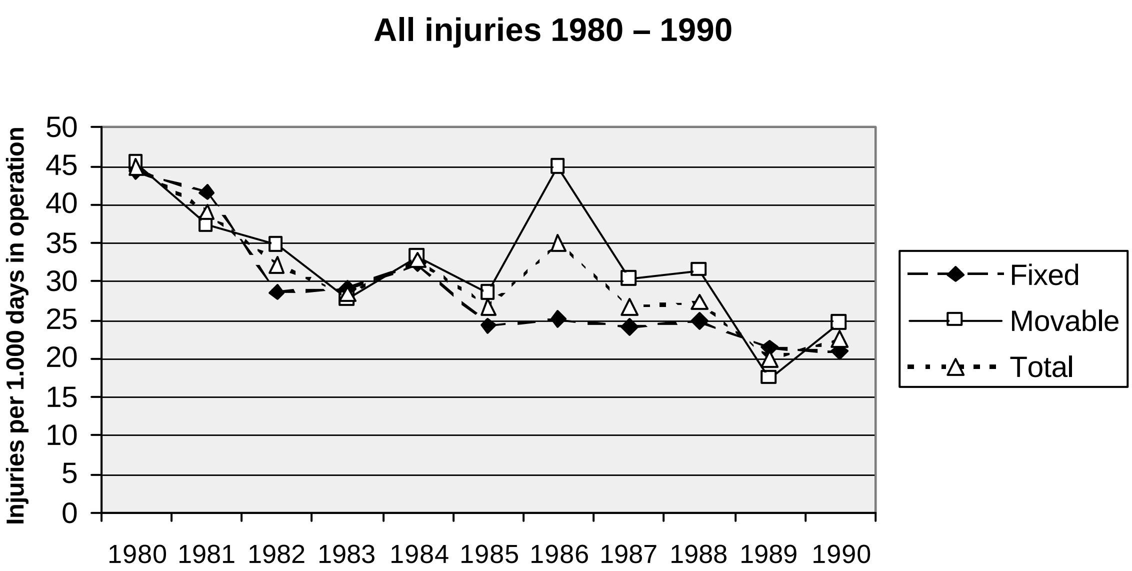
2. Frequency data. We will apply frequency distribution where level of activity will not be correct. We will on the other hand, study the distribution of injuries in various categories i.e. professions and type of equipment. This type of data can be analysed to reveal whether the distribution of injuries with various marks have changed systematically, before and after the introduction of remote controlled pipe handling equipment. The chi-square test will be used to measure out statistic significance.

3 Injuries in Drilling: Results

3.1 Reduction during 1980 – 1990

An even trend in lower frequency of injuries can be seen on fixed installations although the most noticeable reduction appears during 1980 and 1986. An equal reduction can be seen for movable installations for the whole period. During 1986 and 1988 a change in the trend can be seen, with a high level of frequency of injuries ref. Figure 1. No statistic significance reduction occurs during 1991 and 1997, ref. figure 2.

Figure 1. Injuries per 1.000 days in operation from 1980 to 1990



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1 Statistic significance in this case shows whether there is a systematic association between time (year) and frequency of injuries, as seen in figure 3 and 4. Statistic significance will not be found between time and frequency of injuries if the frequency of injuries fluctuates from year to year, as a result of pure coincidence. The association between time and frequency of injuries is not coincidental if the fluctuations show p, e value between 0 and 1, where the value is less than 0.05.1

Figure 2. Injuries per million hours from 1991 to 1997

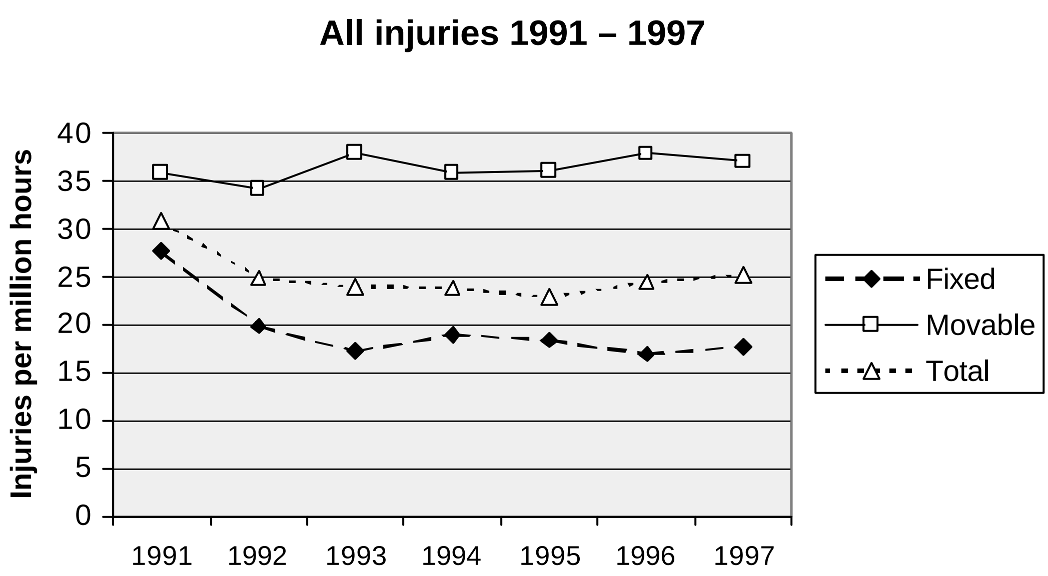


Figure 2 display a negative trend for fixed installations during 1991 and 1993. The frequency of injuries after this period is even with approximately 17 injuries per million working hours. Movable installations display no significant changes from 1991 to 1997.

A regression plot has been developed to compare development of injuries between the two periods in time. Figure 3 indicates the development during 1980 and 1990 while figure 4 indicates the development during 1991 and 1997.

On the basis of the analysis we have come to conclude that there has been a genuine reduction in number of injuries per million working hours during 1980 and 1990, but not during 1991 and 1997.

Pearson's correlation coefficient between time and frequency of injuries as shown in the regression plots (figure 3 and 4) indicates that the years 1980 to 1990 are larger than during 1991 and 1997. The correlation during 1980 and 1990 are statistic significant on 5 percent level ($p<0.05$), while the correlation during 1991 and 1997 are not statistic significant.

Figure 3. Regression plot for all injuries from 1980 to 1990

80-90: YEAR vs. TOTAL

TOTAL = 3702.4 – 1.850 * YEAR

Correlation r = -.8453

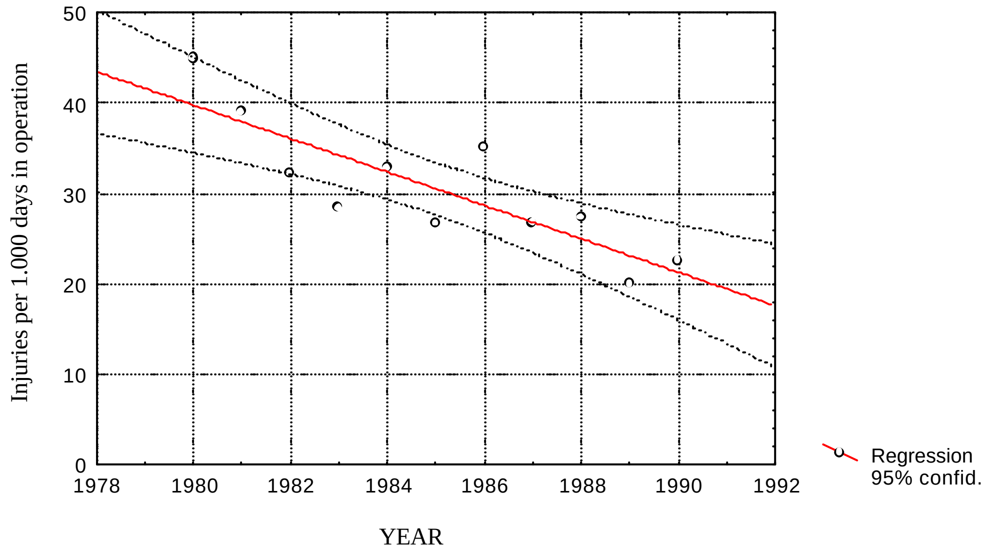
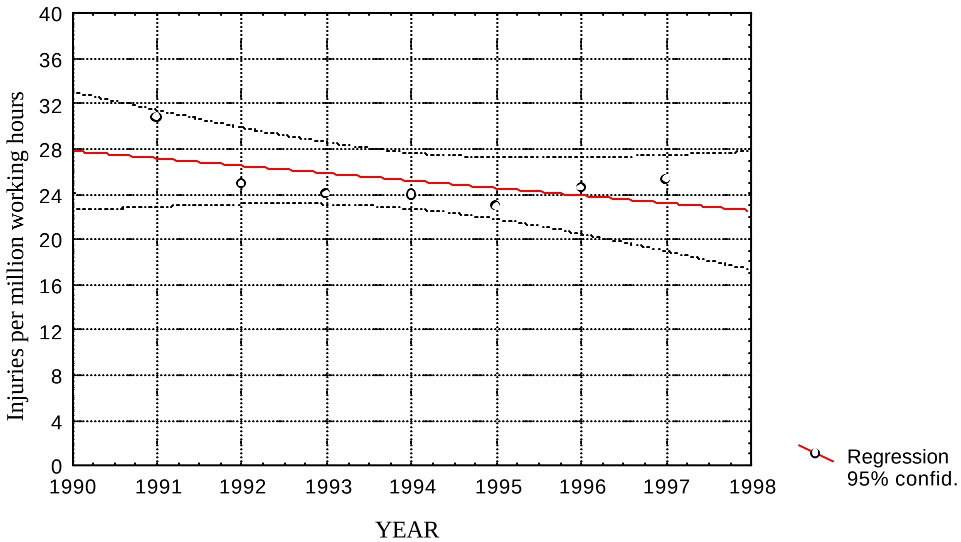


Figure 4. Regression plot for all injuries from 1991 to 1997

91-97: YEAR vs. TOTAL

TOTAL = 1341.1 - .6599 * YEAR

Correlation: r = .5481



3.2 Reduction in injuries on the drilling deck

The injuries (per 1.000 days in operations) in figure 5 and 6 are categorised by location on board: drilling floor, derrick and pipe deck/main deck. **The numbers display no genuine reduction with the exception of the pipe deck during 1980 and 1990, ref. Table 5 and 6.** It is worth noticing that the reduction already began in 1980 and therefore before the drilling regulation of 1981. Figures 7 to 10 displays changes in injuries over time on the various places of injury. All fixed and movable installations have been merged within the table and figures if nothing else is indicated.

Figure 5. Injuries categorised by location onboard, 1980 – 1990

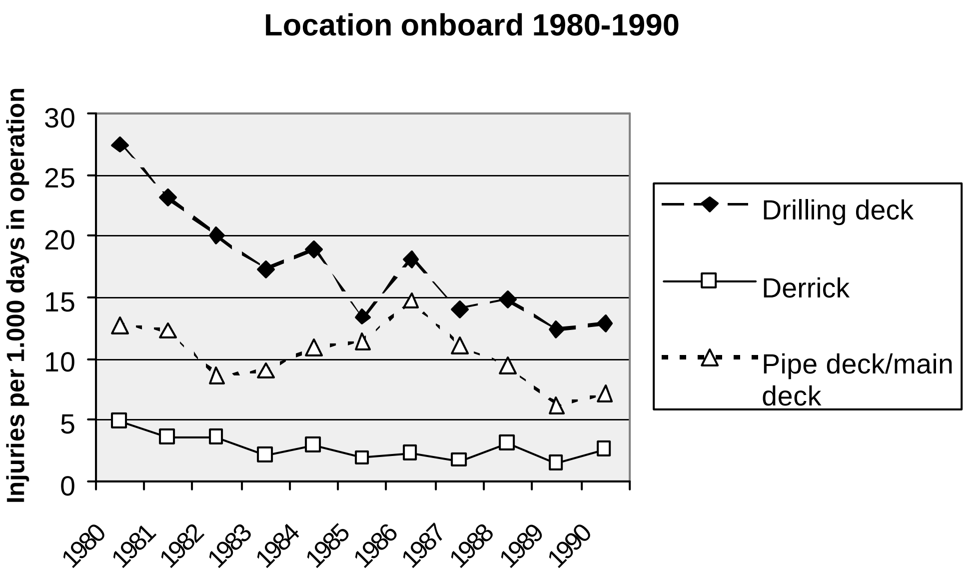


Figure 6. Injuries categorised by location onboard, 1991-1997

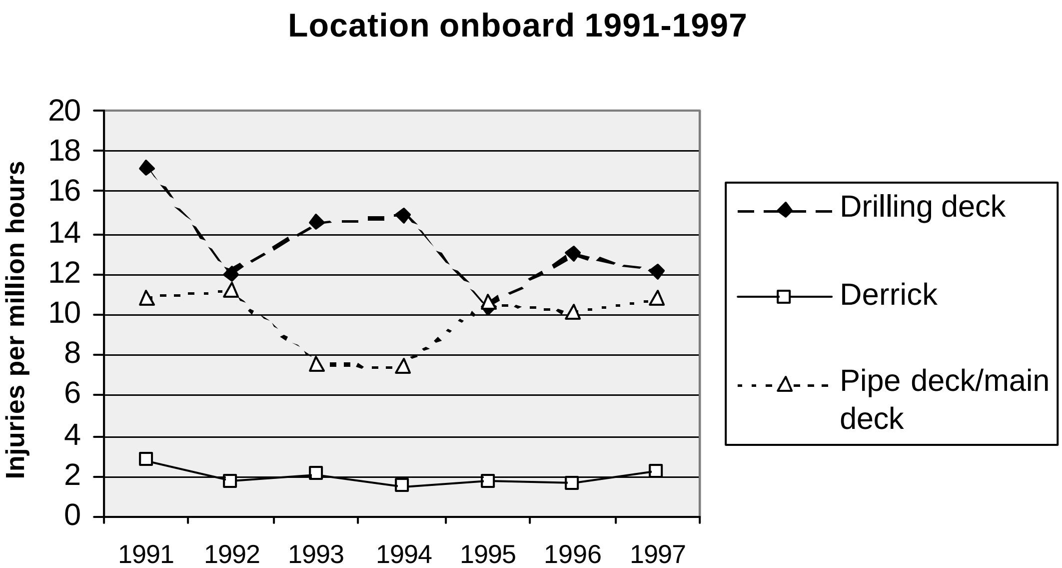
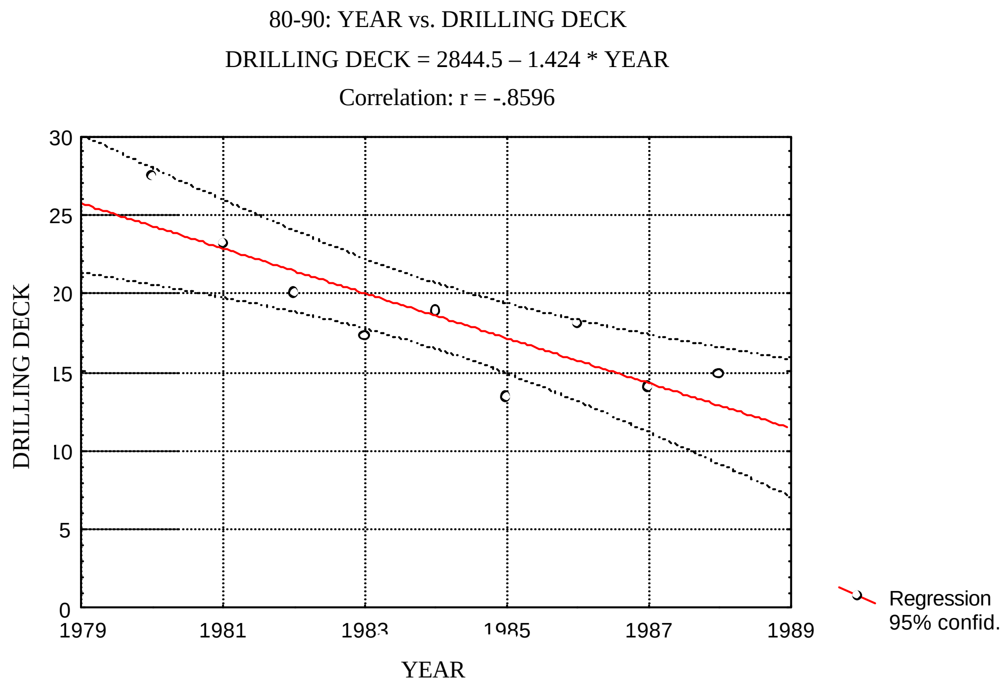
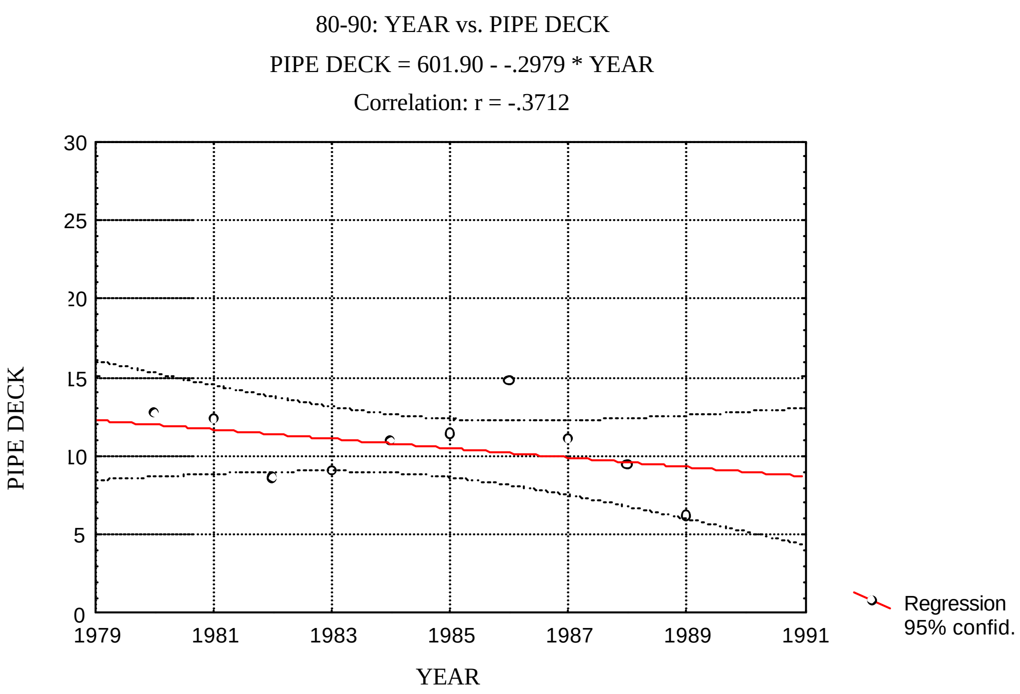


Figure 7. Regression plot for injuries on drilling floor from 1980 to 1990



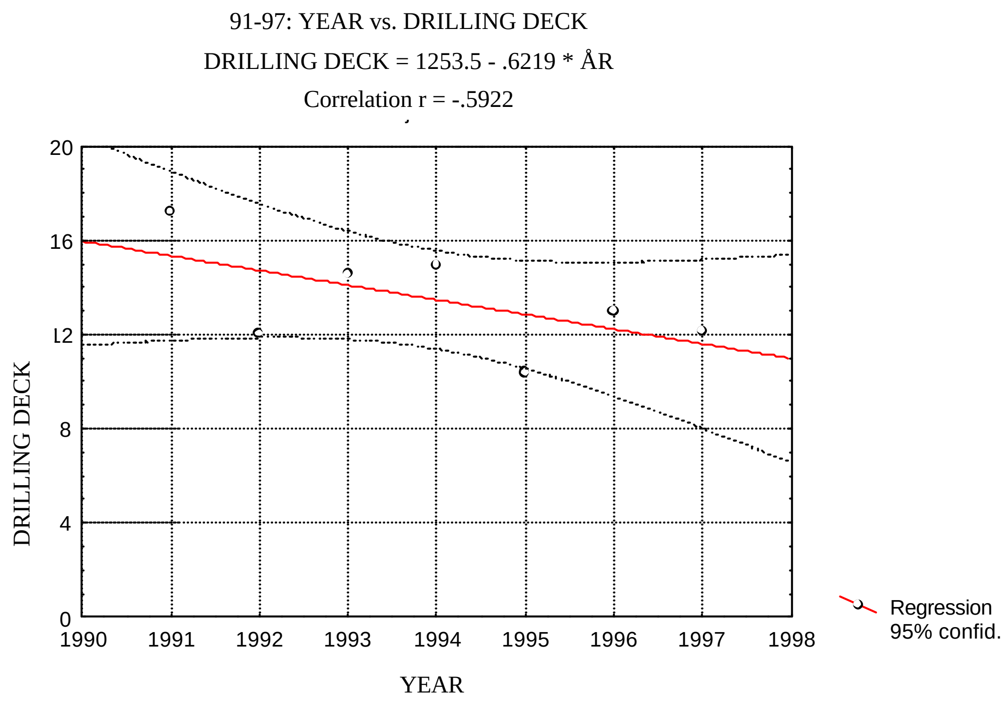
The correlation between time and sequence of injuries on drilling floor during 1980 and 1990 is statistic significance on 5 percent level ($p<0.05$).

Figure 8. Regression plot for injuries on pipe deck/main deck from 1980 to 1990



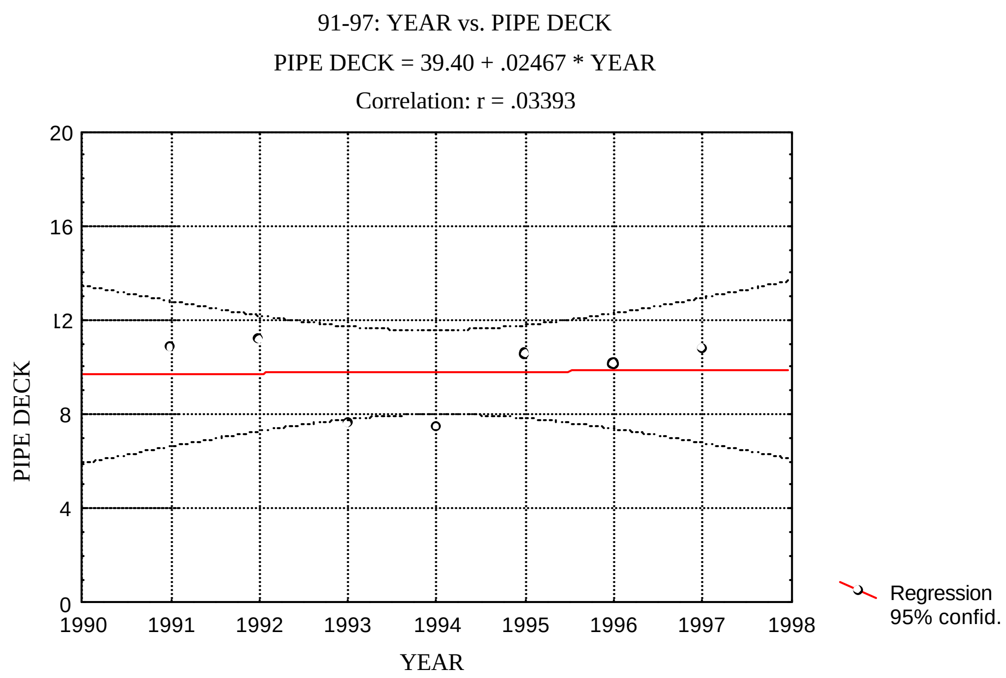
The correlation between time and sequence of injuries on pipe deck during 1980 and 1990 is statistic significance.

Figure 9. Regression plot for injuries on drilling floor from 1991 to1997



The correlation between time and sequence of injuries on drilling floor during 1991 and 1997 is not statistic significance

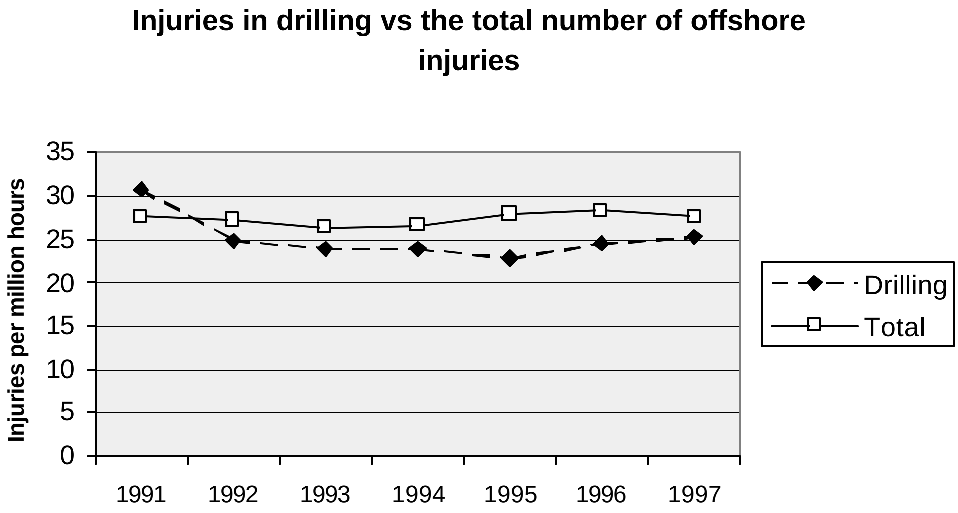
Figure 10. Regression plot for injuries on pipe deck/main deck from 1991 to 1997



The correlation between time and sequence of injuries on pipe deck/main deck during 1991 and 1997 is not statistic significance.

Figure 11 display injuries in drilling per million working hours compared to total injuries in the offshore industry as stated in NPD Annual Report from 1998. The sequence of injuries in drilling does not vary much to the total number of injuries in drilling, when the drilling injuries are not put into sub-groups. As shown above, only the development of injuries on drilling floor distinguish from the general trend.

Figure 11. Injuries in drilling compared to the total number of offshore injuries



3.3 Trends in injuries related to various professions

The injuries have changed to some degree from drilling crew towards other professions. This may support to the assumption that new equipment causes harder conditions for maintenance personnel, ref. Figure 12. Meanwhile, during these years a change in division of drilling activity has occurred, ref. Figure 13. It displays that the number of days in operation in drilling has been equally reduced for the same period. Shifts in professions do not automatically indicate a change in pattern of injury.

This section cores only 1991 to 1997 considering that the two databases in use are too different to give a compatible description for both of the involved approaches

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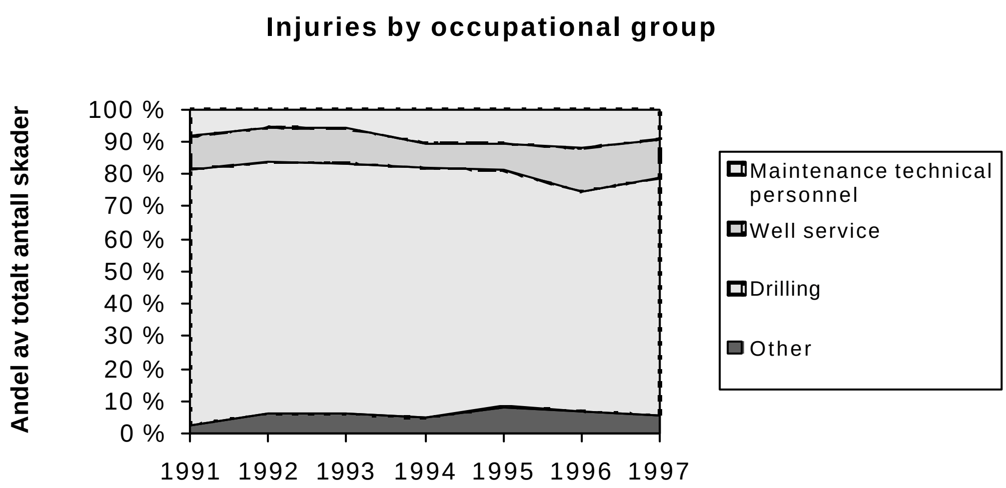
2 This section cores only 1991 to 1997 considering that the two databases in use are too different to give a compatible description for both of the involved approaches

Due to the fact that the NPD includes several professions, an account of the frequency of accidents for various professions it is difficult to find exact working hours. Well service personnel and sections of maintenance work are reported as drilling. There is a problem to find exact working hours for each personnel group.

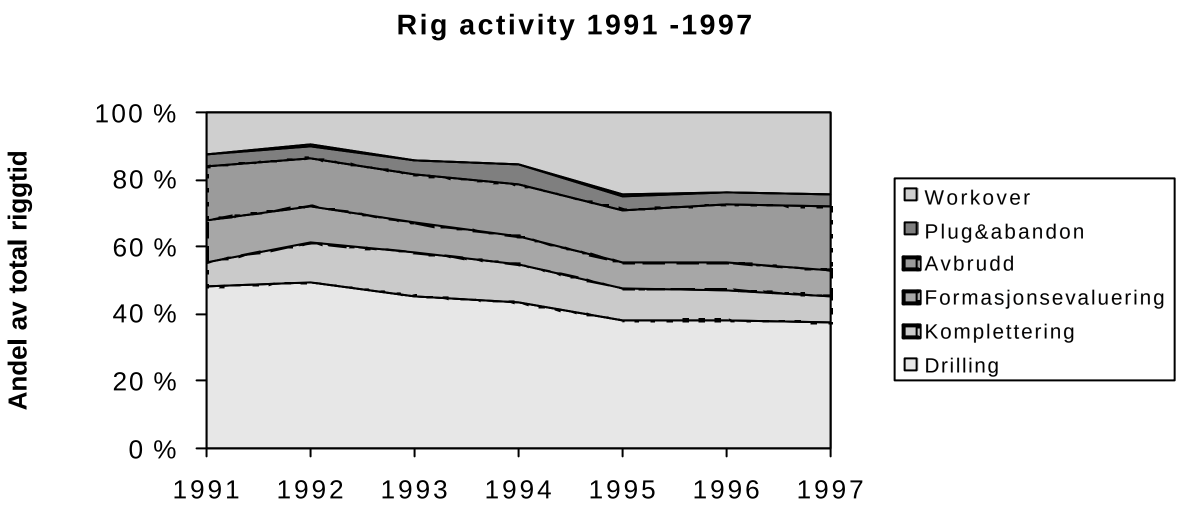
The personnel in our selection will be divided into groups of drilling personnel, well service personnel and maintenance technical personnel. An overview of injuries divided into professions can additionally be found in table A6.1, Appendix 2.

Figure 12. Percentual distribution of injuries by various professional categories



Alterations as seen in figure 12 shows a reduction in number of drilling personnel compared to other professional groups, and can be explained by the number in drilling being reduced for the same period. Figure 13 is based on numbers from NPD (DDRS, Daily drilling report system) is showing the number of days and nights in operation with various types of drilling operations. It is important to notice the considerable increase in the activity level during this period (ref. figure 14). This requires fresh recruitment without increasing frequency of accidents.

Figure 13. Rig activity 1991 to 1997



3.4 Injury trends related to various types of equipment

Injuries related to use of pipes or pipe-handling equipment indicates a decreasing trend from 1991 to 1997, while injuries in the "other equipment" category shows no consistent trend during 1991 and 1997.

Several types of equipment are registered in the database from 1991 to 1997 (271 different types in section "injured by". We have categorised the injuries into two (main) groups to describe injuries related to pipe handling: a) Pipe-handling injuries and b) "other". Creating an additional category for each field containing equipment information in the database has made this classification. "Pipes", "Pipe-handling equipment" and "other" are used to describe these additional categories. Equipment such as sub/crossover couplings/couplings, drill pipes, drill collars, casings or risers were categorised as "pipes", while iron roughnecks, tubular loading units, vertical pipe handling systems, pipe handling systems, overhead cranes, rig tong, spinner tong/hydraulic tong, casing tong, chain tong, slips/drill pipe or elevator) were categorised as "Pipe-handling equipment".

The database from 1991 to 1997 contains four data-fields per injury.

1. The equipment the injured worked with

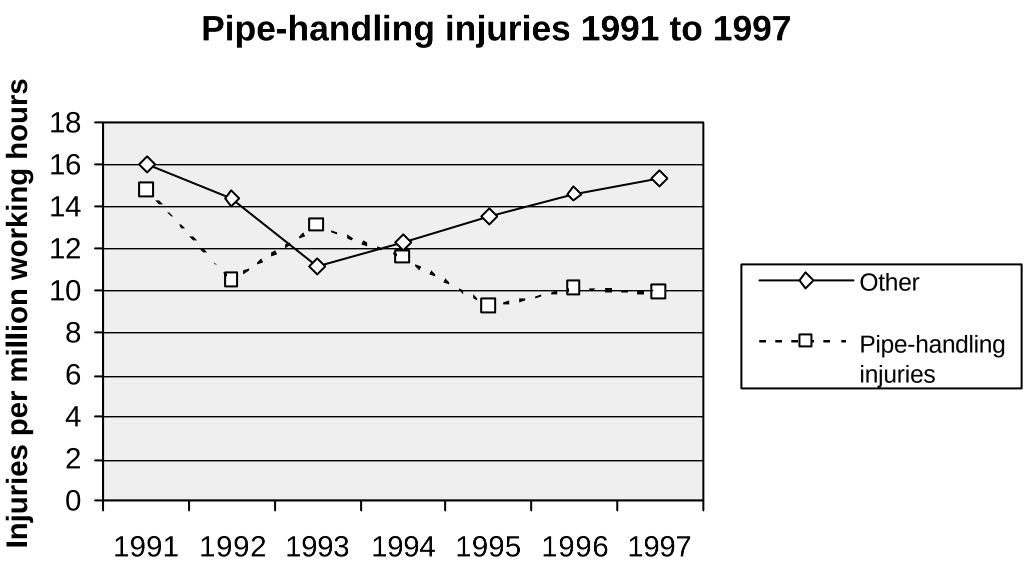
2. Equipment I involved in incident leading to injury

3. Equipment II involved in the incident leading to injury

4. Equipment in physical contact with the injured and causing the injury

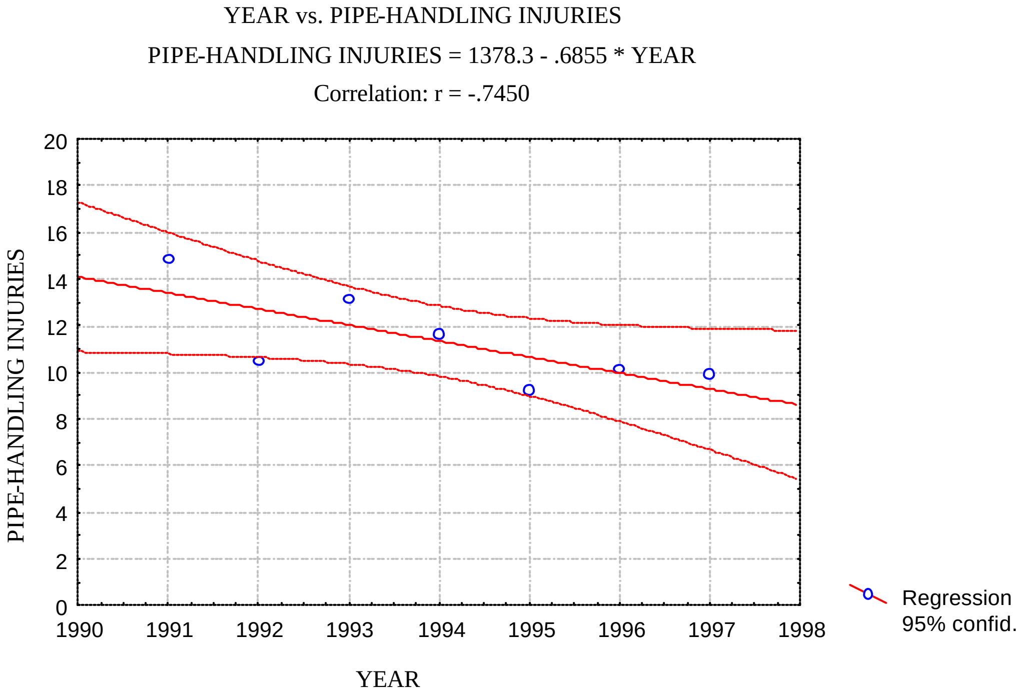
The injury categorised as a "Pipe-handling injury" had the equipment belonged to one or more of these sections "Pipe" or "Pipe-handling equipment". The remaining injuries were named "Other". Tendencies for injuries according to this categorisation can be seen in figure 15.

Figure 14. Pipe-handling injuries and other injuries 1991 to 1997



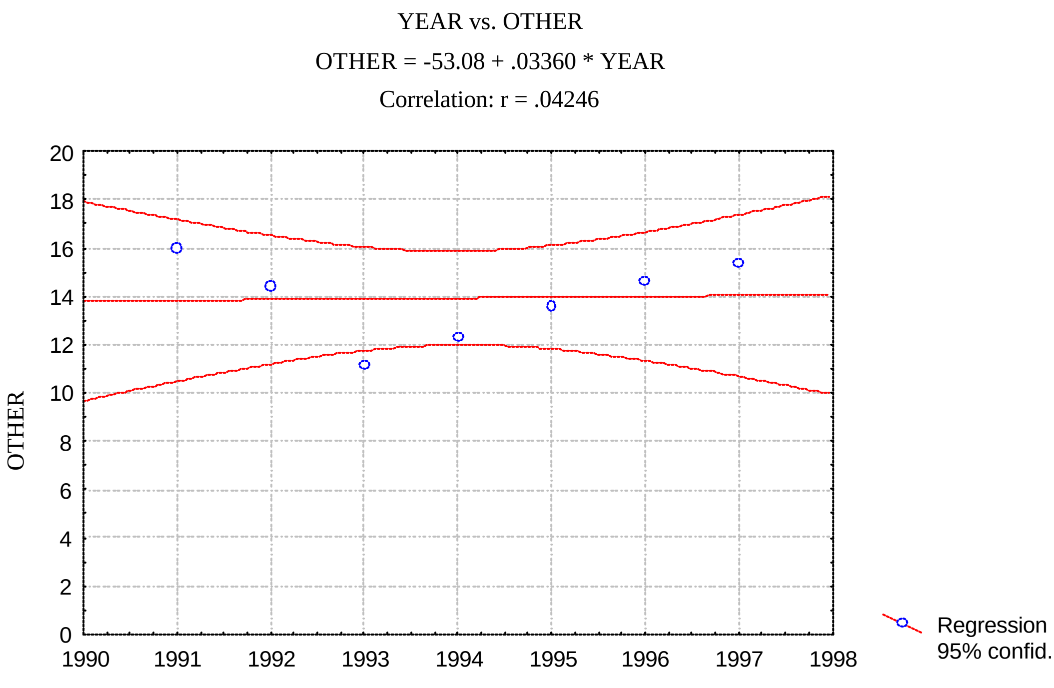
Injuries related to use of pipes or pipe handling equipment indicates a declining tendency from 1991 to 1997, while the injuries in the category "Other" indicates no consistent tendency for the same period, ref. figure 14. Also view figure 16 and 17 testing statistic significance for the changes.

Figure 15. Regression plot for “Pipe-handling injuries”



Pearsons correlation coefficient on r=-0.745, p <0.05, indicate a statistic significant relation between years and pipe-handling injuries per million working hours. As seen in figure 16 no relation can be found between years and injuries categorised as “Other”. Pearsons correlation coefficient r=0.0426 is not statistic significance

Figure 16. Regression plot for “Other”



3.5 What equipment causes injury

By giving a detailed description on what type of equipment giving a direct physical cause to injury, we will study what causes the difference in development of pipe-handling injuries and other injuries. On the basis of the classification, which will be further discussed below, the data-material indicates as follows: for pipe-handling injuries the most common injury-caused equipment are drilling pipes, elevator, rig tong, slips and casing. There are no noticeable differences during 1991 – 1993 and 1995 – 1997. In the category "Other injuries" the most common injury-caused equipment during 1991 and 1993 are pipe deck, unlit products, main deck, ladders and drilling floor as causing injuries equipment during 1995 and 1997, but less injuries caused by main deck. Injuries caused by other types of equipment such as iron bars, knifes, sledgehammer and wires have risen noticeably, ref. table 3.

The above analysis is based on processing of the data material reviewed in following: Table 1 indicates number of injuries involving the ten most common injury-caused equipment types for "pipe-handling injuries" while table 2 indicates number of injuries involving the ten most common injury-caused equipment type for injuries is the "Other " category.

Table 1. The ten most common types of equipment in "Pipe-handling injuries"

	1991	1992	1993	1994	1995	1996	1997	Total
Drilling pipe	11	3	9	7	7	7	7	51
Elevator	7	8	8	8	5	7	4	47
Rig tong	8	9	6	5	4	7	6	45
Slips	4	4	6	3	1	7	5	30
Casing	4	6	3	2	2	6	5	28
Sub UNA	3	0	4	7	1	4	4	23
Pipe	0	0	2	1	2	1	6	12
Loading of pipes	3	4	1	0	3	0	0	11
Spinner tong	1	1	2	2	1	1	2	10
Casing tong	6	0	0	1	0	0	2	9

Table 2. The most Common types of equipment in "Other" injuries

	1991	1992	1993	1994	1995	1996	1997	Total
Pipe deck	2	7	5	4	9	7	4	38
Drilling floor	2	4	2	6	5	5	5	29
Other technical parts	9	5	5	3	3	1	3	29
Iron bar, girder,	2	1	4	4	2	5	6	24
Knifes	1	2	0	8	2	1	4	18
Sledges	3	2	1	0	3	6	2	17
Wires	2	3	0	1	3	3	5	17
Protectors UNA	2	3	1	3	1	3	3	16
Main deck	6	2	4	0	0	1	3	16
Ladders	2	4	2	1	3	1	3	16

The number of injuries per equipment-type each year is too low to interpret statistical. It is therefore difficult to draw conclusions on the basis of these numbers. We will conduct a rough "before and after" division in relation to NPD's drilling regulation from 1992. The regulation had a transitional period of two years, although data from the equipment vendor indicates that a number of rigs did not have the required equipment towards the end of 1994. As mentioned earlier, data from RF's database from 1980 to 1990 states that most rigs had vertical pipe handling systems on drilling floor, iron roughnecks, remote controlled slips and remote controlled elevator at the beginning of 1991. Meanwhile, only a few rigs had remote controlled pipe handling equipment on pipe deck and equipment to receive pipes in v-shaped door. According to Munch Søgaard's report (1999) most rigs on Norwegian Shelf had towards the end of 1998, remote controlled pipe handling equipment on pipe deck handling most drilling pipe dimensions including casing (except dimensions <20") and drill collars. On the basis of this information a division of time before/after the introduction of remote controlled pipe handling equipment which meets the required demands set by NPD's drilling regulation from 1992 will be a compromise between the consideration that one requires certain amount of data to draw statistical conclusions and the question whether such equipment were widely spread during the respectively periods of time. From our point of view an acceptable compromise will be to compare the years 1991 – 1993 with 1995 – 1997.

Table 3. The ten most common types of equipment in "Pipe-handling injuries" and "Other"

Pipe-handling injuries

	1991-	1995-
Drilling pipes	23	21
Elevator	23	16
Rig tong	23	17
Slips	14	13
Casing	13	13
Sub UNA	7	9
Pipes – unspecified	2	9
Loading of pipes	8	3
Spinner tong	4	4
Casing tong	6	2

"Other" injuries

	1991-	1995-
Pipe deck	14	20
Drilling floor	8	15
Technical-	19	7
Iron bar, girder	7	13
Knifes	3	7
Sledges	6	11
Wires	5	11
Protectors UNA	6	7
Main floor	12	4
Ladders	8	7

These tables only include the ten most common types of equipment for injuries attached to pipe handling equipment or pipes and other injuries. Regarding the table it is important to view the numbers being in mind that the rig activity was considerable higher in 1995-1997 than in 1991-1993.

3.6 Mechanism of injury by pipe-handling injuries and other injuries

Table 4 indicates which mechanisms of injuries occurring in relation to pipe-handling injuries and "other" injuries.

Table 4. Mechanism of injury in pipe-handling injuries and "other" injuries.

Mechanism of injury in	**1991**	**1995**
Crushed	122	80
Falling/bumping into	40	57
Overloading UNA	27	27
Hit by swinging	13	18
Hit by UNA	13	16
Hit by falling	14	13
Contact on skin and eyes	4	1
Contact with sharp	0	3
Hit by flying	2	2
Contact to sharp	2	1
Injury mechanism	2	1
Hit by rotating	2	0
Foreign body	0	1
Contact with sharp/rough/pointy	0	1
Hit by rolling	1	1
Contact with rough	0	1
Contact with damaging substance	0	1
Contact with hot	0	1

Mechanism of injury in	**1991**	**1995**
Crushed	58	58
Overloading UNA	40	66
Falling/bumping into	35	61
Hit by swinging	21	34
Hit by UNA	23	22
Hit by falling	14	25
Contact on skin and eyes	16	13
Foreign object	12	10
Contact sharp	8	10
Contact with point	3	4
Contact with damaging	2	3
Contact with sharp/rough/pointy	1	3
Injury mechanism	1	3
Hit by flying	2	1
Contact to warm	3	0
Injury mechanism UNA	3	0
Hit by rotating	2	0
Contact with rough	0	1
Inhalation of	1	0
Hit by rolling	1	0

We have registered considerable fewer crush injuries in the category Pipe-handling injuries during 1995 and 1997 compared to 1991 to 1993. This reduction is more evident considering the level of activity being considerable higher during 1995 and 1997 than 1991 to 1993.

To achieve a statistic expression for this amendment we will compare crush injuries to injuries where the injured person was in movement walking into or falling towards constructions or equipment. Such a comparison can be achieved by a chi-square test based on table 5.

Table 5. Crush injuries compared to falling/collision/bumping into injuries in pipe-handling injuries.

	1991-1993	1995-1997	Total
Crush	122(40,8%)	80(26,8%)	202(67,6%)
Fall/collision	40(13,4%)	57(19,1%)	97(32,4%)
Total	162(54,2%)	137(45,8%)	299(100%)

Chi-square (1 degree of freedom)=9,69, p<0,001.

The chi-square test is in this case a measure of the independence of type of injury and year. Crush injuries decreases and injuries caused by “falling/bumping into” increases. The table indicates that the difference seen in division of the various types of injuries indicates opposite development during the two periods. Relatively seen, there are more crush injuries during 1991 and 1993 compared to 1995 to 1997 while the tendency for falling/bumping into turns towards the opposite direction. It is important to note that the chi-square test measures the relation between the two variables, rather than a measurement of total amendment in frequency of damage. It is therefore not essential to correct working hours.

Table 6. Crush injuries compared to “falling/bumping into” injuries for “Other” injuries.

	1991-1993	1995-1997	Total
Crush	58(27,3%)	58(27,3%)	116(54,7%)
Fall/collision	35(16,5%)	61(28,7%)	96(45,3%)
Total	93(43,8%)	119(56,1%)	212(100%)

Chi-square (1 degree of freedom)=3,61, p<0,05.

Falling/bumping into injuries also increases here in relation to crush injuries.

3.7 Degree of seriousness: tendencies

Data from the period 1991 to 1997 indicate a reduction in number of serious injuries. We account for the data analysis below.

Degree of seriousness is not coded as a separate field in the database for the years 1991 to 1997. However, we do have information on which body-part being damaged, the type of injury in question as well as information about the consequence of the injury. To further investigate the degree of seriousness our starting point is that injuries with only registered consequence “medical treatment” or registered on the RTV-forms will be considered to be fewer than injuries which requires “hospital treatment”, “absence next shift”, “disability for 3 days” and “death”. The division of the consequences of the injuries for 1991 to 1993 vs. 1995 to 1997 is presented in table 7.

Table 7. Consequences of the injuries for 1991-1993 compared to 1995-1997.

Consequences of injury	1991-1993	1995-1997
Death	2	0
Absences next shift	20	19
Medical treatment	355	451
Hospital treatment	49	27
Disability over 3 days	43	18
Occupational injury	3	1

If we add "absence next shift", "death", "hospital treatment", "disability over 3 days" and name these injuries "serious injuries" we can then compare it to "medical treatment", here named "other injuries", ref. table 8.

Table 8. Serious injuries and other injuries, 1991-1993 compared to 1995-1997

Consequence of injury	1991-1993	1995-1997	Total
Serious injury	86(9,0%)	61(6,4%)	147(15,4%)
Other injuries	355(37,3%)	451(47,3%)	806(84,6%)
Total	441(46,3%)	512(53,7%)	953(100%)

Chi-square (1 degree of freedom)=10,45, $p<0,0012$.

This chi-square test indicates that for the two periods 1991-1993 and 1995-1997 the number of serious injuries has declined, compared to the category "other" injuries. The number of serious injuries was 9 percent in 1991-1993 compared with 6,4 percent in 1995-1997. The number of other injuries was 37 percent in 1991-1993 to 47 percent in 1995-1997.

The two categories indicating the level of seriousness have an opposite development: the number of "other" injuries increase, while "serious" injuries decline.

It is likely to assume that the number of injuries is too high if one view the consequence of the injury in a longer perspective of time, considering the RTV forms to be filled in 24 hours after the accident. We will also present an overview of the nature of the injury (table 9) to validate these numbers.

Table 9. The nature of the injury 1991-1993 compared to 1995-1997

Nature of injury	1991-1993	1995-1997
Soft tissue injury	155	183
Wound injury	114	118
Sprain	76	118
Closed fracture	49	44
Injury unspecified	29	25
Corrosive	15	9
Amputation	14	6
Joint dislocation	2	7
Open fracture	6	1
Concussion	4	0
Whiplash injury	1	4
Heat/cold injury	4	1
Shock/Internal injuries	3	2
Poisoning	2	1
Radiation injury	0	3
Hearing damage	0	2
Corrosive	0	2

The degree of seriousness is more difficult to assess within these categories due to the fact that the concept soft-tissue injury can be used to describe anything from minor bruises to considerable damage of tissue. The same applies for the concept wound injury, which might cover everything from splint in fingers to deep severe cuts. This table will not summarise the categories “severe” and “other”. Meanwhile it is worth noticing a reduction from 1991-1993 to 1995-1997 in injuries such as “open fracture”, “amputation” and “closed fracture”.

3.8 Injuries involving remote operated pipe handling equipment

It is possible to separately view injuries related to single explicit reported types of equipment in the database. This includes catwalk machine, iron roughneck, vertical pipe-handling systems on drilling floor and travelling crane/pipe-handling systems on pipe deck. Incidents involving injuries from slips and elevators does not always state whether manual or remote controlled equipment has been in use. This has to be interpreted in connection with incidence of injury and the use of equipment. We therefore wish to solely summarise injuries involving remote controlled equipment’s such as:

- Vertical pipe-handling system
- Iron roughneck
- Tubular loading unit

- Travelling crane/pipe-handling system on pipe deck

3.8.1 Vertical pipe handling system

The database has all together 15 injuries related to vertical pipe handling systems in one or more of the equipment fields. The injuries can be found in the section stating what sort of equipment used by the injured, or in the two sections stating incidence of injury or in the section stating what physically caused the injury

Two of the injuries originate from an episode where a stand slipped due to the breakage of one of the hydraulic arms. The stand hit a rig tong resulting in a balance weight being winded outwards the drilling floor, hitting two persons. One of the persons was hit in the arm, the other one in the head. The person who was hit in the head has to be sent on shore to a hospital. Furthermore, two injuries has occurred as a consequence of a backslide of a stand from the pipe handling system. One of these injuries was a head injury leading to hospital treatment on shore. The other injury was a crush injury on an arm leading to medical treatment on the rig.

3 injuries have occurred as a result of injured standing in the way of equipment in use. One of these injuries resulted in an amputation of a finger. The remaining injuries has occurred as a result of the injured stumbling or falling towards the pipe handling system or whilst the injured has worked with the pipe handling system and been injured by other type of equipment.

3.8.2 Iron roughneck

With reference to the same criteria's as for vertical pipe handling systems, 31 injuries involve iron roughnecks. Two of the injuries have lead to hospital treatment and two injuries to absence on next shift. Four of these injuries have occurred by the injured getting the foot underneath the iron roughneck while it have been moving on the tracks. Nine of the injuries have occurred by the injured getting fingers or hands squeezed by the iron roughneck. Three of the injuries occurred by pipe/subs sliding out of the iron roughneck hitting the injured. The remaining injuries were caused by missteps on the tracks of the iron roughneck, or missteps by the injured jumping/sliding down. This also includes injuries where the injured has been operating the iron roughneck and been injured by other equipment or by incidents where the iron roughneck has no direct involvement.

3.8.3 Tubular loading unit

With reference to the same criteria as for iron roughnecks, 16 injuries involve a tubular loading unit. Two of the injuries lead to hospital treatment, one injury lead to disable over 3 days and one injury to absence on next shift. Two of the injuries were caused by the same incidence where a drilling pipe fell out of the tubular loading unit and down onto the pipe deck hitting two persons. One of the persons was severely injured i. a. with a broken foot. In addition four similar injuries can be found all caused by pipes or subs falling out of the tubular loading unit and hitting the injured. Four of the injuries were caused by the tubular loading unit/pipes from the tubular loading unit being driven forward and hitting the injured. The remaining injuries are mostly injuries were the injured has fallen towards the tubular loading unit or taking missteps on it.

3.8.4 Overhead crane/pipe handling system on pipe deck

With reference to the same criteria as for the previous type of equipment, 6 injuries involve the equipment. A pipe loosening and hitting the injured caused three of the injuries. One of these injuries did lead to hospital treatment and one to absence on next shift. The injured standing in the way of the loading of pipes caused one injury. One injury occurred due to the injured grabbing a chain leading to a strained finger and one injury by installation of a craneway unit.

3.9 Discussion

A significant decline in injuries on pipe deck, drilling rig and drilling floor can be seen from 1980 to 1990. This general decline from 1980 top 1990 is most likely caused by more than the equipment, due to the relatively modest amendment of equipment on pipe deck during these years. Meanwhile, there was a relatively larger and more consistent decline for injuries on drilling floor compared to injuries on pipe deck. This can be seen in the regression plots were only the decline for injuries on drilling floor were statistical significant.

There was no falling trend in injuries in drilling during 1991 and 1997, provided one did not separate pipe handling injuries and other injuries. By conducting such a division one could quantify a significant falling trend for pipe handling injuries from 1991 to 1997, but not for other injuries. There was a decline in number of crush injuries compared to injuries from falling. This applied for injuries related to pipe handling and other injuries, but most evident for pipe handling injuries. The cause of this may be found in several conditions. It is likely to imagine that the profit gained by the introduction of new equipment to a certain extent is lost due to less space. This causes one to easier bump into object, stumble or fall.

There has been a shift of injuries from drilling personnel to maintenance personnel and well service personnel. This can be explained by the number of drilling declining compared to various other drilling operations, as seen in the summary of rig activity in drilling during 1991 and 1997.

The hypothesis about the increased degree of seriousness after the introduction of remote controlled pipe handling equipment has no support from data used for this report. On the contrary, the analysis indicates that the most severe injuries had a decline during 1995 and 1997 compared to 1991-1993. We have to make certain reservations in regards to the reliability of this information. The tendency in the reduction of severe injuries can however be supported by findings indicating a reduction in number of the injury categories “amputation” and “fraction”, compared to same period in injury category soft tissue injury.

In conclusion there does not seem to be particularly many injuries related to the direct use of remote controlled pipe handling equipment compared to manual equipment.

Injuries related to iron bars are still more common than those related to iron roughnecks. In instances involving failure of equipment, situations with massive potential for injuries might occur, as seen in two instances where several persons were injured in each instance. (Fracture on hydraulic arm on vertical pipe-handling system and falling drilling pipes from tubular loading unit.)

4 Work related illness

The basis of data in connection to information on the extent and changes in work related illnesses vary in quality. Isolated sources of data can be found in the operating companies, the industrial health service (used by contractor companies) and on installations. It will overall be difficult to find documentation to demonstrate the amendments in reported incidents of illness, before and after the automation of pipe handling. We also make use of information from the database regarding work-related illness in Norwegian Petroleum Directorate, (ref. section) and a survey conducted in Phillips.

A number of factors make it difficult to create a statistically reliable overview describing the extent, changes and development of work related illnesses. There was no common understanding nor definition of the concept work related illness. No common criteria have therefore existed to include work-related illnesses. In many cases it is uncertain whether an illness is work related or not. It is also difficult to establish which work place the illness originated from. Drill crews may rotate between various installations whilst other crew remain stationary. It may therefore be difficult to establish which exposures caused a particular illness. Some illnesses and diseases within e.g. the muscular or skeletal system will develop over time and the causal chain will therefore be hard to map.

A general problem with all registration of work related illnesses is that not all of them are reported. All informants we have been in contact with feel that work related illnesses that have been discovered in private clinics are not reported to company or authorities.

There are also other conditions that can cause systematic distortions of the illness incidence. (Incidence is the proportion of people falling ill during a given time frame). Crews have chosen different career paths over time. Advancing from the drill floor to other higher position was more common in the early phase of the oil industry. The time being exposed to possible health hazards might therefore vary depending on when one began working in the North Sea. One informant also claims there have been changes in the recruitment base. A number of experienced seamen were recruited for work in the North Sea in an early stage, but this has now changed. The recruitment today most often takes place in the educational establishment by people with less sea duty. This might influence the development of sickliness and possibly create systematic variations within various age groups. Ageing in general is also a factor to be considered when making comparison over time. Sickliness will normally increase at older age. It might therefore be difficult to separate causes to possible alteration in sickliness i. e. to what extend the alteration in incidents is caused by new technology, ageing or other factors.

Informants claim that safety was the main focus during an early stage of the operations in the North Sea. As a result, reports of injuries and documentation of injuries and unwanted incidents were thoroughly carried out. Work related illness at operator companies and drilling contractors on the other hand were not as well documented.

According to the health departments in the operating companies, the department focused on working environment and health (beyond injuries) on an early stage. The company management gave priority to safety and injuries and were less concerned with the illnesses. This has only been the case in later years. During the first period of searching and drilling in the North Sea, health information was only recorded in manual written journals. We have been informed that there are no electronic data sources going as far back in time. The retrieval of data is therefore quite complicated and time consuming and will go beyond the frames set for this project. Another factor in relation to the quality of data is that of the employed drilling operator choose to report an incidence of illness to the doctor himself, either to separate HMS service or private practising doctor. There is no duty related to further reporting an instance of illness to a central instance i. e. NPD. Local archives on installations and centrally in NPD are comprised by such sources of error.

It is therefore, due to causes mentioned earlier, difficult to propose systematic and reliable data regarding work-related illnesses and changes in sickliness related to technological changes.

We do have some information about the working environment given to us by service companies and occupational health service, which we will come back to on a later stage. On the other hand we have little information about work related illnesses. On the basis of several interviews with people of long experience from the oil activities, we will now present views on working environment and sickliness. A dissertation from NTNU (Norwegian university of technology) is available witch deals with working environment and safety in the introduction of what is called semiautomatic pipe handling equipment offshore (Haugastøyl 1998). The report does not include work-related illness. Results from this report will be discusses in chapter 6.

Statoil has a database on illnesses from 1996 (HAMS). Information regarding earlier years may only be found manually in journals. Both BP/Amoco and Shell reports having no reliable data regarding work related illnesses over time.

The Norwegian Petroleum Directorate has a data base on work related illness from 1992. We will study the information from this source in the next section.

4.1 Information from NPD's data base

The Norwegian Petroleum Directorate set up the database "Reports on work related illness" on the basis of reports from installations in the North Sea. The Norwegian Petroleum Directorate's annual report from 1992 states that the Norwegian Petroleum Directorate requires reports about illness related to working conditions as well as personnel injuries related to the oil activity. The Directorate states that the requirement regarding these reports was not followed up by the companies, resulting in a more strict duty to report work related illnesses in 1992. Reports of illnesses had been quite inconsistent and only a few companies represented the major part of the reported incidents. Even so, according to the Directorate there are reported insufficient numbers of incidents.

There are weaknesses (as mentioned earlier) with the system used for reporting illnesses to NPD's database. One circumstance is the lack of guidelines to classify work-related illness. It is likely to expect NPD to prepare such guidelines.

Another circumstance is the fact that employees use their own MP where they live and such incidents will not be systematically reported to NPD. One might assume, due to this fact, that only a small part of the current incidents of illness are reported to NPD. It is claimed that new forms for medical certificates will include a check box for illness related to the work place. This might give a basis for improved reporting to NPD's database.

The database does not include information on which installation or company the reports come from. Due to this fact it is not possible to evaluate the sickliness in relation to level of automation of the pipe operation on the drilling floor.

The aim for the automatization of pipe handling is to increase safety of the employees and therefore reduce exposure-causing injuries to health. If this had occurred one might expect a decline in number of reported incidents of illness. As mentioned above, circumstances can be found which moves in opposite direction, i. e. increased sickliness due to higher average age amongst employees off shore, systematic changes in recruitment for oil operations etc.

Even though there are several methodical weaknesses and sources of error with the material, we still choose to make use of NPD's database covering work-related illnesses.

Development

We will view the material of work-related illnesses available in the Norwegian Petroleum Directorate's database. The database contains information about the diagnosis for each incident of illness, job title and year for each employee reported to the database.

The tables below describes individual categories of illnesses (ICD-classification) regrouped in 10 groups which is used in NPD's annual report, ref. table 10. The job titles are regrouped into three main groups: drilling, maintenance and catering. A smaller group has also been set up to include executive positions, which did not fit in any of the other groups. 2384 incidents have been reported for the period 1992 to 1997. There has been an increase in number of reported incidents from 110 incidents in 1992 to 616 incidents in 1997. Due to weaknesses in routines for reporting illnesses it is most likely that the increase in incidences is due to improved reporting from the companies. Therefore, we can not draw the conclusion that the increase is due to increased sickliness. We can however not disregard the fact that for certain groups an actual increase in sickliness has occurred, i. e. due to increases in average age.

Although an insufficient reporting of incidents of illnesses has occurred, the distribution of incidents between the categories of illness and occupational groups will still be an exception due to a insufficient report caused by a number of these incidents being reported individually attached to certain people (reported nominative).

In total (for all years) illnesses in the muscle- and skeleton system (repeated static work, uncomfortable working position etc.) make up the largest group and amount to half of all incidents reported. Illnesses in sense organ (mostly loss of hearing) are the second largest group with 22 percentages, while skin diseases (eczema caused by exposure to chemicals) represent 17 percentages of all incidents. Loss of hearing was mainly reported summary. This table however does only include individual reported cases (nominative reported cases). For 1993 i. e. nominative reported incidents came to be 78 incidents in loss of hearing compared to 313 summarily reported incidents (NPD, annual report 1993). Summarily reported loss of hearing did also occur in 1992 with 35 incidents. The table therefore shows a systematic insufficient reporting on loss of hearing. The total increase in incidents of illnesses from 1995 to 1996 is mainly caused by the increase in number of reports regarding loss of hearing. This group of illness then has a drastic decline from 1996 to 1997 (from 238 to 51 incidents).

The number of reported muscle- and skeleton diseases has increased a lot, from 45 incidents in 1992 to 390 incidents in 1997, whilst the number of skin diseases has been some reduced. It is difficult to find evidence of change in the pathological picture (apart from hearing diseases though these are due to form of reporting).

Table 10. Reported incidents of illness 1992-1997. Total numbers and percentages.

		Year						Total
		1992	1993	1994	1995	1996	1997	
Muscle and skeleton	Number	45	53	165	270	271	390	1194
	Percent	40.9%	27.9%	49.4%	60.3%	39.5%	63.3%	50.1%
Skin and dermis	Number	29	35	64	76	106	98	408
	Percent	26,4%	18,4%	19,2%	17,0%	15,5%	15,9%	17,1%
Breathing organs	Number	4	10	4	6	17	14	55
	Percent	3,6%	5,3%	1,2%	1,3%	2,5%	2,3%	2,3%
Digestive organs	Number	1			9	8	1	19
	Percent	0,9%			2,0%	1,2%	0,2%	0,8%
Mental disorder	Number	1	4	1	2	6	12	26
	Percent	0.9%	2,1%	0,3%	0,4%	0,9%	1,9%	1,1%
Neural network	Number				2	3	5	10
	Percent				0,4%	0,4%	0,8%	0,4%
Circulation organs	Number			1		1	1	3
	Percent			0,3%		0,1%	0,2%	0,1%
Sense organs	Number	27	78	89	40	238	51	523
	Percent	24,5%	41,1%	26,6%	8,9%	34,7%	8,3%	21,9
Tumours	Number				1	1		2
	Percent				0,2%	0,1%		0,1%
Toxic effects	Number	3	10	6	7	1		27
	Percent	2,7%	5,3%	1,8%	1,6%	0,9%		1,1%
Unspecified conditions	Number			4	35	34	44	117
	Percent			1,2%	7,8%	5,0%	7,1%	4,9%
Total	Number	110	190	334	448	686	616	2384
	Percent	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Table 11 gives an overview over illnesses and occupational groups for all the years as one. Muscle- and skeletons diseases, skin diseases and hearing diseases are the most widespread amongst drilling personnel. In relative numbers, both maintenance personnel and catering personnel are more vulnerable to get muscle- and skeleton diseases than drilling personnel. On the other hand drilling personnel stand for the highest relative part in the group skin diseases and toxic effects.

Table 12 on the other hand indicates an even in number of skin diseases for drilling personnel. The numbers for 1992 were 48 percent compared to 27 percent in 1997. This might indicate that the exposure of drilling fluid, etc. has been reduces during the 1990's.

The development in muscle- and skeleton diseases varies some, due to coincidences. The last three years does however indicate a clear increase in comparing to the three earlier years. This might be an indication in increase in sickliness as well as improved reporting and more focus on this group of illness. There are signs of a reduction in toxic effects. There have been no reported incidents in this group of illness during the last two years.

Table 13 indicates the development of illnesses in total for 1992 – 1997 within various occupational groups. The drilling personnel stand's for 28 percent of all the incidents throughout the period. The section for drilling personnel varies between 20 percent (1993) and 32 percent (1995) during the period, while the share in 1997 were 26 percent. The variation might have been caused by coincidence, weaknesses in reporting etc. Information on rig operations (figure 13) indicates the highest activity in drilling in 1992 and some decline in activity towards 1997. By viewing the numbers as we see them it can be said that the section of incidents of illnesses concerning drilling personnel has increased some, while rig operations on drilling has been somewhat reduced. As the numbers appears, an expectable reduction in sickliness as a consequence of changed technology can not be confirmed. We can not draw a final conclusion due to the number of sources of error related to time analysis of the data. We are viewing percentage and not total numbers. Due to this, it is likely that the effect of the insufficient reporting to some extent will be eliminated. An additional methodical weakness with the data material is that it does not distinguish between installations with or without altered technology and only gives an average for types of installations. The relation between age and sickliness might break out as we operate with data on time series. Increased sickliness as a result of higher age might then reduce a possibly positive effect from new technology.

Although we can not draw any clear conclusion from the numbers, it seems that the relative number of incidents of illnesses in drilling are not reduces during 1992 and 1997. The material is at the same time not adequate to decide whether new technology, under same conditions, leaves basis for less sickliness.

Table 11. Reported incidents of illness by position. Total numbers and percentages.

		CATEGORY group of positions				Total
		1.0 Drilling	2.0 Maintenance	3.0 Catering	4.0 Management	
1,0 Muscle and skeleton	Numbers	274	607	304	9	1194
	Percent	41,3%	48,9%	67,1%	36,0%	50,1%
2,0 Skin and dermis	Numbers	179	169	58	1	407
	Percent	27,0%	13,6%	12,8%	4,0%	17,1%
3,0 Breathing organs	Numbers	17	34	4		55
	Percent	2,6%	2,7%	0,9%		2,3%
4,0 Digestive organs	Numbers	2	15	2		19
	Percent	0,3%	1,2%	0,4%		0,8%
5,0 Mental disorders	Numbers	7	13	4	2	26
	Percent	1,1%	1,0%	0,9%	8,0%	1,1%
6,0 Neural network	Numbers	1	8	1		10
	Percent	0,2%	0,6%	0,2%		0,4%
7,0 Circulation organs	Numbers	1	2			3
	Percent	0,2%	0,2%			0,1%
8,0 Sense organs	Numbers	115	348	50	10	523
	Percent	17,3%	28,0%	11,0%	40,0%	22,0%
9,0 Tumours	Numbers		2			2
	Percent		0,2%			0,1%
10,0 Toxic effects	Numbers	12	12	2	1	27
	Percent	1,8%	1,0%	0,4%	4,0%	1,1%
11,0 Unspecified conditions	Numbers	55	31	28	2	116
	Percent	8,3%	2,5%	6,2%	8,0%	4,9%
Total	Number	663	1241	453	25	2382
	Percent	100,0%	100.0%	100,0%	100,0%	100,0%

Table 12. Reported incidents of illness during 1992 and 1997 – Drilling personnel. Total numbers and percentages.

Drilling

		Year						Total
		1992	1993	1994	1995	1996	1997	
Muscle and skeleton	Number	8	9	38	79	68	72	274
	Percent	29.6%	23.1%	35.8%	55.2%	36.4%	44.7%	41.3%
Skin and dermis	Number	13	14	37	26	45	44	179
	Percent	48.1%	35.9%	34.9%	18.2%	24.1%	27.3%	27.0%
Breathing organs	Number		8	1	2	3	3	17
	Percent		20.5%	0.9%	1.4%	1.6%	1.9%	2.6%
Digestive organs	Number				1	1		2
	Percent				0.7%	0.5%		0.3%
Mental disorder	Number	1		1	1	1	3	7
	Percent	3.7%		0.9%	0.7%	0.5%	1.9%	1.1%
Neural network	Number						1	1
	Percent						0.6%	0.2%
Circulation organs	Number					1		1
	Percent					0.5%		0.2%
Sense organs	Number	3	5	24	12	55	16	115
	Percent	11.1%	12.8%	22.6%	8.4%	29.4%	9.9%	17.3%
Toxic effects	Number	2	3	3	4			12
	Percent	7.4%	7.7%	2.8%	2.8%			1.8%
Unspecified conditions	Number			2	18	13	22	55
	Percent			1.9%	12.6%	7.0%	13.7%	8.3%
Total	Number	27	39	106	143	187	161	663
	Percent	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Table 13. Reported incidents of illness 1992-1997 by various occupational groups.

Category: Position groups		Year 1992	1993	1994	1995	1996	1997	Total
Drilling	Number	27	39	106	143	187	161	663
	Percent	24.5%	20.5%	31.7%	31.9%	27.3%	26.2%	27.8%
Maintenance	Number	64	119	137	201	396	324	1241
	Percent	58.2%	62.6%	41.0%	44.9%	57.7%	52.8%	52.1%
Catering	Number	18	32	89	99	94	121	453
	Percent	16.8%	16.8%	26.2%	22.1%	13.7%	19.7%	19.0%
Management	Number	1		2	5	9	8	25
	Percent	0.9%		0.6%	1.1%	1.3%	1.3%	1.0%
Total	Number	110	190	334	448	686	616	2384
	Percent	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

5 Working environment

We have gathered information about working environment as part of this project. The information is based on interviews and written material from operating companies, drilling contractors and company health services. The contractors we have been in contact with are Odfjell, Transocean, Procon and Smedvig. From the operating companies we have been in contact with drilling section leaders and persons within health- and safety departments.

As a whole, the interviewed persons represent extensive experience from operations in the Northsea. The experiences pass over a long period in time and include manual and remote controlled pipe handling equipment. We also refer to results from a dissertation from NTNU (Haugastøyl 1998). The study is conducted on Ekofisk and maps out experiences gained through the transition from manual to semiautomatic pipe handling equipment on three platforms, EKOX, EKOK and ELDB. A study including a questionnaire has been conducted on how the employees experienced changes when introduced to new equipment. The questionnaire was answered by 40 individuals and equally gave a response rate of 40 percent. Statistic of experience on medical consultations and physical measures has also been collected from the platform.

Apart from the dissertation mentioned earlier, the information in this chapter is mainly supported by subjective evaluations from individuals with particular good knowledge of the conditions.

We will study some parts of the working environment, such as ergonomics, pace of work and stress, noise, sludge treatment/chemicals and safety.

Ergonomics

Muscle- and skeleton torments is the most spread group of illness on the installations and count for almost 40 percent of reported work related illnesses (ref. previous chapters). The informants claim that the transition to remote controlled pipe handling equipment has given quite positive results in ergonomic conditions for the drilling personnel. The remote control has reduced the need for heavy lifting and other nuisance which, over time, leads to wear and tear on the muscle- and skeleton system. This is the case for operations both on drilling floor and transport of pipes from pipe deck to drilling floor.

The interviewed claims that remote controlled technology is the basis for reduced sickliness and enables the employees to serve in their positions in the professional career for a longer time. Older employees will still experience some nuisance due to abrasion with manual systems. It is therefor likely to assume that it will take some time before we can see the effect mechanisation has had on reduced sick leave and less need for medical treatment. Static strain related to automatic equipment can be found in some incidents, but these are conditions that can be fixed according to our informants. One example: A strain injury was registered on a platform because a switch was too heavy and caused infection in an operator’s elbow. The condition could be improved by amendments to drilling chair and switch. Generally, there might be some static strains in the drilling cabin although shaping of the workplace constantly improves, following new equipment on the market. The equipment on the various installations varies on quality and age. New equipment is expected to be of higher quality than older ones. Examples from upgrading (i.e. Veslefrikk A) show that there are problems with new equipment as well. It might be relatively huge variations in the working environment on the various installations, depending on the quality of the equipment. The consequences of changed technology for the working environment are therefore not entirely positive amongst the personnel on the installations.

The Phillip survey indicates that employees themselves experience good working conditions when using automated equipment. The number of consultations related to muscle- and skeleton torments per 1.000 days and nights was reduced during 1990 and 1998. There was a tendency towards an increase in number of consultations with MP's at the introduction of automated equipment, but the number decreased after a while on one of the platforms (EKOX). The results from further two platform's (EKOK and ELDB) show a higher number of consultations when using manual instead of automated equipment.

The conclusion of the working environment related to muscle- and skeleton torments indicates a considerable improvement of remote controlled equipment when compared to manual equipment. Problems in the physical working environment do occur, even with new equipment. It indicates that the chosen technical solutions do not always fulfil the set requirements to working environment. It is important to let HES in on an early planning phase, as a preventive attempt when constructing new equipment.

Pace of work, stress

The transition to remote controlled equipment has created a better situation at work in regards to pace of work, psychosocial conditions and experience of stress according to the interviewed. There is one exception to this opinion. One representative from the occupational health service claims that the transition to remote controlled equipment has only caused more stress reactions.

Automation can not be seen as one isolated factor controlling stress reactions and psychosocial working environment. It is also important to view how the employer and the employee handle changes in external conditions as a result of automation. This will vary in the individual work places.

Operations in drilling floor might take longer time using automated rather than manual pipe handling. The involved parties have agreed to adjust the pace of work on technological frames where new equipment is in use. The persons interviewed claim that this is not a stress factor. A number of the informants do claim that there are far worse problems with stress in manual pipe handling. The automation has resulted in a reduction of crew, which again leaves to more tasks per individual. It does not automatically cause more stress although we can not rule out the possibility that it might.

It is claimed that remote controlled pipe handling result in smoother pace of work and reduced stress reactions over time. The Phillips survey indicates that consultations on psychosocial problems have been low. At the introduction of automated equipment the number has increased some and then decreased. The employees do not see stress as problem at work.

Noise

Remote controlled equipment creates noise. There is some uncertainty amongst the interviewed whether the equipment has improved the level of noise. Some of the interviewed claim that the noise level has gone down a little while others claims that the problems in the working environment are the same as before (using manual equipment). One of the interviewed claims that the remote controlled equipment has not contributed to reduce the noise, rather on contrary. One of the drilling contractors reports that it is difficult to hold the noise level below 85 db on drilling floor. Some of the interviewed claim that the noise level in more modern drilling cabins are securely within the regulations. In other instances, informants claim the noise level does not fulfil the regulations in areas such as drilling cabins, hydraulic rooms and drilling floors. There are considerable differences between new and old drilling cabins, and the noise level will therefore vary, claim informants. Problems with new equipment can be documented e.g. on the Veslefrikk A platform (Veslefrikk had new pipe handling equipment installed in 1997 to meet the regulations set by the Norwegian Petroleum Directorate). A number of the persons interviewed claim that it is harder to reduce the noise level on older installations than on newer ones. This is due to the fact that older installations has old equipment and therefore more difficult to undertake a deafening.

The Phillips survey indicates that a number of the interviewed reported an improvement of the noise level after the transition to semi automated pipe handling equipment (Haugastøyl 1998, p. 24). The physical measures indicated that the exposure of noise are within the requirements for working environment on drilling floor and in drilling cabin, except from one installation. Haugastøyl writes that the noise level is reduced after the transition to automated equipment both by a subjective evaluation and physical measures. The personnel still experience irritating noise in the drilling cabin on the installation.

Ear protection with radio contact has become everyday use and this equipment is therefore commonly used. Where the employees wear ear protection there are little chance of being exposed to damaging noise. Some areas such as mudroom can be problematic. Noise may cause large problems even with ear protection. (These areas where remote controlled technology and are not of current interest.) The exposure to noise also occurs selectively to drilling personnel, which are a particular exposed group.

The reduced exposure to the individual employee caused by less remote controlled equipment is connected with less time spent in noise exposed areas. Ear protection has a favourable effect, regardless equipment, and by using radio communication with ear protection one contribute to higher usage of this protective equipment. Physical noise measures show that it is difficult to considerably lower the noise level in some areas. There is varied experience in terms of noise reduction, especially on drilling floors where the level of health damaging exposure will vary depending on type of equipment.

Sludge treatment/chemicals

Sludge treatment and use of chemicals has particularly caused illness in skin, such as eczema and toxic effects. A number of changes have taken place in this field with positive consequences for the general public health. The use of water based drilling fluid has had a positive effect, equally for the machines used to cut open bags of chemicals and the use of steel tanks for mixing chemicals.

The use of continuously stronger and larger amount of chemicals causes pollution of inner environment. Installations on Statfjord report an increase in number of consultations on skin problems during the last few years, following a falling tendency in first part of the 1990's. Health personnel claim that every fifth consultation relates to skin problems.

The handling of chemicals in drilling operations is a critical area in relation to health.

Safety

The persons interviewed claim that the safety has improved in relation to personal injuries. The transition to remote controlled equipment eliminates several changes to get injured. Falling objects still causes great concern, although the injury statistics show a reduction in this type of injuries. The informants claim there are fewer injuries although the injuries occurring are potentially more serious. Some operating companies report a small decline in number of incidents, including accidents involving personnel injury and close call.

Problems might occur with remote controlled equipment e.g. that the pipe size does not fit the equipment. This creates risk situations. Hydraulic equipment does also create some risk problems during maintenance. The survey performed by Phillips confirms that the safety has improved and the reduction in number of injuries. There has however, been reports of individual incidents and serious close calls during usage of new pipe handling equipment. It can be argued that there are great challenges related to operations involving use of cranes and lifting systems. This might crate risk situations.

The main conclusion is that the safety has been improved when it comes to personnel injuries. New equipment, has however, created situations for new types of injuries and incidents causing risk of personnel injuries. The analysis of injury data, chapter 3, can however not confirm that the injuries have become more severe at the transition to remote controlled equipment.

Other conditions regarding the working environment

Informants from drilling companies are clearly positive in their main conclusion regarding the effect remote controlled equipment has on the working environment. The transition from manual to remote controlled equipment is a great improvement to drilling personnel in regards to working environment. The working environment has been improved in most areas: ergonomic, safety and the organisation of labour. Most of whom we interviewed thinks that new technology has lead to more positive changes in the working environment in relation to illness.

The survey on working environment from Phillips mainly confirms the statements we have collected from service companies and operators. A statement from one informant does however lead in opposite direction. The person concerned claims that the automation has given only a small profit in relation to sickliness and emphasises that psychosocial factors, stress and depressions is a large and continued part of the sickliness. Organising conditions, psychosocial torments and stress have however been an underestimated factor in the working environments, and are therefore rarely seen in statistic sources. Working time arrangements might cause problems for some, i.e. 12 hours night shift might lead to problems sleeping and result in a high consumption of sleeping medicine.

There are varied experiences in areas with noise. The Phillips survey indicates a favourable development in this area, but statements from informants indicates that noise problems still exist and that the new equipment has not reduced the noise level.

Informants claim that there is greater understanding of HES on installations lately, making it much easier to raise subjects compared to a few years ago. It also makes it easier to correct errors and faults.

Training is an important factor for new equipment to have full effect on working environment and safety during installation. Some drilling companies report the need for a long running-in and training period during transition to new equipment. It is claimed that working environment problems increases during such periods, but will be reduced over time.

Example: On an installation with automated equipment the personnel no longer have physical contact during drilling operations. The working day is totally changed with personnel away from the floor and instead in positions as operators. The steering is handled by screen. The employees struggle with getting to grips with the system and feel insecure about steering by screen.

A number of the interviewed underlines the importance of training on new equipment as early as possible, to gain a positive effect of the equipment.

New, automated equipment has a long running-in period, approximately one year. New equipment is often prototypes, which often causes problems, so it is not uncommon to send it back to the contractor for adjustments. It creates uncertainty and a larger number of the employees do not have experience in handling manual equipment. Informants claim that in such instances, incidentally worsening of the working environment is registered.

Problems occur when one needs to grant an exemption from a regulation and return to manual equipment. Examples of diverge is 3 days exemptions due to equipment braking. Long exemptions of 1 year or more does occur, even on new rigs. Personnel have to work amongst heavy equipment and dangerous situations might occur during the period of divergence. One of the safety deputies is concerned that The Norwegian Petroleum Directorate's require few arguments from the operating companies to grant an exemption.

Maintenance of new equipment can be difficult and cause health- and safety problems. Here the quality of the equipment is important. It is important to pay attention to HMS requirements when constructing equipment for remote control.

Informants have also made comments about problems with technical upgrading of old rigs. The opinion here is that old rigs are not constructed for remote controlled equipment and therefore gives no profit in relation to safety and working environment. No separate analysis has been carried out in injury occurrence on new constructions with remote controlled pipe handling equipment installed during the building process and existing installations that are upgraded with remote controlled pipe-handling system. The report does not give specific information about the profit gained by upgrading existing rigs compared to new rigs. It must however be stated that a large number of the installations in operation are upgraded. The observed reduction in sequences of injury and the evaluations of the working environment referred to in this report are mostly based on statistics and experiences from older, upgraded installations.

5.1 Conclusion

From an overall evaluation, most representatives from the drilling companies and drilling contractors believe there has been a very positive development in working environment and health after the transition to automated equipment. Important challenges in remote controlled systems are: safety in relation to crane operations and handling of chemicals and noise problems.

Great many informants claim that there are positive changes in **attitudes** about safety and working environment. This is a major factor when evaluating causes to improved working environment. The overall improvement in the working environment is therefore a consequence of both changes in attitude towards the working environment and safety, increased supervising of routines etc. and transition to new equipment.

The main conclusion is that when the quality of the equipment is good, remote controlled pipe handling equipment contributes to create a better working environment, health and safety. The actual consequences (for HMS) of new equipment will therefore vary depending on quality, which operations that are modernised and the operation regularity of the equipment.

6 Conclusion

The main object of this report has been to analyse developing trends in personnel safety, working environment and health on drilling deck, drilling rig and pipe deck caused by remote controlled pipe handling. A major approach is whether new technology for pipe handling has had a positive impact on the employee's health and safety. Development trends in terms of injuries have been analysed on basis from a database on injuries from RF and NPD. The data related to illnesses of occupational conditions are not completed to indicate an accurate documentation about the development. The information NPD's database on illness indicates the extent of various groups of illness; though it is unsteady for use in a trend analysis, due to change in the company routines for reporting. The information about the working environment related to the introduction of new technology has been collected through interviews of people with long experience and practice from the oil industry.

The various sources of information put together create enough bases to draw a few conclusions. The frequency of injuries indicates an evident reduction during 1980 and 1990, especially on drilling floor. This is in connection to the drilling regulations of 1981, which requires equipment changes on drilling floor, but not on pipe deck. Data indicates that technological changes have had a probable effect on the frequency of personal injuries. Data indicates a reduction in incidence of pipe handling injuries during 1991 and 1997. There are no significant changes for other types of injuries during the period (ref. figures 15 and 16). This indicates that new equipment has effect on the extent of injuries.

There has been a reduction in number of injuries, which may have been caused by new equipment, but also by changes in type of drilling operations. We have not managed to reduce injuries caused by traffic on deck etc. A significant finding is that the number of sever injuries has been reduced. Over time there has been a shift in number of injuries amongst various professions. The injury incidence amongst drilling personnel has been reduced but has risen for all other personnel. It is not possible to conclude that this is caused by change of equipment (ref. figures 12 and 13).

The separate descriptions of injuries related to new equipment do not indicate many injuries compared to manual equipment in similar operations.

There are frequent incidences of equipment failure with new equipment and it can not always handle every pipe dimensions and type of pipes. There are still a number of manual operations, which creates risk situations. It is critical to handle this and therefore remove all manual operations. High requirements are set on the reliability of new equipment. Experience shows that new equipment does not always fulfil the expectations and that and that on some occasions need longer running-in period to work properly. It is also important to remove personnel from areas where they might get hit by equipment or pipes.

The databases on work related illnesses are related to sources of error. It is therefore difficult to draw correct conclusions regarding sickness incidents in relation to new equipment. Information about the working environment shows that the probability for development of illnesses caused by improved ergonomic conditions has been reduced by new equipment. There are large similarities in evaluations amongst the informants on this point. We can expect a decline in muscle- and skeleton torments in years to come, although it is uncertain what statistical effects it will give. The sickliness is influenced by a number of circumstances. The employee's health condition may have been influenced by working on oil platform's, with manual equipment over a long period of time. It is likely to say that there is a generation effect in relation to sickliness. Employees that have only worked with remote controlled equipment should be able to go through a longer employed period without torments that needs medical attention. Others should also be able to work for longer than they normally would. Statements from informants indicate that this is the case.

Information on torments caused by noise does not give a clear picture. The report from Phillips indicates that damaging noise has been reduced at the introduction of remote controlled equipment. Most of the informants we have been in contact with from drilling companies and drilling contractors strongly doubt that the noise conditions have improved due to new equipment. Our impression is that noise still is a problem area although the use of ear protection will prevent noise pollution for each individual. On the basis of information on the working environment we claim that the reduction of noise still is an area in need for improvements.

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Appendix A)

Index A1. All injuries 1980-1990. Injuries per. 1000 days and nights in operation

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Fixed	44,35	41,59	28,66	29,05	32,3	24,3	25,13	24,19	24,92	21,41	20,92
Mobile	45,41	37,36	34,75	27,8	33,15	28,61	44,95	30,28	31,47	17,49	24,66
Total	44,93	39	32,17	28,38	32,78	26,68	35,09	26,74	27,32	19,97	22,57

Index A2. All injuries 1991-1997. Injuries per 1 million working hours

	1991	1992	1993	1994	1995	1996	1997
Fixed	27,7	19,9	17,2	19	18,4	16,9	17,7
Mobile	35,9	34,2	38	35,9	36,2	37,9	37,1
Total	30,8	24,9	24	23,9	22,9	24,5	25,3

Index A3. Injuries in drilling vs. Industry total. Injuries pr 1 million arbeidstimer.

	1991	1992	1993	1994	1995	1996	1997
Drilling	30,80	24,91	23,97	23,91	22,87	24,50	25,28
Total	27,56	27,23	26,37	26,58	27,91	28,34	27,62

(1) Indexl A4. Injuries per. 1000 days and nights in operation drilling according to location

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Drill floor	27,44	23,16	20,04	17,29	18,89	13,41	18,07	14,04	14,87	12,33	12,84
Derrick	4,80	3,52	3,54	2,07	2,97	1,88	2,26	1,67	3,04	1,47	2,62
Main deck/pipe deck	12,69	12,31	8,59	9,02	10,93	11,40	14,76	11,03	9,41	6,17	7,11
Total	44,93	39,00	32,17	28,38	32,78	26,68	35,09	26,74	27,32	19,97	22,57

Index A5. Injuries per million working hours according to location on board 1991-1997

	1991	1992	1993	1994	1995	1996	1997
Drill floor	100	70	90	90	65	95	98
Derrick	16	10	13	9	11	12	18
Main deck/Pipe de	63	65	47	45	66	74	87
Total	179	145	150	144	142	181	203

Index A6. Number of injuries 1991-1997 according to occupational groups

	1991	1992	1993	1994	1995	1996	1997
Other	5	9	9	7	12	13	12
Drilling	141	112	116	111	104	122	149
Well service	18	16	16	11	12	24	24
Maintenance/techr	15	8	9	15	15	22	19

Index A6.1. Injuries for all occupational groups 1991 to 1997

	1991	1992	1993	1994	1995	1996	1997	Total
Roughneck	69	60	58	59	48	65	80	439
Roustabout	27	22	22	19	20	17	20	147
Dekksarbeider* **	4	4	2	9	6	7	21	53
Operator	6	3	4	6	3	13	5	40
Fitter/Rigger	3	5	5	1	7	6	9	36
Assistant driller	8	4	4	4	4	7	4	35
Derrickman	5	8	4	5	6	2	5	35
Driller	5		9	5	3	4	2	28
Assistent rigger	8	5	4	2	3	2	4	28
Work supervisor	1	2	4	3	4	5	4	23
Assistant derrickman	3	3	4	2	2	7	2	23
Service technician	5	4	5			3	4	21
Crane operator		4	4	3	3	3	3	20
Electrician	2	2	2	3	1	2	4	16
Engineer	3		1	1	3	1	7	16
Mechanic	1	1	1	3	2	4	4	16
Welder	3	1	3	6		1	2	16
Cable operator	1	4	3	2	3		1	14
Rig mechanic	2		1	1	3	4	3	14
Assistant roughneck	2	1	3	2	2	3		13
Well service technician		2		1		5	4	12
Toolpusher	2			1	2	2	1	8
Well cementer		2			2	1	2	7
Mud engineer	1	1			2	1	2	7
Hydraulic technician				1	1	3	1	6
Drilling Foreman			1	2	1		1	5
Drilling engineer	2		2				1	5
Well tester		1	1	1	1	1		5
Materials administrator	1	1			1	1	1	5
Painter	2			1	1			4
Offshore worker'''	2					2		4
Scaffolding worker		1			1	2		4
Technician					2	2		4
Sub-sea engineer		2			1		1	4
Maintenance foreman	1				1	1	1	4
Drilling supervisor	3							3
Works manager	2		1					3
Metal worker	1				1		1	3
Assitant toolpusher	2							2
Electrician'''		1					1	2
Plumber					1		1	2
Unclassified					1	1		2
Company nurse							1	1
Deck personnel	1							1
Managing engineer						1		1
Electro work* **			1					1
Flag man					1			1
Inspector				1				1
Instrumental technician		1						1
Control room operator							1	1
Apprentice UNA* **			1					1
Motor man						1		1
Petroleum engineer	1							1
Technical assistent						1		1
Grand Total	179	145	150	144	143	181	204	1146

Index 7. Rig activity 1991 til 1997

	1991	1992	1993	1994	1995	1996	1997
Drilling	5343	5334	5360	4849	4221	4919	5593
Completion	825	1265	1520	1293	1047	1173	1214
Formation evaluation	1408	1193	1035	930	849	1038	1124
Disruption	1755	1531	1707	1714	1759	2199	2798
Plug&abandon	419	396	534	684	462	440	550
Workover	1379	1060	1654	1722	2738	3088	3683
Dummy	101	244	585	448	548	299	599

Index 8. Pipe handling injuries per. 1 million working hours 1991 to 1997.

	1991	1992	1993	1994	1995	1996	1997
Other	16,00	14,43	11,17	12,29	13,59	14,64	15,37
Pipe handling injuries	14,80	10,48	13,12	11,62	9,27	10,13	9,91