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HEALTH & SAFETY LABORATORY

Underlying Causes of Offshore Incidents

FP/09/21

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EXECUTIVE SUMMARY

Objectives

Offshore Safety Division (OSD) is committed to providing the Offshore Industry Advisory Committee (OIAC) with an analysis of the causes of offshore incidents. To achieve this, the underlying causes of offshore incidents (fatalities, major injuries and major dangerous occurrences) were identified using OSD Inspection Management Teams (IMT) inspectors' investigation reports supplied to the Health and Safety Laboratory (HSL) by OSD. The project objectives were to:

- identify as far as possible the underlying causes of offshore incidents resulting in fatalities, major injuries and (time permitting) major dangerous occurrences - over the period 2004 to 2008 and determine any trends that may emerge; and

- use the existing work done by HSL for Offshore Division on Hydrocarbon Releases (HCR) and Key Programme 3 (Asset Integrity Programme) to see if they can provide any other information on underlying causes.

Main Findings

1) A sample of 67 offshore incidents involving fatalities and major injuries has been analysed using both investigation reports and RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations) reports. These incidents resulted in 5 fatalities and 62 major injuries. By far the most predominant injury type was fractures. Younger workers seem to be involved in fewer incidents than older age groups. The injured party was more likely to work for a contractor (42 individuals) rather than the installation operator (25 individuals).

2) The most common kinds of accidents were (in order of importance):
- Hit by moving, flying or falling object (mostly impact from dropped object);
- Injured while handling, lifting or carrying;
- Falls from height; and
- Slips trips and falls on the same level.

3) The most important underlying causes of accidents were (in order of importance):
- Inadequate hazard analysis / risk assessment;
- Inadequate supervision;
- Lack of / inadequate operating procedures; and
- Inadequacies in permit-to-work.

4) As might be expected, the work process environment and grouping of RIDDOR defined agents involved in the incidents correlated with the kind of accident:
- Hit by moving, flying or falling object was associated with offshore production, construction and maintenance and with the agents of lifting and storage (hit by object free falling from lifting machinery).
- Falls from height and slips, trips and falls at the same level were associated with offshore construction, maintenance, deck operations and transport and the main agent was surfaces at different levels.
- Injured while handling, lifting or carrying was mainly associated with offshore drilling / workover and the agent of building materials and components.

5) The main underlying causes associated with the main kinds of accident were:

- Operating procedures for ‘hit by moving, flying or falling object’;
- Permit-to-work for ‘fall from height’;
- Permit-to-work for ‘injured while handling, lifting or carrying’; and
- ‘Unknown’ for ‘slipped tripped or fell at the same level’.

In addition supervision was implicated for the agents ‘surfaces at different levels’ and ‘lifting and storage’, which were associated with slips, trips and falls and with being hit by falling objects.

6) The main identified safety management failings were in monitoring, audit and review and planning and implementation. In terms of failings associated with the main kinds of accident:

- Hit by moving, flying or falling object was due to poor monitoring; and planning and implementation;
- Falls from height were due to poor monitoring; and
- For slips, trips and falls at the same level and injured while handling, lifting or carrying, the management failing was usually unknown.

7) The main health and safety regulations referred to in investigation of incidents were LOLER (Lifting Operations and Lifting Equipment Regulations) and MHSWR (Management of Health and Safety at Work Regulations).

8) Consideration of previous causal analysis of offshore incidents confirmed the current analysis and adds the additional underlying causes and Safety Management System (SMS) failings:

- Human factors including distractions, stress and culture for slips, trips and falls;
- Operator error and poor positioning for lifting incidents;
- Poor communication was an underlying cause of hydrocarbon releases in addition to all the underlying causes found in the current analysis; and
- Backlogs and deferrals in the maintenance of Safety Critical Elements (SCEs) were highlighted by the analysis of the Key Programme 3 (Asset Integrity Programme) and indicate underlying management system failures.

Recommendations

1) Targeted inspection activity is needed on the following issues:

- Falls from height – Permit to work, monitoring;

- Injured whilst handling, lifting or carrying – Permit to work, supervision, audit and review, reference to MHSWR (Management of Health and Safety at Work Regulations); and

- Hit by moving, flying or falling object. – Operating procedures, monitoring, planning and implementation, use of LOLER (Lifting Operations and Lifting Equipment Regulations) and MHSWR.

2) Further work could usefully be undertaken to improve understanding in the following areas:

- Slipped, tripped or fell - Underlying causes are often unknown, health and safety management failings are often unknown, there is little reference to regulations and guidance.

- Injured while handling, lifting or carrying – Sometimes no reference to guidance or regulations.

3) Underlying causal analysis using both RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations) and HSE (Health and Safety Executive) Inspectors' reports could usefully be undertaken for major offshore dangerous occurrences.

1 INTRODUCTION

Offshore Safety Division (OSD) is committed to providing the Offshore Industry Advisory Committee (OIAC) with an analysis of the causes of offshore incidents. To achieve this, the underlying causes of offshore incidents (fatalities, major injuries and major dangerous occurrences) were identified using OSD Inspection Management Teams (IMT) inspectors investigation reports supplied to the Health and Safety Laboratory (HSL) by OSD. The project objectives were to:

- identify as far as possible the underlying causes of offshore incidents resulting in fatalities, major injuries and (time permitting) major dangerous occurrences - over the period 2004 to 2008 and determine any trends that may emerge; and

- use the existing work done by HSL for Offshore Division on Hydrocarbon Releases (HCR) and Key Programme 3 (Asset Integrity Programme) to see if they can provide any other information on underlying causes.

Given the time and resources available, only offshore fatalities and major injuries have been investigated. Underlying causes of major dangerous occurrences (including HCRs) can be done separately if required.

Investigation reports were available for 67 of the offshore incidents, involving fatalities and major injuries, which occurred over the period 2004-2008. Information on these 67 incidents was available from two sources: the RIDDOR [31] reports (supplied by the offshore operators) and HSE Inspectors' Investigation Reports. The RIDDOR reports include records of: Injury Type, Injury Location, Kind of Accident, Operating Company, Agent and Work Process Environment. The inspectors reports were searched and any information on Direct Causes, Underlying Causes, Regulation / Guidance mentioned and Health and Safety Management System Failing was recorded. Therefore as well as highlighting major issues in offshore incidents identified from RIDDOR and inspection reports, cross–referencing of data was possible.

The report also includes comparison with KP3, HCR and HSE Offshore Annual Accidents Reports. Relevant Guidance is discussed: OSD-specific, LOLER, PUWER, MHSWR and HSWA. Human factors issues are also commented on.

2 RIDDOR DATA

Appendix D gives the following information on the 67 incidents – number of major injuries, number of fatalities, calendar year of incident, age of injured party, and injured party - employee status (worked for a contractor or worked for the installation operator). These incidents resulted in 5 fatalities and 62 major injuries. Younger workers seem to be involved in fewer incidents than older age groups (11 individuals came from the 21-30 age group, 18 from the 31-40 age group, 17 from the 41-50 age group and 15 from the 51-60 age group). The injured party was more likely to work for a contractor (42 individuals) rather than the installation operator (25 individuals).

2.1 INJURY TYPES

Figure 1 shows the injury types for the 67 incidents considered. Fracture is the largest injury type with over 40 cases. None of the other injury types show more than six cases. The incident data on fracture injury types will go forward to a detailed comparison with other data in section 4.

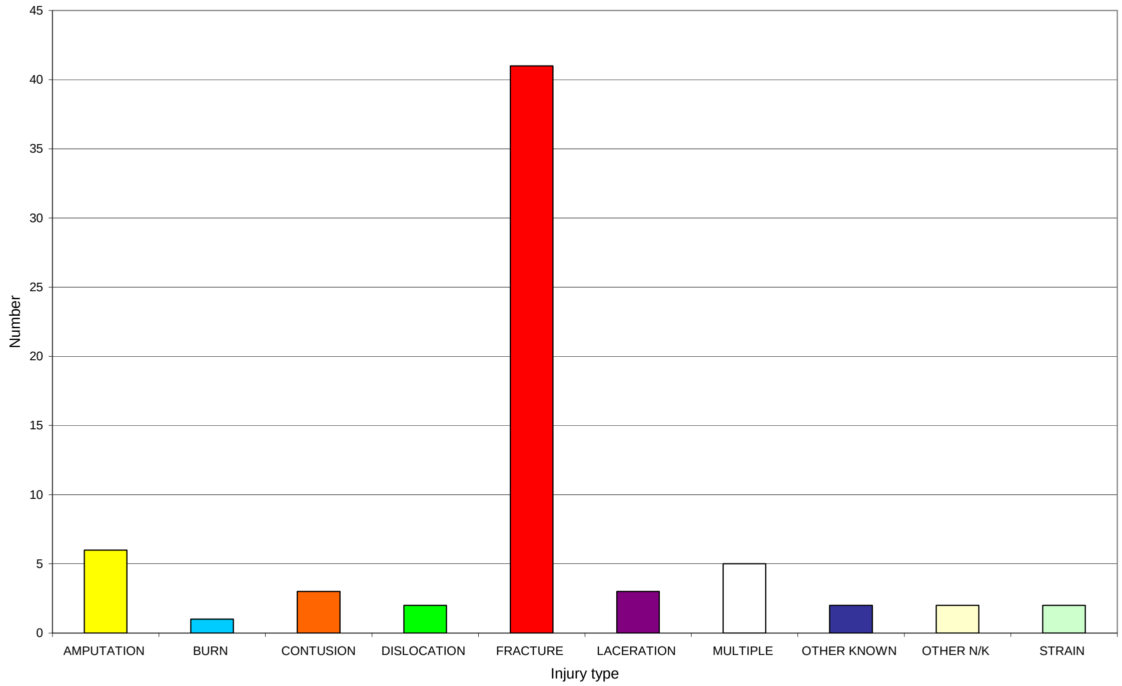


Figure 1 Injury types

2.2 INJURY LOCATION

Figure 2 shows the injury location for the 67 incidents considered. There is more variation in the injury location than the injury type. Injury location was not selected to go forward for the detailed comparisons in section 4.

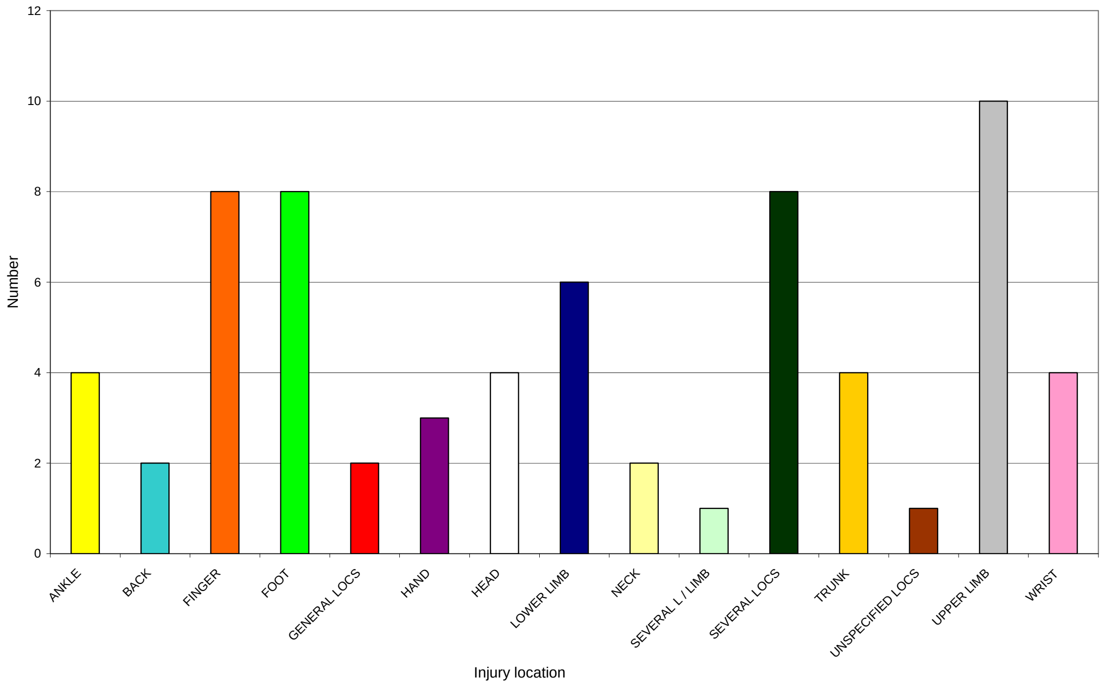


Figure 2 Injury location

2.3 KIND OF ACCIDENT

Information is recorded in RIDDOR on the kind of accident, using a large number of categories. The kind of accident can easily be grouped into a number of condensed categories, which are generally similar to the actual response provided. Figure 3 shows the kind of accident, using these condensed categories for the 67 incidents considered. Hit by moving, flying or falling object is the dominant kind of accident with over 20 cases. Falling from a height, Injured while handling lifting or carrying and Slipped, tripped or fell on the same level also show some prominence. The four kinds of accidents data mentioned here will go forward to a detailed comparison with other data in section 4.

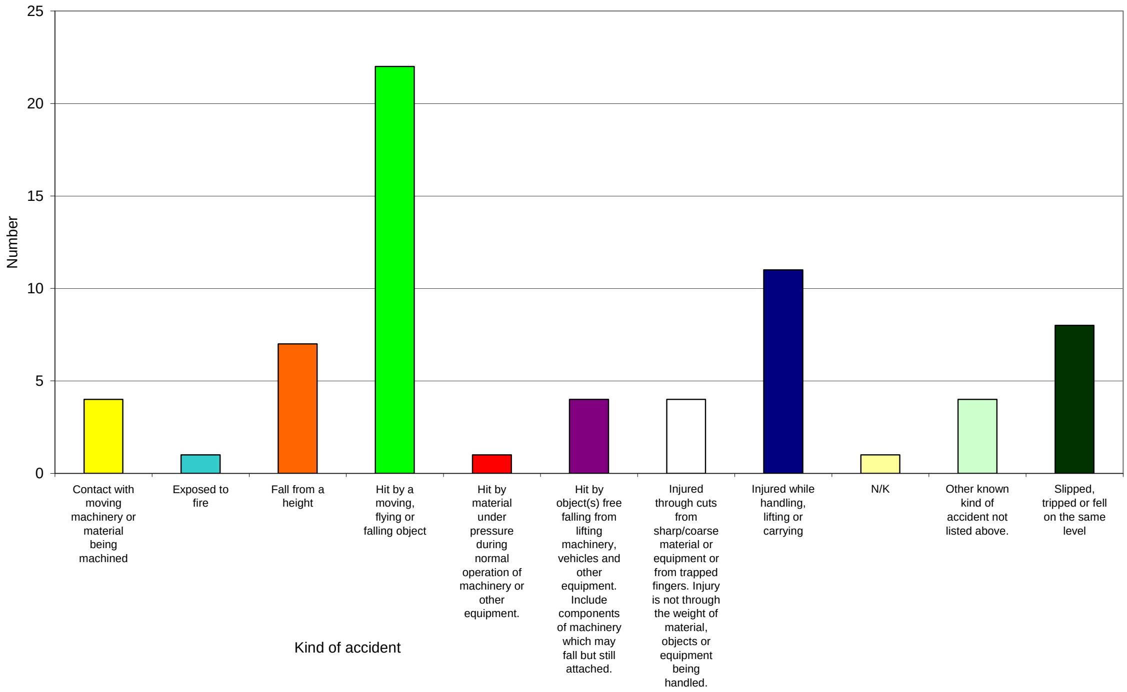


Figure 3 Kind of accident

2.4 OPERATING COMPANIES

Figure 4 shows in anonymous way, the offshore operating company involved in the 67 incidents. Three companies seem to have many incidents (FL, EY and HS with seven to eight incidents). Operating companies were not selected to go forward for the detailed comparisons in section 4. Normalisation of this data is necessary to take account of the number of installations each company has and the total number of people (direct staff and contractors) working on all the company's installations.

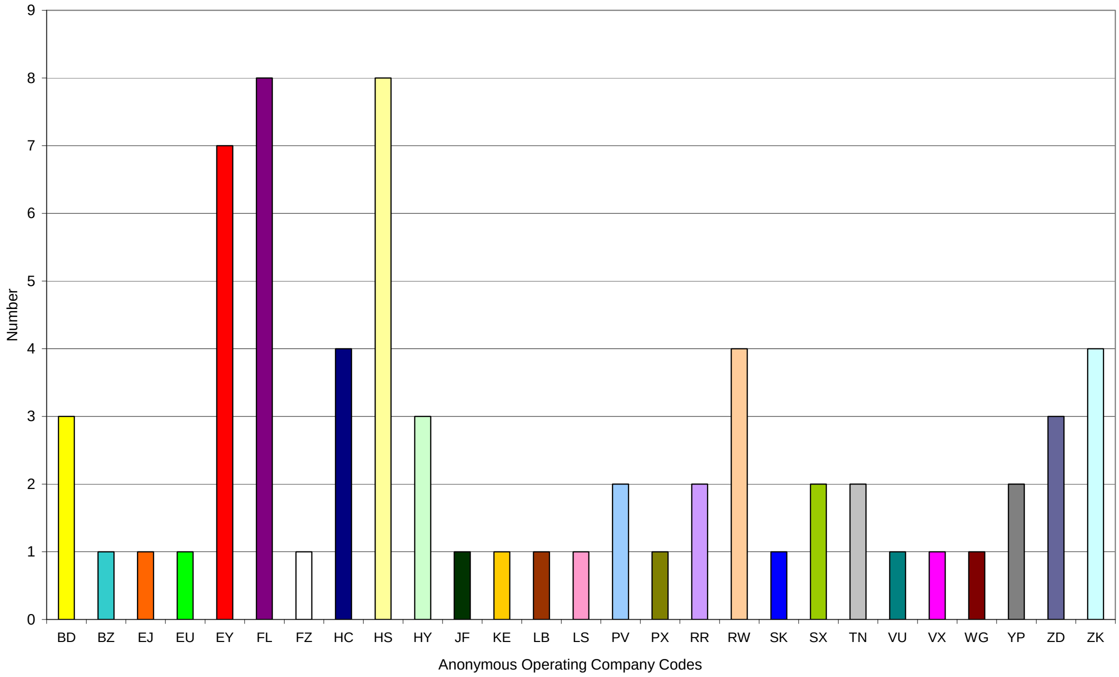


Figure 4 Operating companies

2.5 GROUPED AGENTS

Information is recorded in RIDDOR on the agent involved in the incident, using a large number of categories. The agent can easily be grouped into a number of categories using the first number in the classification. Figure 21 in Appendix C (section 11) shows the agents and how they are grouped together. Figure 5 shows the various agent groupings for the 67 incidents. Five of the agent groupings shown seem to be significant and this data will go forward to a detailed comparison with other data in section 4. The significant five agent groupings are:

- Surfaces at different levels: floors ladders, scaffolding;
- Pipes and pipe Fittings;
- Lifting and storage;
- Tools and machines; and
- Building materials and components.

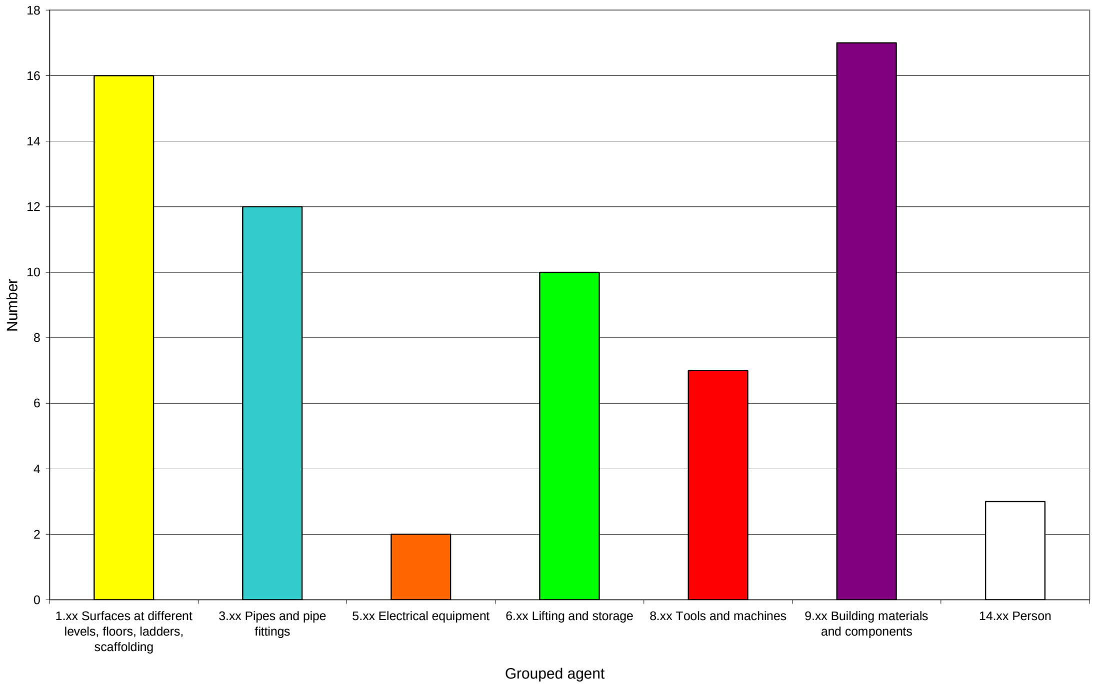


Figure 5 Grouped agents

2.6 WORK PROCESS – ENVIRONMENT

Figure 6 shows the work process carried out in the environment where the incident occurred. Offshore construction and maintenance (code 1814) and Offshore production (code 1811) with 20 and over cases would seem to the worst working environment. Offshore drilling (code 1812) and Offshore deck operations (code 1818) also significant cases. Data for the four working environments mentioned here will go forward to a detailed comparison with other data in section 4. Normalisation of this data is necessary to take account of the number of people working in each work process environment.

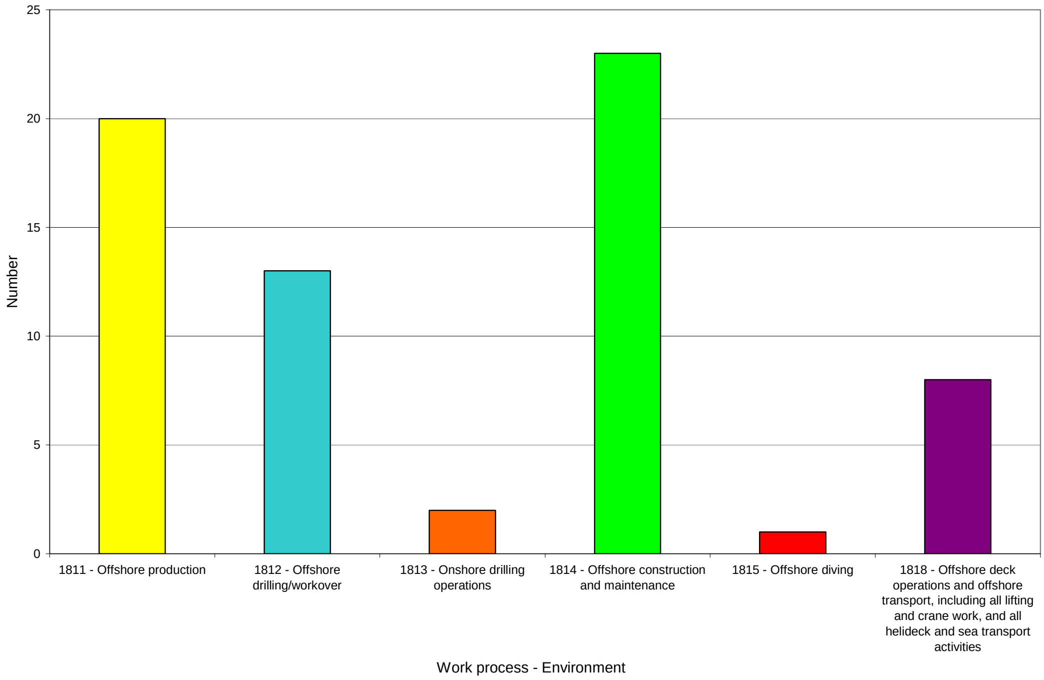


Figure 6 Work process – Environment

3 INVESTIGATION REPORT DATA

3.1 INVESTIGATION REPORTS

The HSE Inspectors' investigation reports for the 67 incidents were studied carefully and information on direct causes, underlying causes, health and safety management failings and regulations/guidance identified by the inspector was noted. The categories used for both sets of causes and the failings were the same as SPC/Enforcement/132 [30]. If more than one cause, failing or regulation was noted, it was recorded. One limitation of some incident analysis recording systems is that only one cause or failing may be selected. Examples of incidents are provided with the same incident sometimes used to illustrate more than issue.

3.2 DIRECT CAUSES

Figure 7 shows the direct causes contributing to the 67 incidents. Impact/dropped objects is the most significant direct cause with nearly 30 cases. The incident data on impact/dropped objects will go forward to a detailed comparison with other data in section 4. Examples of incidents involving this direct cause are provided below.

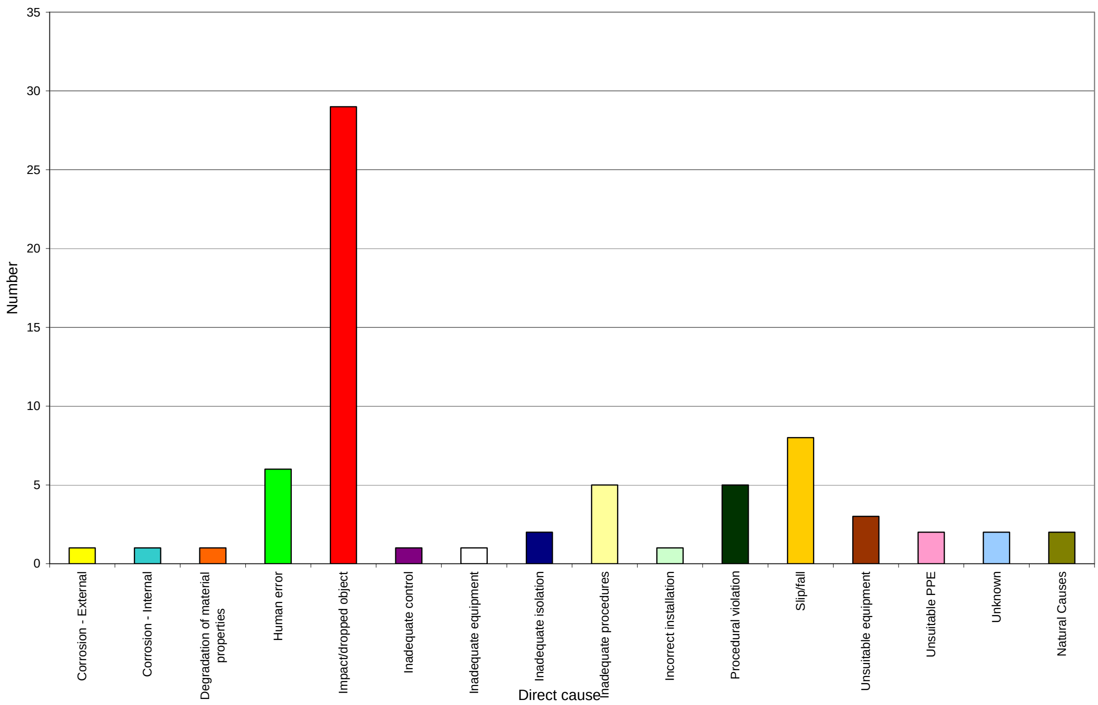


Figure 7 Direct causes

3.2.1 Examples of incidents involving impact/dropped object as a direct cause

- The IP was guiding a suspended load when part of it slipped and hit him on the foot, the resulting injury required parts of two toes to be amputated.

- A suspended load was being manoeuvred through a gap between handrails and the IP pushed the load with his foot. The load moved suddenly and trapped the IP's ankle against the handrail.

- A scaffolder knocked an old bolt through the grating deck while he was working in an area directly above the IP. The bolt hit the IP on the neck, fracturing a vertebra.

- Four workers including the IP were sliding a 'skidding claw' and because of the way the IP was holding the claw, one of his hands was trapped under it. The IP should not have had his hand in the position he did, and sustained tendon damage.

- The IPs were working in an oil tank while some shackles and clamps were being lifted out of the tank using an air hoist. They had no way of telling whether the equipment had been fully lifted out of the hatch on the top of the tank, other than looking up. The IPs thought that the load had been safely removed through the tank hatch and resumed their work, but four angle clamps and a shackle fell back into the tank. One IP was fatally injured; the other received a laceration on his arm.

3.3 UNDERLYING CAUSES

Figure 8 shows the underlying causes contributing to the 67 incidents. Hazard Analysis/Risk Assessment problems are the most significant underlying cause with nearly 40 cases. Problems with Operating Procedures, Permit to Work and Supervision are also significant underlying causes. The incident data on all four underlying causes mentioned here will go forward to a detailed comparison with other data in section 4. Examples of incidents involving these four significant underlying causes are provided below.

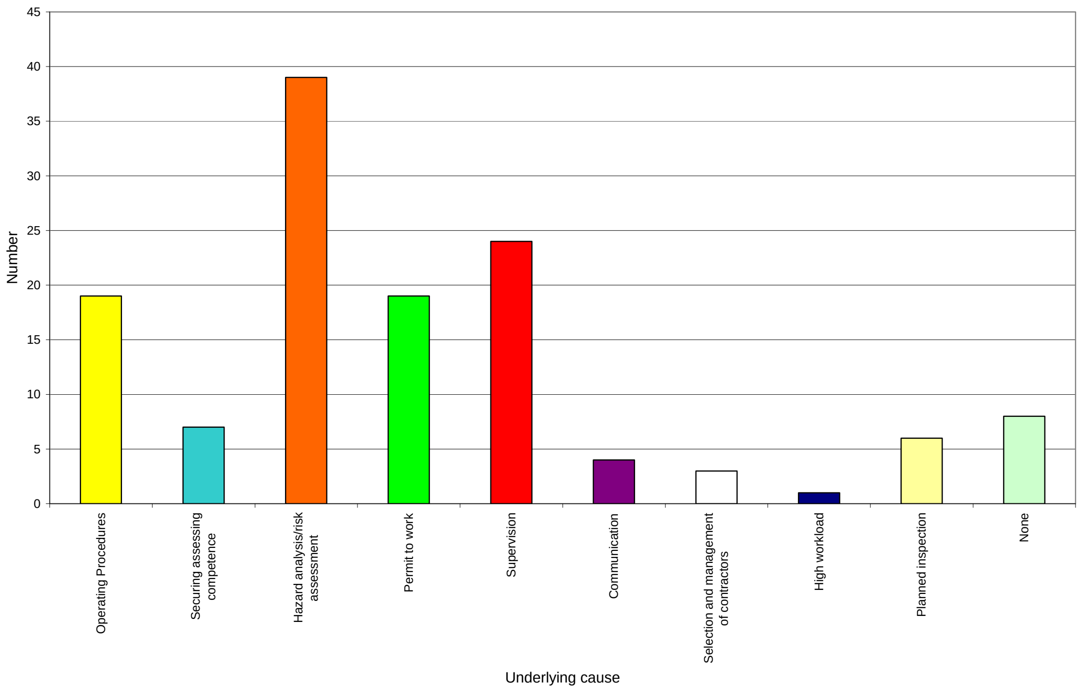


Figure 8 Underlying causes

3.3.1 Examples of incidents involving significant underlying causes

- Operating Procedures

    - The IP entered an area between a suspended load, which was being moved, and a 'Samson post' in order to retrieve a tag line (that was no longer being used) from the load. The load moved suddenly and crushed the IP's hand against the Samson post. The IP entered the area in which the load was being handled against procedures and, as a result of the incident, the duty holder carried out a refresher training course to reinforce the lifting procedures.

    - A 15 tonne section of a wind turbine was being craned into position when it swung and stuck the IP, who was part of a team of three that was guiding the load. The lifting procedures in place were insufficient to prevent this injury; the IP should not have been allowed to work in a position where he could have been struck by the suspended load.

    - A new wire/rope was being fitted to a crane and the IP was helping to pass it through a sheave. The wire became jammed and the IP freed it with his foot, but it jammed a second time. As the IP was attempting to free the wire with his hand, the wire freed itself and the IP's hand got caught in the sheave. It was found that the permit to work for this wire-fitting task was issued without a detailed procedure. If there had been a proper procedure in place, different sheaves would have been used and the rope would not have snagged so easily.

- Hazard analysis/risk assessment

    - A length of drilling wire (35 m long, 225 kg) was being lifted into a scrap skip. The wire slipped out of its sling while suspended by crane and fell overboard, hitting the IP on its way. Lifting the drilling wire was not discussed in advance, hence there was no risk assessment in place, nor was there a toolbox talk, and the method used was poor practice. A specific risk assessment should have identified a safe method of lifting the drilling wire.

    - An anchor chain was lost overboard on a semi-submersible installation. During the recovery of the chain, part of the winch being used had to be removed in order to wrap a wire around it. Whilst the OIM was arranging the removal of this winch component, the deck crew decided to carry on with the chain recovery using different equipment. Part of this equipment, a reel, fell over and rolled, pinning the IP against a stanchion. There was a lack of awareness of the hazards involved with the task, due to a lack of a sufficient risk assessment.

    - A pump was being moved for maintenance; when it was lifted it swung and hit the IP. The lift was not a routine job, as the pump had been laid in a skewed manner instead of flat, resulting in the lifting hoist remaining under constant tension. This change to a routine job was not risk assessed and the hazards involved were therefore not fully appreciated by the working party.

    - Part of a beam crane (the trolley) fell, having been hit by another trolley, and struck the IP on his hard hat. The trolley fell because it was not designed for use on that beam, so the end-stops on the beam were too wide. The use of different trolleys was not subject to a risk assessment process.

- The IP was fatally injured when a mandrel weighing approximately 270 kg fell on him. There was no permit to work issued for the lifting operation taking place at the time of the incident, therefore there was no risk assessment. A risk assessment would have identified the hazards and risks involved in this task and defined appropriate control measures, which may have prevented the fatality.

- Permit to work

    - The IP and his immediate manager were on separate adjacent ladders removing some piping. The manager had a harness but the IP did not, and during the course of the job the IP fell from the ladder, breaking several bones. The removal of this piping was not part of the original work so there was no permit to work, hence the hazards involved in the task were not adequately assessed.

    - The IP was replacing stair treads when he fell six metres though a gap made by removing two treads, sustaining fatal injuries. There was a permit to work for the job which stipulated that one tread should be removed at a time, however this was not backed up by a risk assessment. The risk of falling through or down the stairs was not identified in the permit to work, and the permit to work system was not well understood by the offshore personnel.

    - During maintenance work on an actuated valve the IP was required to loosen bolts, which involved leaning underneath the valve. As the bolts on the valve were loosened, the weight of the valve was such that it rotated and the actuator struck the IP, trapping him and causing fractured vertebrae. The permit to work system on this installation was insufficient given that all work in a specific area was covered by one permit rather than having a separate permit for each task.

- Supervision

    - The task being carried out by the deck crew involved rolling heavy drill pipes across the deck onto a wooden dunnage. The supervisor of the task untied the drill pipes, allowing them to roll, and one hit the IP's foot. The IP was not part of the team involved in the task, and had been involved in a cleaning job nearby when he decided to help. The supervisor should really have been supervising the task rather than participating in it, as this would have enabled him to prevent the IP entering an unsafe area.

    - The bolts were removed from an actuator but it was not supported on slings as it should have been, according to the permit to work. The IP and his colleague expected the actuator to be seized on and that it therefore would not fall off, however it fell and injured the IP's arm. The supervisor was not present at the start of the work, which could have prevented the incident.

    - The IP was repairing a pump which had not been isolated and drained properly, so as bolts were slackened, high pressure fluid was released, causing fatal injuries. This occurred as a result of the mechanical isolation procedure for the pump not being supervised adequately.

    - A crane was being used to move bundles of drill collars, and when one of the bundles was raised it moved across the deck and struck the IP, causing a fractured hip. The IP was not involved in that part of the lifting operation and was leaving the area at the time of the incident. Both the banksman, who was directing the load, and the crane driver failed to supervise the lift effectively, one or other should have ensured that the IP was not in a dangerous position before commencing the lift.

◦ Two workers were unbolting flanges on what they thought was an empty pipe when there was a release of approximately 270 kg of flammable and explosive gas. They had unbolted the wrong pipe, and the pressurised gas caused injuries to both workers: tissue damage and a broken finger. The supervision of the task was poor, for example an opportunity to stop the task when the permit to work was violated was not taken.

3.4 HEALTH AND SAFETY MANAGEMENT FAILINGS

Figure 9 shows the Health and Safety management failings identified for the 67 incidents. Monitoring is the most significant identified failing with over 20 cases. Audit and Review and Planning and Implementation are also significant failings. The incident data on all three failings mentioned here will go forward to a detailed comparison with other data in section 4. Examples of incidents involving these three significant failings are provided below. None indicates there was no Health and Safety management failing whereas Unknown indicates that the failing was unknown.

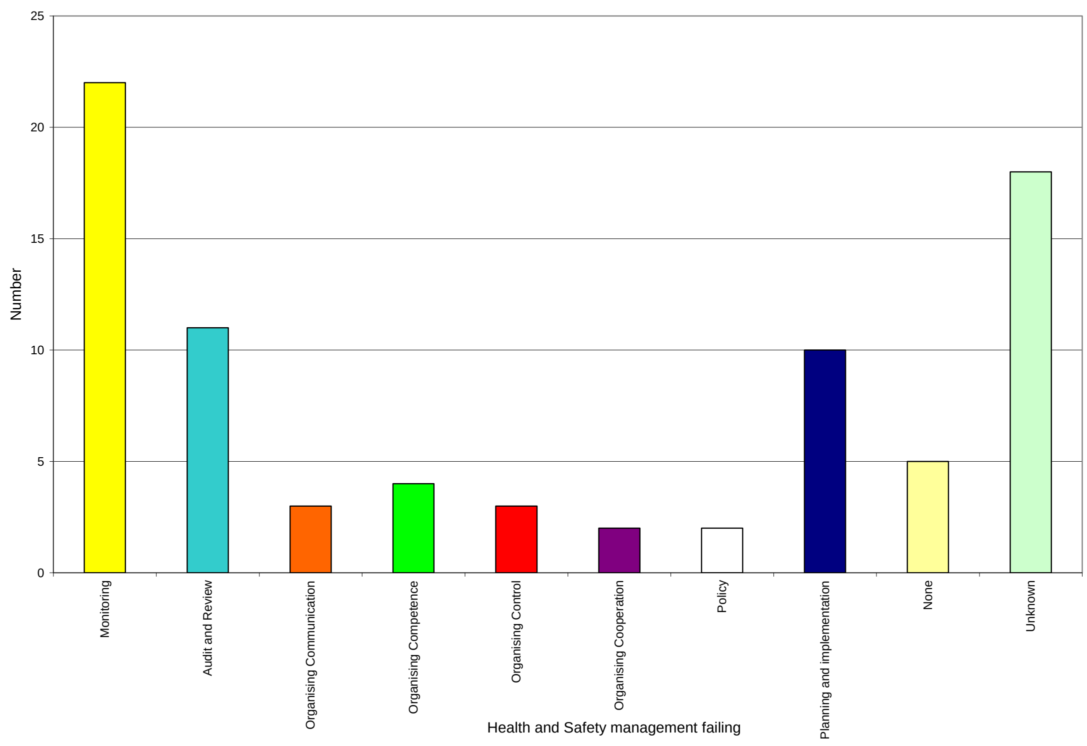


Figure 9 Health and Safety management failings

3.4.1 Examples of incidents involving significant Health and Safety management failings

- Monitoring
  - The IP was cleaning the deck using a high-pressure water jet when he accidentally directed the jet onto his foot. The safety boots he was wearing contained no upper foot protection, so he sustained a water penetration injury requiring hospital treatment. Monitoring systems were inadequate because unsuitable footwear had been worn during pressure jetting for years, but not identified as an issue.
  - The IP was repairing a pump which had not been isolated and drained properly, so as he slackened the bolts high pressure fluid was released, causing fatal injuries. The findings of successive audits were not actioned and the permit to work for this (and other procedures) was not adequately monitored.
  - During a storm, chemical drums stored on the deck of an FPSO became loose in the storage corral. In an attempt to secure the drums, several crew members were injured, three seriously, having been struck by loose drums. The drums had not been adequately secured, hence the implementation and monitoring of the safe storage of materials on the vessel's deck was insufficient.
  - The IP tripped over a sea fastening (welding plate) that was wrongly positioned near the door of a tool container. He sustained ligament damage and a twisted ankle. A safety officer had identified the incorrect sea fastening on an inspection before sailing, but the matter was not resolved, showing insufficient monitoring.
  - The IPs were working in an oil tank while some shackles and clamps were being lifted out of the tank using an air hoist. They had no way of telling whether the equipment had been fully lifted out of the hatch on the top of the tank, other than looking up. The IPs thought that the load had been safely removed through the tank hatch and resumed their work, but four angle clamps and a shackle fell back into the tank. One IP was fatally injured; the other received a laceration on his arm. There was a failing in the monitoring of permits to work, in that there were three permits for the tasks being carried out, but conflicts between them were not identified.
- Audit and Review
  - Two crew members were preparing to move a flange, having discussed the correct method during a toolbox talk. The IP decided to try to roll the flange by himself and it fell over, landing on his foot and breaking two toes. The IP was a contractor, and the duty holder's audit and review programme did not focus on contractors in sufficient detail.
  - A scaffolder was climbing using an inertia reel when he stood on a corroded Unistrut beam which broke. The broken piece of beam, which weighed approximately 15 kg, fell two metres and hit the IP on the head; he was wearing a safety helmet at the time. The auditing and review of the scaffolding activities by the contractor may not have been effective.
  - A crane was being used to move bundles of drill collars, and when one of the bundles was raised it moved across the deck and struck the IP causing a fractured hip. The IP was not involved in that part of the lifting operation and was leaving the area at the time

of the incident. Both the banksman, who was directing the load, and the crane driver failed to supervise the lift effectively, one or other should have ensured that the IP was not in a dangerous position before commencing the lift. The conducting of lifting operations was not sufficiently audited and reviewed.

- Planning and implementation

  - A suspended load was being manoeuvred through a gap between handrails and the IP pushed the load with his foot. The load moved suddenly and trapped the IP's ankle against the handrail. There was no specific lifting plan for the non-routine lift and with better planning the restriction point could have been removed.

  - An anchor chain was lost overboard on a semi-submersible installation. During the recovery of the chain, part of the winch being used had to be removed in order to wrap a wire around it. Whilst the OIM was arranging the removal of this winch component, the deck crew decided to carry on with the chain recovery using different equipment. Part of this equipment, a reel, fell over and rolled, pinning the IP against a stanchion. There was a lack of awareness of the hazards involved with the task due to poor planning and inadequate provision of information. The duty holder failed to ensure a safe system of work for the retrieval of the winch.

  - The IP was clearing a blocked section of drill line with an air hose, and when the blockage was cleared the pipe moved, striking his foot causing multiple fractures. There was no formal procedure for clearing the blocked pipe and, as such, there was insufficient risk assessment for the task. Before the job was started procedures were accepted, which included those for unblocking the pipe, however hazards were not identified, showing poor planning.

3.5 REGULATION AND GUIDANCE

Figure 10 shows the relevant HSE Regulations and Guidance mentioned for the 67 incidents. MHSWR and HSWA are the most significant with around 25 to 30 cases. LOLER and PUWER are also significant with just over 10 cases. The incident data on all four regulations mentioned here will go forward to a detailed comparison with other data in section 4. Examples of incidents involving these three significant regulations are provided below. All four regulations will be reviewed in the guidance section of this report (section 6). None indicates that no regulation or guidance was mentioned.

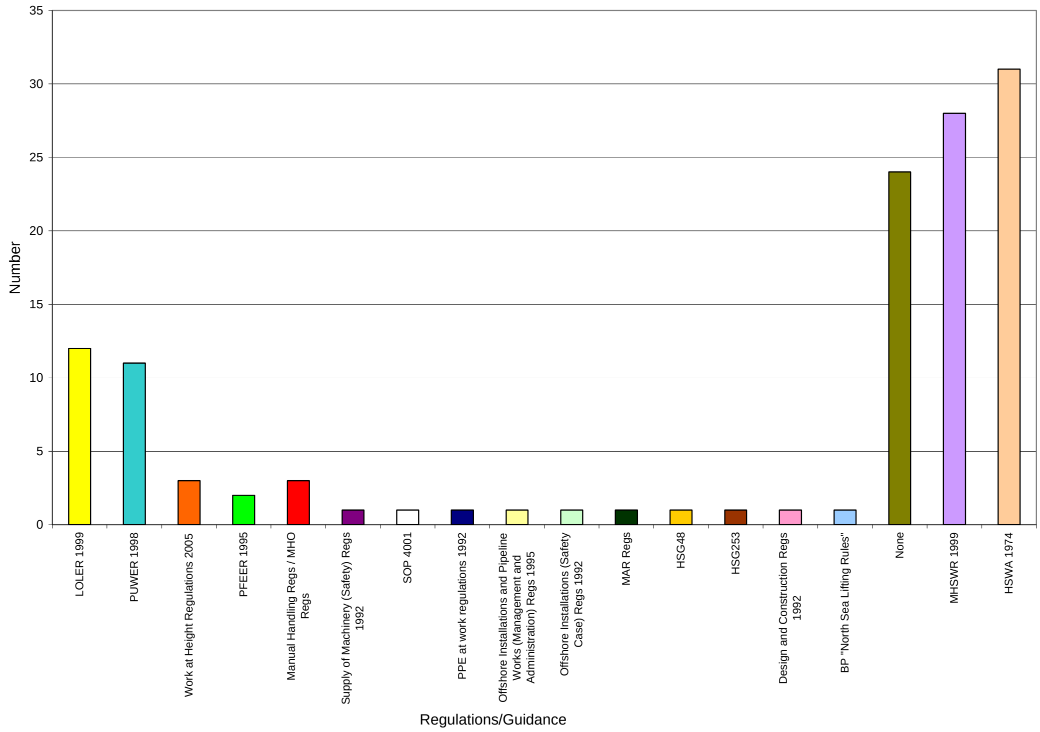


Figure 10 Mentioned regulations and guidance

3.5.1 Examples of incidents where significant regulations and guidance were mentioned

- Lifting Operations and Lifting Equipment Regulations (LOLER) 1998

    - As a suspended load was being lowered it started to swing, so the IP entered an unsafe area to retrieve a tag line, in order to steady the load. As the load swung it hit a Samson post and rebounded into the IP, breaking his arm. There was a failure to take account of a blind spot when planning the lifting operation, hence a potential breach of LOLER, regulation 9.

    - As a load was being lifted from the deck, two load handlers were holding the slings to ensure that they did not slip when the load was lifted. This was against procedures, which specify that hands should not be placed on loads during lifts, and that tag lines should be used to stop the slings slipping. As soon as the load was clear of the deck it swung towards the load handlers, striking one of them and fracturing his leg. LOLER regulation 8 is relevant in this case.

    - A routine lift was being carried out during strong winds, close to the operating limit of the crane. A representative of the company who owned the equipment being lifted was present, and told the crew to change the method of lifting (meaning that it was no longer a routine lift). The equipment was made up of two parts, one fitting quite tightly inside the other, which were usually lifted both at once. They were lifted separately; the outer part caused no problems, but the inner part was swinging making it difficult to line up above the outer part. The IP tried to steady the load, which weighed about a tonne, and his wrist was crushed. This is also a possible breach of LOLER regulation 8.

- Provision and Use of Work Equipment Regulations (PUWER) 1998

    - The IP was manually opening a choke; initially he tried using the electrical system on the choke, which failed to operate so he used the hand wheel. As the choke was cracked open the actuator was forced from the front of the choke, hitting the IP and causing extensive injuries including a fractured skull. The choke was designed to be operated from a control room and had a history of opening problems. When the choke was inspected, a significant amount of scale was found inside that should have been cleaned during regular maintenance and is thought to have caused the ejection of the actuator. There are several PUWER regulations applicable to this incident: numbers 4, 5, 6, 8, 9 and 12.

    - While two workers were assisting with drilling operations, part of the derrick drilling machine spun round rapidly and unexpectedly. It hit them and both were seriously injured. The control system software for the drilling equipment should have been upgraded, which would have prevented this incident, but it had not been. PUWER regulations 4, 5 and 18 are pertinent in this case.

    - A heat exchanger failed catastrophically, releasing hydrocarbon gas which subsequently ignited. The IP was caught in the fire and suffered burns. The fire was extinguished effectively by the deluge system, and the installation was successfully evacuated. The heat exchanger failed due to corrosion at an interface between explosion-bonded titanium and carbon steel. PUWER numbers 5 and 6 are relevant here.

- Management of Health and Safety at Work Regulations (MHSWR) 1999

    - The IP was cleaning the deck using a high-pressure water jet when he accidentally directed the jet onto his foot. The safety boots he was wearing contained no upper foot protection, so he sustained a water penetration injury requiring hospital treatment. The PPE required for water jetting was not adequately specified, so regulations 3, 4 and 5 of the MHSWR are relevant.

    - The IP was removing some slings from counterbalance weights when he was struck on the arm by one of the slings. His arm was fractured in several places. Regulation 3 of the MHSWR was potentially breached as there was no task specific risk assessment.

    - The IP was clearing a blocked section of drill line with an air hose, and when the blockage was cleared the pipe moved striking his foot. He sustained multiple fractures to his foot. MHSWR number 3 is relevant here because there was no formal procedure for clearing the blocked pipe and, as such, there was insufficient risk assessment for the task.

    - The IP and a colleague tried to move some heavy (about 800 kg in total) steel plates to retrieve a specific plate that was underneath. When the plates were positioned vertically they started to tip over, and landed on the IP’s legs resulting in a severe crush injury. This task should not have been carried out without a risk assessment but it was perceived to be a quick and simple job so the two workers decided to have a go. MHSWR number 3 is appropriate to this, due to the lack of risk assessment.

- Health and Safety at Work etc. Act (HSWA) 1974

    - Two mud motors had been incorrectly laid on top on one another by an inexperienced banksman. The top mud motor was leaning against a pipe which was subsequently moved by the IP, causing the top motor to slip down and trap his leg. The IP was diagnosed with a double leg fracture. There was a possible breach of HSWA section 2, as the crew were inexperienced and were not provided with adequate training and supervision.

- During a storm, chemical drums stored on the deck of an FPSO became loose in the storage corral. In an attempt to secure the drums several crew members were injured, three seriously, having been struck by loose drums. The drums had not been adequately secured, so there was a breach of HSWA sections 2 and 3.

- The IP was replacing stair treads when he fell six metres, though a gap made by removing two treads, sustaining fatal injuries. There was a permit to work for the job which stipulated that one tread should be removed at a time, however this was not backed up by a risk assessment. The risk of falling through or down the stairs was not identified in the permit to work, and the permit to work system was not well understood by the offshore staff. HSWA sections 2 and 3 were breached in this incident.

- The IP was fatally injured when a mandrel weighing approximately 270 kg fell on him. There was no permit to work issued for the lifting operation taking place at the time of the incident, therefore there was no risk assessment. A risk assessment would have identified the hazards and risks involved in this task and defined appropriate control measures, which may have prevented the fatality. The applicable regulations in this incident included HSWA sections 3 and 7.

3.6 DESIGN FAULTS

Six of the 67 incidents analysed were found to have a design fault in the equipment that contributed to the incident. These are described below.

- While making up joints with a manual Power tong the IP got his wrist trapped against a Sampson post, causing a fracture. There is a piece of equipment available called a Powerscope casing tong that does not require manual intervention. If this had been used, the incident would have been avoided.

- While two workers were assisting with drilling operations, part of the derrick drilling machine spun round rapidly and unexpectedly. It hit them and both were seriously injured. The control system software for the drilling equipment should have been upgraded, which would have prevented this incident, but it had not been. This is both a design fault, as the original control system was insufficient, and a maintenance issue as the software should have been upgraded.

- A heat exchanger failed catastrophically, releasing hydrocarbon gas which subsequently ignited. The IP was caught in the fire and suffered burns. The fire was extinguished effectively by the deluge system, and the installation was successfully evacuated. The heat exchanger failed due to corrosion at an interface between explosion-bonded titanium and carbon steel. It was thought that this heat exchanger was impervious to corrosion but the steel-titanium interface was a weak spot that was not considered in the design.

- IP was operating a hydraulic paint mixer, which did not have a guard, when his clothing became entangled in the mixer paddle resulting in a broken arm. The mixer has now been redesigned to incorporate an interlocked guard that will prevent such incidents happening again.

- The IP was manually opening a choke; initially he tried using the electrical system on the choke, which failed to operate so he used the hand wheel. As the choke was cracked open the actuator was forced from the front of the choke, hitting the IP and causing extensive injuries including a fractured skull. The choke was designed to be operated from a control room and had a history of opening problems. When the choke was inspected, a significant amount of scale was found inside that should have been cleaned during regular maintenance and is thought to have caused the ejection of the actuator. Had the choke been controlled remotely from another room, as its design intended, this incident would have been avoided.

- Part of a beam crane (the trolley) fell, having been hit by another trolley, and struck the IP on his hard hat. The trolley fell because it was not designed for use on that beam, so the end-stops on the beam were ineffective as they were too wide. Had trolleys that were designed specifically for the particular beam been used, they would have been prevented from falling by the end stops.

4 FURTHER ANALYSIS

Further analysis was carried out by cross-referencing all the data obtained from both RIDDOR (section 2) and the investigation reports (section 3). Appendix A gives further details.

4.1 KIND OF ACCIDENT

Hit by moving flying or falling object, Fall from height, Injured while handling, lifting or carrying, Slipped, tripped or fell on the same level data is shown in Table 8, section 9.1 in Appendix A. For most of the sample incidents, the kind of accident was hit by moving, flying or falling object. In the other tables in Appendix A, those incidents where another kind of accident was significant are shown underlined in red. They are listed below for each category:

- Permit to work (fall from height and injured while handling, lifting or carrying), Supervision (injured while handling, lifting or carrying);
- 1812 offshore drilling/workover (injured while handling, lifting or carrying), 1818 offshore deck operations (slipped tripped, (or fell);
- 1.xx surfaces at different levels (fall from height, slipped, tripped or fell at the same level), 6.xx lifting and storage (hit by object free falling from lifting machinery), 8.xx tools and machines (contact with moving machinery or material being machined), 9.xx building materials and components (injured while handling, lifting or carrying); and
- Monitoring (fall from height), Audit and Review (injured while handling, lifting or carrying).

4.2 INJURY TYPE

Fracture data is shown in Table 9, section 9.2 in Appendix A. For most of the sample incidents, the injury type was fracture. In the other tables in Appendix A, those incidents where another injury type was significant are shown underlined in orange. They are listed below for each category:

- Injured while handling, lifting or carrying (amputation).

4.3 DIRECT CAUSE

Impact Dropped Object data is shown in Table 10, section 9.3 in Appendix A. For most of the sample incidents, the direct cause was impact dropped object. In the other tables in Appendix A, those incidents where another direct cause was significant are shown highlighted in yellow. They are listed below for each category:

- Slipped, tripped or fell (slip/fall);
- 1818 offshore deck operations (slip/fall);
- 1.xx surfaces at different levels (slip/fall), 8.xx tools and machines (human error); and
- Monitoring (procedural violation).

4.4 UNDERLYING CAUSES

Operating Procedures, Hazard Analysis/Risk Assessment, Permit to Work, Supervision data is shown in Table 11, section 9.4 in Appendix A. Hazard Analysis/Risk Assessment was by far the most significant cause but Operating Procedures, Permit to Work and Supervision were also significant. In the other tables significant underlying causes are highlighted in bright green. References to these causes (other than Hazard Analysis / Risk Assessment) and Unknown are:

- Hit by moving, flying or falling object (Operating Procedures), Fall from height (Permit to Work), Injured while handling, lifting carrying (Permit to Work), Slipped, tripped or fell (Unknown);
- Fracture (Supervision);
- 1.xx surfaces at different levels (Supervision, Permit to Work), 6.xx lifting and storage (Supervision , Operating Procedures);
- Monitoring (Supervision, then Operating Procedures, Permit to Work); and
- PUWER (Operating Procedures), LOLER (Supervision, Permit to Work, Operating Procedures),

4.5 WORK PROCESS ENVIRONMENT

Data on the various work process environments (1811, 1812, 1814, 1818) is shown in Table 12, section 9.5 in Appendix A. Codes 1814 (offshore construction and maintenance) and 1811 (offshore production) dominate the sample but 1812 (offshore drilling/workover) and 1818 (offshore deck operations and offshore transport) are also significant. In the other tables significant Work Process Environment issues are underlined in dark red. References to these issues are:

- Hit by moving, flying or falling object (1811 offshore production and 1814 offshore construction and maintenance), Injured while handling, lifting or carrying (1812 offshore drilling/workover), slipped tripped or fell (1814 offshore construction and maintenance and 1818 offshore deck operations and offshore transport).
- Fracture (1814 offshore construction and maintenance).
- Impact / dropped object (1811 offshore production, 1814 offshore construction and maintenance, 1812 offshore drilling/workover).
- Operating Procedures (1811 offshore production, 1814 offshore construction and maintenance), Hazard Analysis/Risk Assessment (1814 offshore construction and maintenance and 1811 offshore production), Permit to Work (1814 offshore construction and maintenance), Supervision (1811 offshore production and 1814 offshore construction and maintenance).
- 1.xx surfaces at different levels (1814 offshore construction and maintenance and 1818 (offshore deck operations and offshore transport), 3.xx pipes and pipe fittings (1811 offshore production and 1814 offshore construction and maintenance), 6.xx lifting and storage (1811 offshore production), 8.xx tools and machines (1814 offshore construction and maintenance), 9.xx building materials and components (1811 offshore production and 1812 offshore drilling/workover).
- Monitoring (1814 offshore construction and maintenance and 1811 offshore production), Audit and Review (1811 offshore production), Planning and Implementation (1814 offshore construction and maintenance).
- LOLER (1811 offshore production), PUWER (1811 offshore production and 1814 offshore construction and maintenance), MHSWR (1811 offshore production).

4.6 GROUPED AGENTS

Data on the following grouped agents - 1.xx Surfaces at different levels: floors ladders, scaffolding, 3.xx Pipes and Pipe Fittings, 6.xx Lifting and Storage, 8.xx Tools and machines, 9.xx Building materials and components - is shown in Table 13, section 9.6 in Appendix A. It was considered important to examine all the five grouped agents shown above. In the other tables significant grouped agents are underlined in blue. References to these issues are:

- Hit by moving, flying or falling object (9.xx Building materials and components and 3.xx Pipes and Pipe Fittings), Fall from height (1.xx Surfaces at different levels), Injured while handling, lifting or carrying (9.xx Building materials and components), Slipped, tripped or fell (1.xx Surfaces at different levels).

- Fracture (mainly 1.xx Surfaces at different levels but also 9.xx Building materials and components, 3.xx Pipes and Pipe Fittings and 6.xx Lifting and Storage).
- Impact / dropped object (mainly 9.xx Building materials and components but also 6.xx Lifting and Storage).
- Hazard analysis/Risk Assessment (9.xx Building materials and components then 3.xx Pipes and Pipe Fittings), Permit to Work (9.xx and 1.xx Surfaces at different levels), Supervision (1.xx Surfaces at different levels, 3.xx Pipes and Pipe Fittings and 6.xx Lifting and Storage).
- 1811 offshore production (3.xx Pipes and Pipe Fittings, 9.xx Building materials and components and 6.xx Lifting and Storage), 1812 offshore drilling/workover (9.xx), 1814 offshore construction and maintenance (1.xx Surfaces at different levels, 8.xx Tools and machines and 3.xx Pipes and Pipe Fittings), 1818 offshore deck operations and offshore transport (1.xx Surfaces at different levels).
- Monitoring (1.xx Surfaces at different levels, then 3.xx Pipes and Pipe Fittings and 8.xx Tools and machines), Planning and Implementation (6.xx Lifting and Storage and 9.xx Building materials and components).
- LOLER (9.xx Building materials and components), PUWER (1.xx Surfaces at different levels and 3.xx Pipes and Pipe Fittings), MHSWR (3.xx Pipes and Pipe Fittings, 9.xx Building materials and components and 1.xx Surfaces at different levels).

4.7 HEALTH AND SAFETY MANAGEMENT FAILINGS

Monitoring, Audit and Review, Planning and Implementation data is shown in Table 14, section 9.7 in Appendix A. Monitoring was the most significant failing but Audit and Review and Planning and Implementation were also significant. Sometimes the failing was unknown. In the other tables significant Health and Safety Management Failings are highlighted in turquoise. References to these failings are:

- Hit by moving, flying or falling object (Monitoring, Planning and Implementation), Fall from height (monitoring), Slipped, tripped or fell (unknown).
- Fracture (Monitoring, Planning and Implementation).
- Impact dropped object (Planning and Implementation, Unknown, Monitoring , Audit and Review).
- Operating Procedures (Monitoring), Hazard analysis/Risk assessment (Monitoring then Planning and Implementation), Permit to Work (Monitoring then Planning and Implementation), Supervision (Monitoring).
- 1811 offshore production (Monitoring, Audit and Review, Unknown), 1812 offshore drilling/workover (Monitoring, Unknown), 1814 offshore construction and maintenance (Monitoring), 1818 offshore deck operations and offshore transport (Unknown).
- 1.xx surfaces at different levels (Monitoring, Unknown), 3.xx pipes and pipe fittings (Monitoring), 6.xx lifting and storage (Unknown, Monitoring, Audit and Review, Planning), 8.xx tools and machines (Monitoring), 9.xx building materials and components (Unknown).
- LOLER (Monitoring, Planning and Implementation), PUWER (Monitoring), MHSWR (mostly Monitoring, but also Audit and Review).

4.8 REGULATIONS AND GUIDANCE

HSWA, MHSWR, LOLER and PUWER. See Table 15, section 9.8 in Appendix A for data. For most of the sample incidents, the general regulations and guidance were referred to (HSWA), and sometimes more specific guidance was referred to (MHSWR, LOLER and PUWER), otherwise no guidance or regulations were mentioned. In the other tables significant Regulations and Guidance issues in other tables are highlighted in red. Reference (other than to HSWA) and non-reference issues are:

- Hit by moving, flying or falling object (LOLER, MHSWR), injured while handling, lifting or carrying (MHSWR, none), slipped, tripped or fell (none);
- Fracture (mostly MHSWR but also none and LOLER);
- Impact / dropped object (MHSWR, LOLER and none);
- Operating procedures (MHSWR, then LOLER and PUWER), Hazard analysis / risk assessment (mostly MHSWR but also LOLER and none), permit to work (MHSWR), supervision (MHSWR, then none and LOLER);
- 1811 offshore production (MHSWR then LOLER), 1812 offshore drilling/workover (none and MHSWR), 1814 offshore construction and maintenance (none then MHSWR), 1818 offshore deck operations and offshore transport (MHSWR);
- 1.xx surfaces at different levels (none then MHSWR and PUWER), 3.xx pipes and pipe fittings (MHSWR), 6.xx lifting and storage (MHSWR and LOLER), 8.xx tools and machines (none), 9.xx building materials and components (MHSWR, then LOLER and none); and
- Monitoring (MHSWR, then PUWER), Audit and Review (MHSWR).

5 COMPARISONS WITH PREVIOUS STUDIES

5.1 OFFSHORE INJURY ILL HEALTH AND INCIDENT STATISTICS

HSE has produced annual reports with injury statistics for 2004/05 [(1)], 2005/06 [(2)], 2006/07 [(3)] and 2007/08 [(4)]; i.e. for the same period as the present study. The reports include annual fatality and major injury data on injury types (nature of injury), location types (site of injury), kind of accident (categories), work process environment and agent (agent of accident - categories). The 67 incidents are a sample of incidents for which investigation reports were available. Appendix D gives the following information on all the major injuries and fatality incidents - number of major injuries, number of fatalities and the calendar year of incident. It is useful to compare these incidents with the full data set of fatalities and major injuries for the period. This comparison is done using the following graphs: Figure 11 (Nature of injury), Figure 12 (Site of injury), Figure 13 (Kind of accident), Figure 14 (Work process environment) and Figure 15 (Agent of accident).

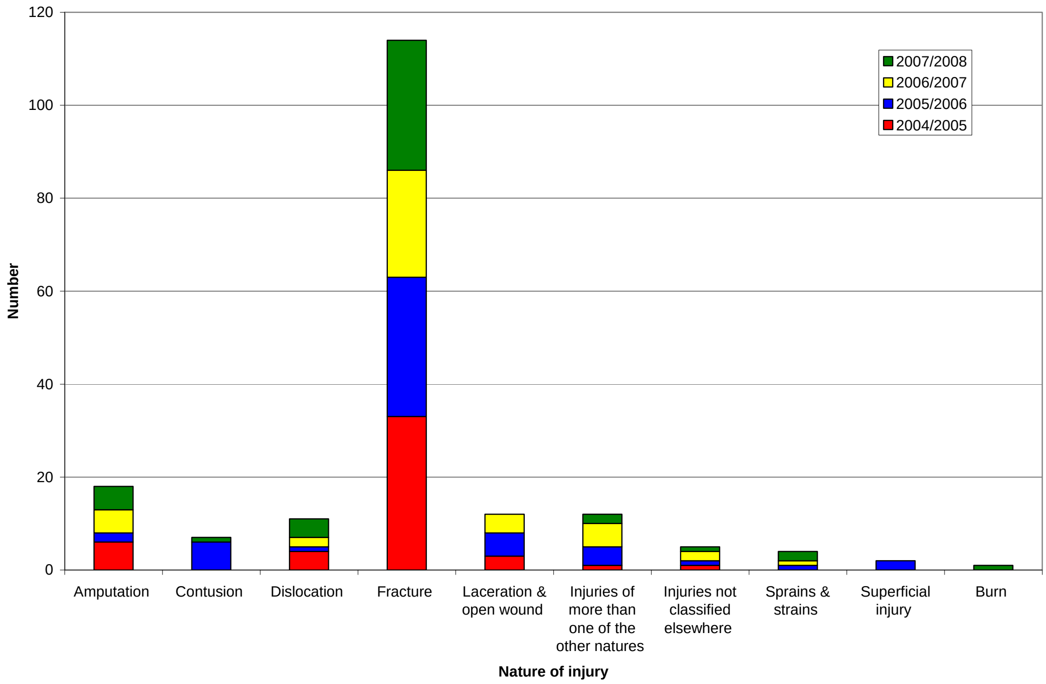


Figure 11 Nature of injury from 2004-2008

Comparing this data with Figure 1 shows that fractures were also the largest injury type for the full set of fatalities and major injuries over the period of study.

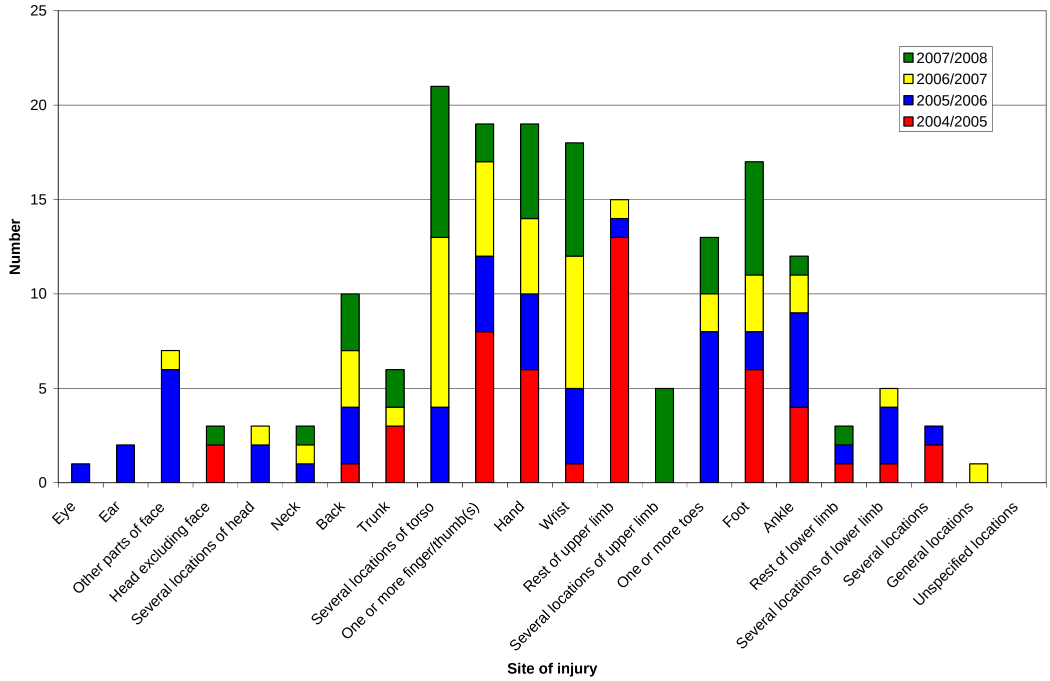


Figure 12 Site of injury from 2004-2008

Comparing this data with Figure 2 shows the same variation in injury location for the full set of fatalities and major injuries over the period of study.

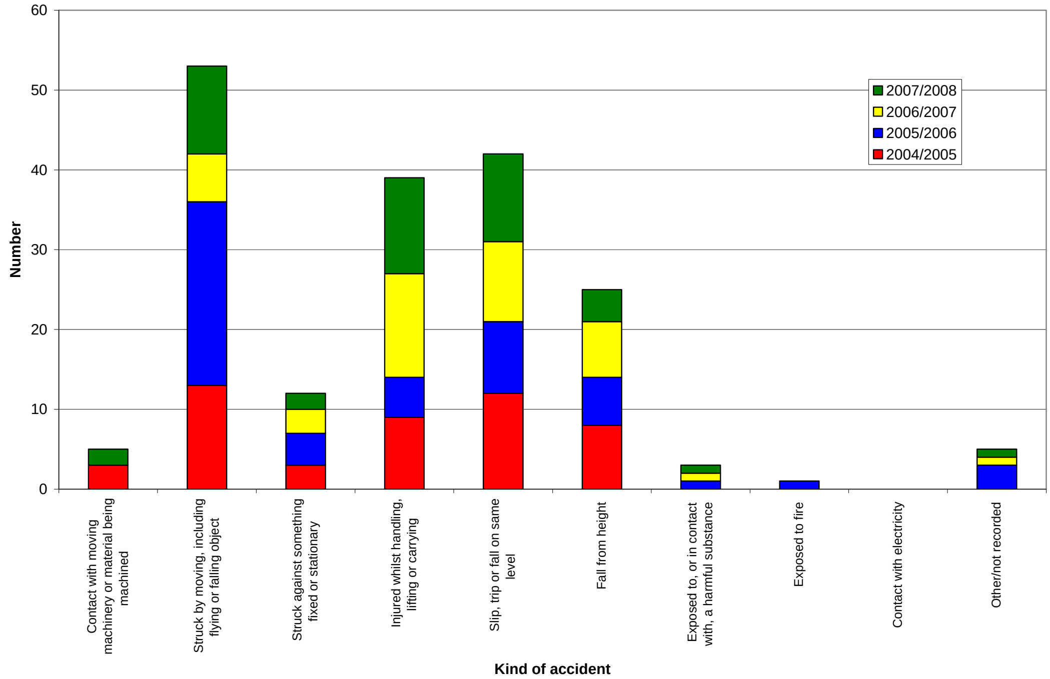


Figure 13 Kind of accident from 2004-2008

Comparing this data with Figure 3 shows that hit by a moving, flying or falling object is still the largest category for the full set of fatalities and major injuries over the period of study, but the peak is less prominent. The three other kinds of accident considered in more detail are again prominent, more so than in Figure 3. They are injured while lifting handling or carrying, slipped tripped or fell on same level and falls from height.

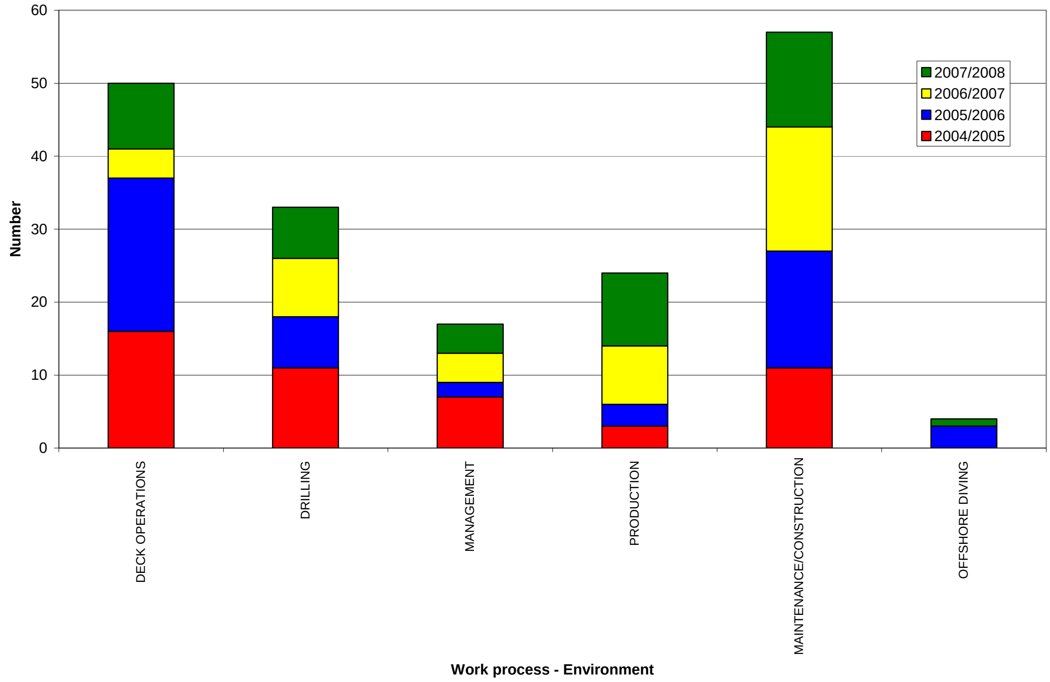


Figure 14 Work process - Environment 2004-2008

Comparing this data with Figure 6 shows that offshore construction and maintenance is still the largest category for the full set of fatalities and major injuries. However the full set of data shows offshore deck operations and offshore drilling to be more prominent than offshore production. However all four work process environments discussed above were taken forward for detailed study.

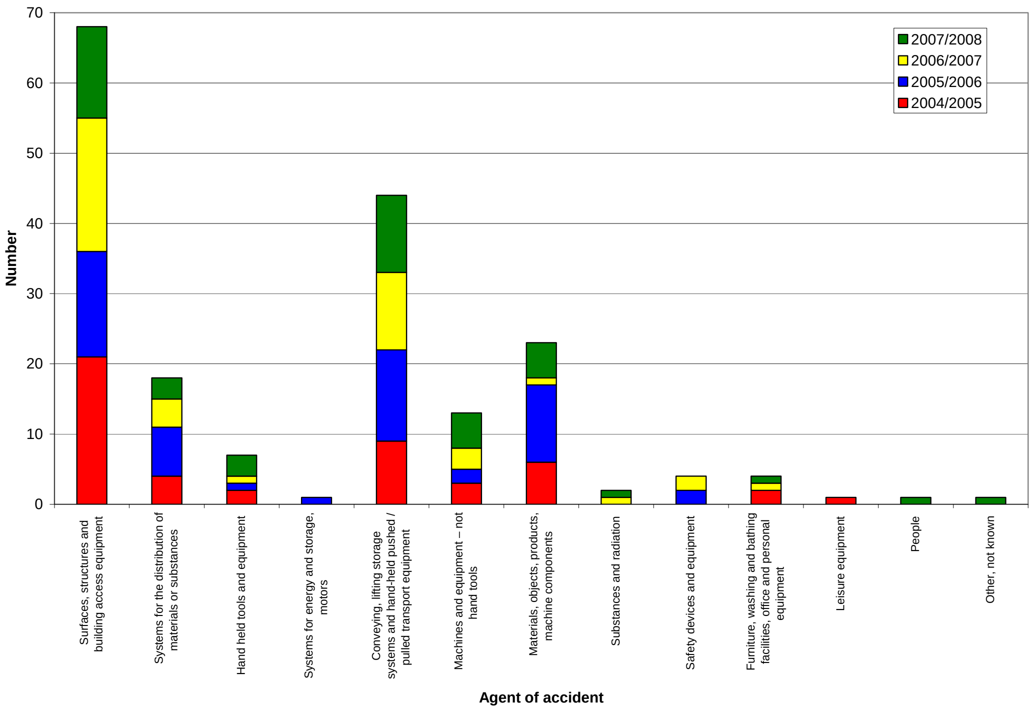


Figure 15 Agent of accident 2004-2008

Comparing this data with Figure 5, noting that the agents of the accident for the full set of fatalities and major injuries have been grouped differently. Figure 15 shows the prominence of surfaces, structures and building access equipment and conveying, lifting storage systems and transport equipment. Distribution systems, materials and machines and equipment also seem to be prominent. This seems to be generally consistent with the five significant agent groupings, identified in section 2.5, which were studied in detail.

5.2 PREVIOUS OFFSHORE INCIDENT CAUSAL ANALYSIS

5.2.1 Slips, trips and falls from height offshore

This work done by BOMEL Ltd [(5)] [(6)] for HSE identified causes from RIDDOR. Offshore slips and trips and falls from height (STFs) were analysed. Data is provided on the accident category against accident kind, number of STFs against activity at time of accident, number of STFs against process environment, number of STFs against installation type, numbers of STFs against process environment by installation type and number of STFs against age of person. There are far more slips and trips than falls from height. The activity at the time of the accident was commonly either climbing/descending or walking at same level. Drilling/workover and maintenance process environments had more STFs, but deck operations process environment had more STFs per person in that environment. Fixed installations had more STFs as numbers and per person compared to mobile installations. For fixed installations, maintenance process environment had more STFs, whilst for mobile installations the deck operations process environment had more STFs per person in that environment. The 41-50 age group had less STFs per person than other age groups. Data was also available from offshore companies on the status of accidents in relation to RIDDOR and activity against direct cause. Some accidents and near misses are non-reportable under RIDDOR. Again climbing/descending and walking on same level were the activities at time of the STF. HSE inspectors were also asked to comment on their perception of the main human causes of slips/trips and falls and the workable strategies to prevent STFs. The main human causes identified were distractions/stress, then poor management/supervision, lack of control, culture and lack of awareness. The main workable strategies were employee focus, training competence pre-management and campaigns. Offshore workers were also questioned and responses were recorded on the main causes of STFs and prevention of STFS (this data included the HSE view). Here the main causes were lack of attention, risk awareness and housekeeping and possible prevention methods were risk assessment, communicate best practice and identify areas/training.

5.2.2 Lifting incidents review 1998-2003

This work done by Sparrows Offshore Services (7) for HSE examined offshore lifting incidents, involving lifting operations or lifting equipment. The lifting incidents were first categorised as either drilling-handling equipment (DHE) or mechanical handling equipment (MHE). Each incident was classified as involving equipment failure (DHE-EF and MHE-EF) or human factors (DHE-HF and MHE-HF). Then the incidents involving either equipment failures or human factors were classified into a number of sub categories, with separate categories for the two types of equipment (DHEs and MHEs).

The number of resulting incidents in each category was presented in the report for both DHEs and MHEs. Detailed analysis of the drilling handling incidents and mechanical handling incidents is presented for both the equipment failures and human factor types. For DHE-EF incidents, dropped objects or dropped loads resulted with root causes difficult to determine. For DHE-HF incidents injuries resulted and human factors causes were discussed. For MHE-EF incidents dropped load/boom and lack of control resulted, with root cause difficult to determine. For MHE-HF incidents injuries resulted and human factor causes were discussed. For the human factor incidents a root cause analysis was done for the drill handling and mechanical handling. For drill handling, operator error was more significant than positioning whilst for mechanical handling, these two human factors causes were equally significant. The effect of various joint industry and HSE initiatives on the number of lifting incidents was also explored.

5.2.3 Human factors in maintenance-related incidents/accidents

This work done by Vectra Group (8) for HSE looked at the offshore incidents reported under RIDDOR involving maintenance. Causal factors and latent errors were examined. The most significant causal factor was unsafe position/posture. The most significant latent errors were lack of awareness/attention, then inadequate work standard/lack of discipline. The number of incidents per anonymous company name was examined. There is also a record of installations in UK waters – Mobile, Fixed, FSU/FPSO/FP, NUI and TLP.

RIDDOR data was analysed and the main findings were that, post-2001, more that 60% of maintenance incidents were human factors related. Lack of awareness/inattention was responsible for 22.7% of latent errors, inadequate work standards/poor discipline made up 19.5%, and inadequate risk assessment + inadequate job planning accounted for 24.2%. The main causal factors were identified as poor position/posture (20%) and poor practice (38%). Poor practice includes failure to follow procedures/industry practice as well as poor preparation/completion of tasks. The report concludes that “incidents / accidents resulting from maintenance are more likely to stem from a human factors-related root cause than an engineering one.”

5.2.4 Supply chain issues – Analysis of incidents

This work done by Loughborough University (9) for HSE analysed offshore incidents for active and latent failures. Shell was the operating company who provided the data. An analysis of incidents by case category showed the most common to be environmental spill and equipment/ hardware failure. An analysis of incidents by first level active failures showed plant and equipment and using procedures to be most significant. Active failures were studied at first and second level. The commonest second level failures were mechanical failure (plant and equipment – first level) then procedure not followed (using procedures – first level) and faulty plant operated (operating plant – first level). An analysis of latent failures at first level showed the most significant to be hardware failures then procedures/instructions/written practices, maintenance management and training/competence/awareness. An analysis of latent failures at second level showed the most significant to be inspection and maintenance, gaps or omissions in individuals training and omissions or weaknesses in procedures. Associations between categories are examined for environmental spills, equipment/hardware failures, hydrocarbon releases, permit to work and dropped objects. For dropped objects there were 10 active failures (5 work environment and 4 operating plant and equipment) and 13 latent failures (5 maintenance management).

5.2.5 Manual handling incidents database

This work done by Hu-Tech Ergonomics (10) for HSE looked at the root causes of offshore manual handling incidents. The various root causes are listed together with a definition/explanation. The root causes are classified as to who is the controlling group (designer/architect, management/planner, supervisors, individual). The root cause analysis findings are provided. The most common causes are poor workplace design then poor equipment design, inadequate equipment, and procedural failing. The next most common causes are avoidable tasks not avoided, lack of planning, poor handling technique, inadequate risk assessment and inadequate risk perception. Table 1 below shows what is the controlling group for the most significant root causes.

Table 1 Sources of control of the most significant root causes

Root Cause	***Controlling Group***			
	Designer architect	***Manager/planner***	***Supervisors***	***Individual***
Poor workplace design	Yes			
Poor equipment design	Yes	Yes		
Inadequate equipment		Yes		Yes
Procedural failing		Yes		
Avoidable tasks not avoided		Yes		Yes
Lack of planning		Yes	Yes	Yes
Poor handling technique			Yes	Yes
Inadequate risk assessment			Yes	
Inadequate risk perception			Yes	Yes

5.2.6 Key Programme 2 – Deck and drilling operations

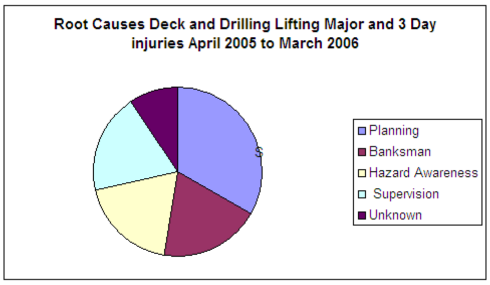
This HSE programme was in response to unacceptable accident statistics from deck and drilling operations offshore. The final report on Key Programme 2 (11) reports on two programme phases. Phase 1 included two root cause analyses, an industry STEP change review of 11 fatalities and an HSE review of fatal investigations (see Table 2). Phase 2 involved HSE inspections and incident investigation root cause analysis. Table 3 shows the results of the KP2 inspections. Management was the worst topic, next Planning and Control, Training & Competence and LOLER on Drill Floor. The root cause analysis in the incident investigation examined both deck and drilling lifting injuries and lifting dangerous occurrences over the years 2005/06 and 2006/07. The dominant accident root causes were planning (includes risk assessment) supervision and hazard awareness (see Figures 16 and 17). The leading root causes of deck and drilling lifting dangerous occurrences were mechanical failure, dropped objects and rigging competency (see Figures 18 and 19). Although the number of deck and drilling accidents has been falling, those which are lift related have been increasing (see Table 4).

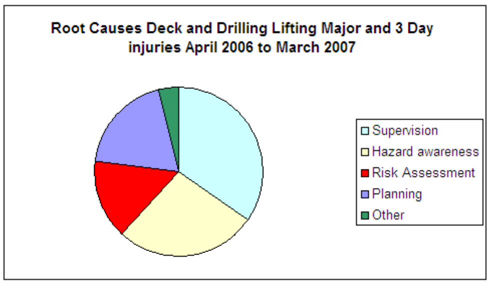
Table 2 KP2 Fatality Root Cause Analyses

Main Findings of STEP Change review of 11 fatalities	Main findings of HSE Review of five fatal investigations
Routine risks underestimated Risk not perceived or deemed acceptable Risk assessment not 'live'	Risk assessment
Procedural violations routine and tolerated	Job design, procedures and control of handovers
Supervisors spending insufficient time on site	Job supervision and monitoring

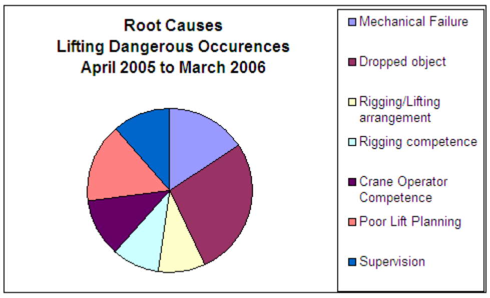
Table 3 KP2 Inspection Results

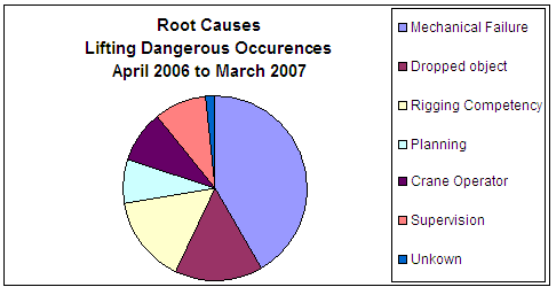
Topic	Management	Plan & Control	Train & Comp	LOLER on Drill Floor	Handling Tubulars	Violations	Risk Assessment	Manriding	Supervision	Communications	Learning
Score	Times Inspected										
Red	2	6	2	1	0	1	2	0	1	0	0
Amber	36	24	26	12	10	14	14	9	10	10	8
Green	25	41	40	21	26	44	50	30	53	52	45
Times Inspected Total	63	71	68	34	36	59	66	39	64	62	53
Times "Failed"	38	30	28	13	10	15	16	9	11	10	8
% Failed	60%	42%	41%	38%	28%	25%	24%	23%	17%	16%	15%





Figures 16 and 17 Accident Root Causes 2005-2007





Figures 18 and 19 Dangerous Occurrences Root Causes 2005-2007

Table 4 Deck and Drilling Accidents 2001-2007

Deck and drilling accidents:		2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Fatal	All	2	0	1	0	1	0
	Lift related	1	0	0	0	1	0
Major	All	28	30	20	27	28	11
	Lift related	5	4	5	5	8	6

5.3 PREVIOUS ANALYSIS WORK DONE BY HSL

5.3.1 Offshore Hydrocarbon Releases 2001-2008

HSL used the Hydrocarbon Release (HCR) Database to analyse the causes of major and significant hydrocarbon releases between 2001 and 2008 [28]. The offshore operating companies supply information on the equipment involved in the releases and causal information to the HCR database on a voluntary basis. Three causal classifications are used in the HCR database: equipment cause, operational cause and procedural cause. Note that only one causal category could be selected for each classification: There are nine possible equipment causes including none, 12 possible operational causes including none, and five procedural causes including none. Table 5 shows what the most common failures were and the associated equipment described in terms of the plant, the process system and the operational mode.

Table 5 Most common failures base on major and significant data

	Associated Equipment or Identified Cause
Equipment	Piping, instruments, flanges
System	Gas compression, export, utilities
Operational mode	Normal production, start up, reinstatement
Equipment cause	Mechanical failure, none, mechanical failure
Operational cause	None, incorrectly fitted, improper operation
Procedural cause	None, no-compliance with a procedure, deficient procedure.

Section 10 (Appendix B) reproduces the causal tables from the HSL report: Table 16 (equipment causes), Table 17 (operational causes) and Table 18 (procedural causes). The blue bold text in the tables indicates the top three causes in each category, also shown in Table 5. Comparing these HCR causes with the direct and underlying causes shown in Figures 7 and 8: Equipment causes (external and internal corrosion, material defect) and operational causes (dropped object, inadequate isolation) tend to be direct causes. Procedural causes are a mixture

of direct causes (inadequate procedure, procedural violation) and underlying causes (operating procedures, permit to work). Operational causes include improper inspection, improper maintenance, improper operation, improper testing, incorrectly fitted and left to open. These operational causes, which involve improper actions, may be caused by underlying causes such as operating procedures, permits to work, supervision and communication. Procedural causes involving procedures and permits to work may be underling causes in themselves or be due to other underlying causes of supervision and communication.

5.3.2 Analysis of Inspection Reports from Asset Integrity Key Programme 3

HSL did some analysis work on the inspection reports from Asset Integrity Key Programme 3 [29]. HSE inspectors visited all the offshore platforms and their onshore offices over a three year period. They judged each platform using an inspection template, which covered a number of related topics. A traffic light system (red, amber and green) was used to indicate the platform's performance on the topic: Red indicated 'non-compliance/major failing', amber indicated 'isolated failure/incomplete system' and green indicated 'in compliance/OK'. Table 6 and Figure 20 (which uses the Topic codes) show the Poor and Good Performance Topics.

Table 6 Poor and Good Performance

Topic	**No of reds**	**No of ambers**	**No of greens**
A - Maintenance basics	6	19	53
B - Communication onshore/offshore	5	19	59
C – Technician /Supervisor Competence	1	35	47
D - Maintenance of SCEs	18	40	24
E - Supervision	2	24	56
F - Maintenance recording	1	42	38
G - Backlogs	16	35	32
H - Deferrals	11	23	47
I - Corrective maintenance	7	30	42
J - Defined life repairs	3	20	57
K - Maintenance system evaluation	2	30	50
L - Measuring compliance with performance standards	9	21	45
M - Measuring quality of maintenance work	6	19	49
O/N - Review of ICP recommendations/ Verification	7	18	51
P - Reporting to senior management on integrity status	3	11	64
Q - Key indicators for maintenance effectiveness	3	5	64

Some topics directly related to underlying causes seem to show reasonable performance (communication onshore/offshore, technician/supervisor competence, supervision and review of ICP recommendations/verification). Likewise those topics directly related to health and safety management failings also show reasonable performance (maintenance system evaluation, measuring compliance with performance standards, measuring quality of maintenance work and review of ICP recommendations/verification). Topics that measure outputs generally show poor performance (maintenance of SCEs, backlogs and deferrals). This would indicate that there are health and safety management failings and underlying issues still present. This shows the advantage of having leading and lagging indicators.

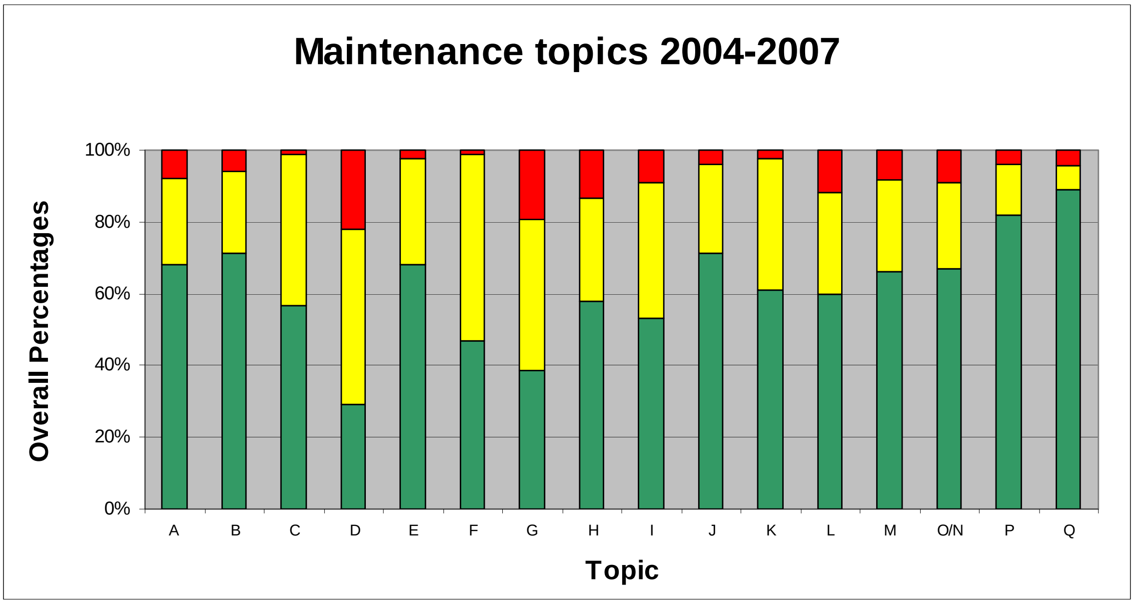


Figure 20 All traffic lights

Figure 21 shows, in an anonymous way, the performance of each operating company in KP3. A comparison with Figure 4 shows that the companies with seven to eight incidents (FL, EY and HS) show variable performance from poor to good.

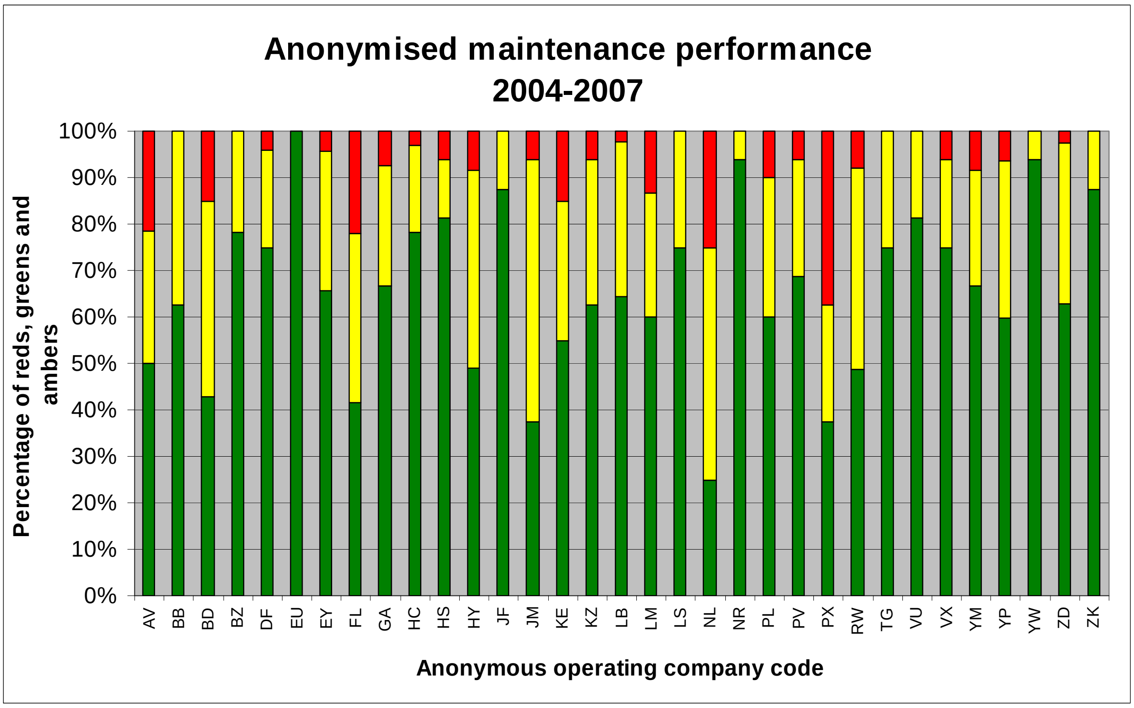


Figure 21 Operating company performance

6 GUIDANCE

IRF report

The International Regulators' Forum (IRF) report on offshore lifting [(12)] presents the results of a questionnaire, which was sent to each IRF member, on issues (listed below) involved in the transfer of goods from the dockside to the drill floor.
A. Loading the supply boat at the dockside
B. Transfer from the supply boat to installation and vice versa
C. Deck to deck lifting operations
D. Drill floor lifting operations
E. Generic lifting issues
F. Intelligence

Replies were received from regulators in the Netherlands, New Zealand, Newfoundland, Norway, Nova Scotia, UK, USA and Western Australia. The top ten issues identified are shown in Table 7.

Table 7 Top ten issues with transfer of goods

	Top ten issues	*Points*
1	Competence of crane operator	22
2	Competence of banksmen / slingers	21
3	Man riding using winches	20
4	Planning of lifting operations	19
5	Analysis of lifting operations	19
6	Static and dynamic crane rating	18
7	Hook snagging on the supply boat	17
8	Competence of lifting operations	17
9	Supervision of lifting operations	17
10	Inadequate maintenance	17

The report lists regulatory initiatives and benchmarks, from those who responded, relevant to each of the top ten issues.

HSE lifting strategy

The HSE lifting strategy [(13)] is described in three sections: key issues, intended outcomes, and programme of work. The key issues are identified as:

1. Installation integrity – This is addressed in Key Programme 3 (KP3).

2. Occupational serious and fatal injuries – Key Programme 2 (KP2) focuses attention on eliminating fatalities and reducing major injuries from drilling and deck-related lifting accidents.

3. Technical excellence – Ensuring that information is up to date and inspectors are well informed.

Intended outcomes of the strategy include reducing the number and severity of accidents, and improving compliance with LOLER, PUWER and other relevant legislation. The programme of work is detailed in a number of sections, and the top ten issues found by the IRF (Table 7) are addressed.

Dropped objects awareness

The Dropped Objects Prevention Scheme (DROPS) published a handbook [14], which brings together relevant requirements for securing fixed and freestanding equipment. It provides examples of the most important factors in the prevention of falling objects, including securing of permanently fixed equipment, securing of tools in use, and galvanic corrosion. Its purpose is to help eliminate the risk of falling objects.

Research report 237

This research report [15] gives guidance and advice on organisational and structural elements of a maintenance system and how to set one up and ensure its effectiveness. Sections of the document include maintenance system elements, design, scheduled and unscheduled maintenance, software programs, and maintenance system assessment.

Research report 213

The aim of this report [8] is to identify ways in which human factors best practice may be integrated into an offshore maintenance strategy. Key human factors issues were identified during interviews with six duty holders, one contractor, and one HSE inspector. The results are given below.

Duty holders and contractor

- Competency
- Learning from experience
- Supervision of multi-skilling
- Backlogs
- Identification of Safety Critical Elements (SCEs)
- Communication
- Hazard awareness
- Roles and responsibilities
- Resourcing
- Environmental issues/concerns

HSE inspector

- Multi-skilling
- Reduction in manning levels
- Supervision
- Hydrocarbon releases
- Backlogs

Offshore technology report 2001/088

Since the offshore oil and gas industry has been operating in the North Sea for over 30 years, many of the early platforms are approaching the end of their design life. This report [16] reviews current regulatory requirements and best practice for the use of offshore cranes beyond their design lives. Testing and inspection procedures are explained, as well as design and testing standards, condition monitoring, and management controls and procedures. Relevant legislation is listed and includes LOLER, PUWER, HSWA and MHSWR.

HSE information sheet number 3/2006

Risk assessment is broken down into several stages in this information sheet [17] including hazard identification, risk estimation and ranking of risks, identification of potential risk reduction, risk evaluation, intolerability, ALARP, and review. The legal background of risk assessments is discussed, and the document explains how risk assessments should be documented. It describes that a duty holder has a responsibility to ensure that risk assessments done by third parties are fit-for-purpose. Appendices offer further guidance on risk assessment approaches and uncertainties in risk assessments.

HSE information sheet number 7/2008

This guidance [18] provides advice on good practice approaches to shift working in the offshore industry. An SMS approach to shiftwork and fatigue is discussed using the HSE's model of policy, organising, planning and implementing, measuring performance, and auditing and reviewing performance. Advice is given on making the working environment more conducive to shift adaptation, such as having high light levels in work and recreational areas and blackout in sleeping accommodation. There is an annex containing information about circadian rhythm (body clock) adjustment and travel risks.

Simple guide to the Lifting Operations and Lifting Equipment Regulations 1998

This is a short HSE document [19] describing what the regulations are for and their requirements. LOLER requires lifting equipment provided for use at work to be, amongst other things, strong and stable enough for its particular use and positioned to minimise risks. The document explains how LOLER relates to other legislation and how the regulations are enforced, and lists several publications for further reading.

Simple guide to the Provision and Use of Work Equipment Regulations 1998

This guide [20] covers the same topics as the simple guide to LOLER, described above, in relation to the Provision and Use of Work Equipment Regulations (PUWER).

Key Programme 2: Auditing

The principal management failure identified by KP2 was a lack of effective auditing. In this guidance [21], auditing is defined as "a structured inspection by a competent independent body which has the required competence and knowledge in the subject or system being inspected, and is sufficiently independent from the subject or system to allow an unbiased judgement to be made".

Auditing of the planning of lifting operations is covered, with reference to LOLER regulation 8(1)(a) and the corresponding approved code of practice (ACOP). The section on auditing of risk assessment refers to MHSWR regulation 3(1), and the section on supervision states that LOLER 8(1)(b) is relevant. There are further short sections regarding auditing of LOLER, man riding, logistics and deck management, and learning from incidents and near misses.

Key Programme 2: Rigging loft guidance

KP2 found that the management and control of portable lifting equipment and lifting accessories was an area in which there were frequent failures. This short guide [22] describes key management elements, the control of lifting slings, and legal requirements such as LOLER 8, 9, 10 and 11 as well as the ACOP, and PUWER 5 and 9.

OMHEC Training Standard Certificate of Expertise

This document [23] gives guidance on training of offshore crane operators to ensure that they have "the necessary professional skills and competency to carry out their work safely and efficiently." Tables list the skills and knowledge required for the crane operator and banksmen (signaller and slinger), and a description of the functions involved in lifting operations, as well as the main tasks involved in each function. Training issues are also tabulated, such as planning lifting operations, implementation of standards, and general safety checks of the crane, lifting equipment and load. The qualifications and experience that an instructor or assessor require are also given. Finally the requirements of the facilities, for instance the classroom, documentation, and equipment, are listed.

LOLER 1998 – Open Learning Guidance

Guidance explaining LOLER in detail [24], the titles of the main regulations are given below:

1. Citation and commencement
2. Interpretation
3. Application
4. Strength and stability
5. Lifting equipment for lifting persons
6. Positioning and installation
7. Marking of lifting equipment
8. Organisation of lifting operations
9. Thorough examination and inspection
10. Reports and defects
11. Keeping of information

Each of the above regulations is described with reference to the ACOP, with definitions of key terms and case studies also included. Self-assessment questions are provided at the end of each regulation to test understanding. Regulations 12-17 deal with amendments, exemptions, and repeals and are not covered in detail.

PUWER 1998 – Open Learning Guidance

This guidance [25] provides information on the Provision and Use of Work Equipment Regulations (PUWER) 1998. PUWER consists of 35 regulations, the first 30 of these are covered in the guidance. Each regulation is described in the same way as in the LOLER guidance, key points are summarised, followed by the regulation text itself, a description with reference to the ACOP, case studies, key terms and self-assessment questions. A practical activity is provided to promote understanding of the regulation and help with application to particular situations. The second edition from 2008 clearly marks any new or altered parts of the regulations.

HSG 221

Technical information is provided for those involved in the supply, operation and control of lifting equipment offshore. The guidance [26] shows how to apply LOLER and PUWER offshore and is relevant to all offshore installations operating within the UK continental shelf. It includes sections about general considerations, such as selecting suitable equipment and planning operations, along with examples of different types of offshore lifting equipment including equipment for lifting people.

MHSWR – ACOP & Guidance L21

The requirements of the Management of Health and Safety at Work Regulations (MHSWR) 1999 are explained in this guidance [(27)]. Each of the 30 regulations is listed along with relevant general guidance and an Approved Code of Practice (ACOP) giving advice with a special legal status.

7 DISCUSSION

7.1 RIDDOR DATA

Fracture was the largest injury type with over 40 cases. Injuries were located in a variety of locations. Hit by moving, flying or falling object is the dominant kind of accident. Falls from height, Injured while handling, lifting or carrying and slipped tripped or fell on the same level are also significant. Some operating companies have more incidents than others. However this information needs normalising, as some operating companies have more staff and installations than others. Five grouped agents were significant:

- Surfaces at different levels: floors, ladders and scaffolding;
- Pipes and pipe fittings;
- Lifting and storage;
- Tools and machines; and
- Building materials and components.

Offshore construction and maintenance, and Offshore production are the worst work process environments having most incidents. Offshore drilling and Offshore deck operations also have significant numbers of incidents. Again it is necessary to normalise this data by taking account of the number of people working in each environment.

7.2 INVESTIGATION REPORT DATA

Impact dropped object was by far the largest direct cause with nearly 30 cases. In terms of underlying causes, the dominant one was Hazard Analysis/Risk Assessment. However other underlying causes were significant including Operating Procedures, Permits to Work and Supervision. Hazard Analysis/Risk Assessment may be dominant as it is the first part of a safety management system. For Health and Safety Management failings, monitoring, audit and review predominate. The failings involving organising are split into a number of sub-categories, so organising failings will be spread between categories. The main regulations and guidance quoted by inspectors were HSWA and MHSWR. More specific regulations and guidance LOLER and PUWER were also significant. Thus there were continuing problems associated with lifting and work equipment. None was also a significant here, perhaps highlighting guidance gaps in certain sectors. There was limited evidence that design faults contributed to the incidents.

7.3 FURTHER ANALYSIS

There is a strong link between the kind of accident – hit by moving, flying or falling object and the direct cause – impact dropped object. The most frequent injury type was fracture. Hazard Analysis/Risk Assessment predominates as the underlying cause and HSWA predominates as the regulation/guidance quoted. Detailed cross-referencing is done in section 4 but a number of useful observations are repeated here.

7.3.1 Kinds of Accident

The grouped agents had their own associated kinds of accident which seem appropriate to them:

- 1.xx surfaces at different levels (fall from height, slipped, tripped or fell at the same level);
- 6.xx lifting and storage (hit by object free falling from lifting machinery);
- 8.xx tools and machines (contact with moving machinery or material being machined); and
- 9.xx building materials and components (injured while handling, lifting or carrying).

There is an association between the work process environment and kinds of accident:

- Hit by moving, flying or falling object (1811 offshore production and 1814 offshore construction and maintenance);
- Injured while handling, lifting or carrying (1812 offshore drilling/workover); and
- Slipped tripped or fell (1814 offshore construction and maintenance and 1818 offshore deck operations and offshore transport).

7.3.2 Underlying Causes

Better use of permits to work would reduce fall from height and injured while handling, lifting or carrying; better supervision would reduce injured while handling, lifting or carrying. These observations could be used to target inspection activity.

The underlying causes tended to vary between accident types: Hit by moving, flying or falling object was caused by operating procedures, Fall from height by permit to work issues, Injured while handling, lifting carrying by permit to work issues and for Slipped, tripped or fell, the underlying cause was frequently unknown. These observations could be used to target inspection activity and highlight the need to study the underlying causes of slips trips and falls.

The grouped agents had their own associated underlying causes:

- 1.xx surfaces at different levels (Supervision, Permit to Work); and
- 6.xx lifting and storage (Supervision, Operating Procedures).

7.3.3 Health and Safety Management Failings

Better monitoring was required to reduce fall from height and better audit and review to reduce injured while handling, lifting or carrying. These observations could be used to target inspection activity.

Health and Safety management failings varied between accident types: Hit by moving, flying or falling object was due to poor monitoring and poor planning and implementation, falls from height were due to poor monitoring and for slipped, tripped or fell the failing was unknown. These observations could be used to target inspection activity and highlight the need to study the health and safety management failings associated with slips trips and falls.

There is an association between the work process environment and health and safety failing with unknown indicating that perhaps human factors have not been properly considered in that work process environment:

- 1811 offshore production (Monitoring, Audit and Review, Unknown);
- 1812 offshore drilling/workover (Monitoring, Unknown);
- 1814 offshore construction and maintenance (Monitoring); and
- 1818 offshore deck operations and offshore transport (Unknown).

The grouped agents have their associated health and safety management failing with unknown indicating that human factors have no been properly considered in that area:

- 1.xx surfaces at different levels (Monitoring, Unknown);
- 3.xx pipes and pipe fittings (Monitoring);
- 6.xx lifting and storage (Unknown, Monitoring, Audit and Review, Planning);
- 8.xx tools and machines (Monitoring); and
- 9.xx building materials and components (Unknown).

7.3.4 Regulations and Guidance

Certain regulations and guidance were cited for particular kinds of accident but for others none was cited, perhaps indicating none was available. Hit by moving, flying or falling object referred to both LOLER and MHSWR, injured while handling, lifting or carrying sometimes referred to MHSWR and none, and for slipped, tripped or fell there was generally no reference. This information could be used by inspectors to reinforce existing regulations/guidance and perhaps generate new guidance to prevent slips, trips and falls.

For the most frequently cited direct cause (Impact/dropped object), again sometimes particular regulations/guidance (MHSWR, LOLER) were referred and sometimes none.

7.4 COMPARISONS WITH PREVIOUS STUDIES

7.4.1 Statistics

The sample data of 67 incidents was compared with the complete fatality and major injury data for the same period. For the complete data:

- Fractures were again the largest injury type;
- There was still a spread in the injury locations;
- Other kinds of accident were also significant (injured while handling lifting or carrying, slip trip or fall on the same level and fall from height);
- Offshore deck operations and offshore drilling were more significant work process environments; and
- Agents of accident were generally consistent with the grouped agents used in section 2.5.

7.4.2 Previous causal analysis

Slips, Trips and Falls: There are far more slips and trips than falls from height. The activity at the time of the accident was commonly either climbing/descending or walking at same level. The main human causes identified were distractions/stress then poor management/supervision, lack of control, culture and lack of awareness. The main workable strategies were employee focus, training competence pre-management and campaigns. The main causes were lack of attention, risk awareness and housekeeping and possible prevention methods were risk assessment, communicate best practice and identify areas/training. Not much analysis of the underlying causes and health and safety management failings for slips and trips has been done, so this work is important and should perhaps be built on.

Lifting Incidents: Lifting incidents involving either drill handling equipment or mechanical handling equipment were classified as to the cause - equipment failures or human factors. For the incidents caused by human factors a root cause analysis was carried out. For drill handling equipment lifting incidents, operator error was a more significant human factors cause than positioning, whilst for mechanical handling equipment lifting incidents, these two human factors causes were equally significant. It would be better not to separate lifting incidents into those caused by equipment failures or human factors, but to look for both causes in all incidents.

Maintenance: The most significant causal factor was unsafe position/posture. The most significant latent errors were lack of awareness/attention, then inadequate work standard/lack of discipline. “Incidents / accidents resulting from maintenance are more likely to stem from a human factors-related root cause than an engineering one.”

Supply Chain Issues: The most significant first level active failures in the incidents studied were plant and equipment and using procedures. The most significant second level active failures were mechanical failure, procedure not followed and faulty plant operated. The most significant first level latent failures were hardware failures, then procedures/instructions/written practices, maintenance management and training/competence/awareness. The most significant second level latent failures were inspection and maintenance, gaps or omissions in individuals training and omissions or weaknesses in procedures. Similar underlying causes and health and safety management failings were noted in sections 7.2 and 7.3.

Deck and Drilling Operations: KP2 was set up in response to the unacceptable statistics from deck and drilling operations. The first phase showed the importance of the following root causes: risk assessment, job design, procedures and control of handovers and job supervision and monitoring. The worst performing topics in the second phase were Management, Planning and Control, Training & Competence and LOLER on Drill Floor. The dominant accident root causes were planning (includes risk assessment) supervision and hazard awareness. The leading root causes of deck and drilling lifting dangerous occurrences were mechanical failure, dropped objects and rigging competency. Although the number of deck and drilling accidents has been falling, those which are lift-related have been increasing. The present study confirms the same issues.

7.4.3 Previous HSL work

Offshore Hydrocarbon Releases: Equipment causes (external and internal corrosion, material defect) and operational causes (dropped object, inadequate isolation) tend to be direct causes. Procedural causes are a mixture of direct causes (inadequate procedure, procedural violation) and underlying causes (operating procedures, permit to work). Operational causes involving improper actions may be caused by underlying causes such as operating procedures, permits to work, supervision and communication. Procedural causes involving procedures and permits to work may be underling causes in themselves or be due to other underlying causes of supervision and communication.

Asset Integrity: Some KP3 topics directly related to underlying causes seem to show reasonable performance (communication onshore/offshore, technician/supervisor competence, supervision and review of ICP recommendations / verification). Topics directly related to Health and Safety Management failings also show reasonable performance (maintenance system evaluation, measuring compliance with performance standards, measuring quality of maintenance work and review of ICP recommendations/verification). Topics that measure outputs generally show poor performance (maintenance of SCEs, backlogs and deferrals). This would indicate that there are Health and Safety Management failings and underlying issues still present. This shows the advantage of having leading and lagging indicators.

7.5 GUIDANCE

A variety of guidance documents are available on the following topics: lifting, dropped objects, maintenance, cranes, risk assessment, shift work/fatigue, work equipment, deck and drilling operations and the management of health and safety at work. Topic areas without guidance have been highlighted in section 7.3.4.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

1) A sample of 67 offshore incidents involving fatalities and major injuries has been analysed using both investigation reports and RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations) reports. These incidents resulted in 5 fatalities and 62 major injuries. By far the most predominant injury type was fractures. Younger workers seem to be involved in fewer incidents than older age groups. The injured party was more likely to work for a contractor (42 individuals) rather than the installation operator (25 individuals).

2) The most common kinds of accidents were (in order of importance):

- Hit by moving, flying or falling object (mostly impact from dropped object);
- Injured while handling, lifting or carrying;
- Falls from height; and
- Slips trips and falls on the same level.

3) The most important underlying causes of accidents were (in order of importance):

- Inadequate hazard analysis / risk assessment;
- Inadequate supervision;
- Lack of / inadequate operating procedures; and
- Inadequacies in permit-to-work.

4) As might be expected, the work process environment and grouping of RIDDOR defined agents involved in the incidents correlated with the kind of accident:

- Hit by moving, flying or falling object was associated with offshore production, construction and maintenance and with the agents of lifting and storage (hit by object free falling from lifting machinery).
- Falls from height and slips, trips and falls at the same level were associated with offshore construction, maintenance, deck operations and transport and the main agent was surfaces at different levels.
- Injured while handling, lifting or carrying was mainly associated with offshore drilling / workover and the agent of building materials and components.

5) The main underlying causes associated with the main kinds of accident were:

- Operating procedures for ‘hit by moving, flying or falling object’;
- Permit-to-work for ‘fall from height’;
- Permit-to-work for ‘injured while handling, lifting or carrying’; and
- ‘Unknown’ for ‘slipped tripped or fell at the same level’.

In addition supervision was implicated for the agents ‘surfaces at different levels’ and ‘lifting and storage’, which were associated with slips, trips and falls and with being hit by falling objects.

6) The main identified safety management failings were in monitoring, audit and review and planning and implementation. In terms of failings associated with the main kinds of accident:

- Hit by moving, flying or falling object was due to poor monitoring; and planning and implementation;
- Falls from height were due to poor monitoring; and

- For slips, trips and falls at the same level and injured while handling, lifting or carrying, the management failing was usually unknown.

7) The main health and safety regulations referred to in investigation of incidents were LOLER (Lifting Operations and Lifting Equipment Regulations) and MHSWR (Management of Health and Safety at Work Regulations).

8) Consideration of previous causal analysis of offshore incidents confirmed the current analysis and adds the additional underlying causes and Safety Management System (SMS) failings:

- Human factors including distractions, stress and culture for slips, trips and falls;
- Operator error and poor positioning for lifting incidents;
- Poor communication was an underlying cause of hydrocarbon releases in addition to all the underlying causes found in the current analysis; and
- Backlogs and deferrals in the maintenance of Safety Critical Elements (SCEs) were highlighted by the analysis of the Key Programme 3 (Asset Integrity Programme) and indicate underlying management system failures.

8.2 RECOMMENDATIONS

1) Targeted inspection activity is needed on the following issues:

- Falls from height – Permit to work, monitoring;

- Injured whilst handling, lifting or carrying – Permit to work, supervision, audit and review, reference to MHSWR (Management of Health and Safety at Work Regulations); and

- Hit by moving, flying or falling object. – Operating procedures, monitoring, planning and implementation, use of LOLER (Lifting Operations and Lifting Equipment Regulations) and MHSWR.

2) Further work could usefully be undertaken to improve understanding in the following areas:

- Slipped, tripped or fell - Underlying causes are often unknown, health and safety management failings are often unknown, there is little reference to regulations and guidance.

- Injured while handling, lifting or carrying – Sometimes no reference to guidance or regulations.

3) Underlying causal analysis using both RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations) and HSE (Health and Safety Executive) Inspectors' reports could usefully be undertaken for major offshore dangerous occurrences.

9 APPENDIX A – CROSS REFERENCING TABLES

Key

- Kinds of accident other than 'hit by moving, flying or falling object' are underlined in red.
- Injury types other than 'fracture' are underlined in orange.
- Direct causes other than 'dropped object' are highlighted in yellow.
- Underlying causes are highlighted in bright green.
- Work Process Environment issues are underlined in dark red.
- Grouped agents are underlined in blue.
- Health and Safety Management Failings are highlighted in turquoise.
- Regulations and Guidance issues are highlighted in red.

9.1 KIND OF ACCIDENT

Table 8 Key factors for selected kinds of accident

Kind of accident	***Issue***	***Key factors***	
Hit by a moving, flying or falling object	Underlying causes	Hazard analysis/risk assessment	17
		Operating procedures	9
	Injury	Fracture	15
	Direct causes	Impact/dropped object	17
	Work process	1811 - Offshore production	9
		1814 - Offshore construction and maintenance	8
	Grouped agent involved	3.xx Pipes and pipe fittings	7
		9.xx Building materials and components	8
	Regulations and guidance	LOLER 1999	10
		MHSWR 1999	11
		HSWA 1974	15
	Health and safety management system failing	Monitoring	6
		Planning and implementation	6
Fall from height	Underlying causes	Permit to work	4
		Hazard analysis/risk assessment	4
	Injury	Fracture	6
	Direct causes	-	-
	Work process	-	-
	Grouped agent involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	6
	Regulations and guidance	-	-
	Health and safety management system failing	Monitoring	4
Injured while handling, lifting or carrying	Underlying causes	Hazard analysis/risk assessment	8
		Permit to work	6
		Supervision	6
	Injury	Amputation	3
		Fracture	5
	Direct causes	Impact/dropped object	7
	Work process	1812 – Offshore drilling/ workover	5
	Grouped agent involved	9.xx Building materials and components	6
	Regulations and guidance	MHSWR 1999	5
		None	4
	Health and safety management system failing	-	-

Kind of accident	*Issue*	*Key factors*	
Slipped, tripped or fell on the same level	Underlying causes	None	4
	Injury	Fracture	6
	Direct causes	Slip/fall	6
	Work process	1814 - Offshore construction and maintenance	3
		1818 - Offshore deck operations and offshore transport, including all lifting and crane work, and all helideck and sea transport activities	3
	Grouped agent involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	6
	Regulations and guidance	None	5
	Health and safety management system failing	Unknown	5

9.2 INJURY TYPE

Table 9 Key factors for selected injury types

Injury type	*Issue*	*Key factors*	
Fracture	Kind of accident	Hit by a moving, flying or falling object	15
	Direct causes	Impact/dropped object	17
	Underlying causes	Hazard analysis/risk assessment	26
		Supervision	16
	Work process	1814 - Offshore construction and maintenance	18
	Grouped agent involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	12
		3.xx Pipes and pipe fittings	7
		6.xx Lifting and storage	7
		9.xx Building materials and components	8
	Regulations and guidance	LOLER 1999	8
		None	12
		MHSWR 1999	19
		HSWA 1974	21
	Health and safety management system failing	Monitoring	6
		Planning and implementation	6

9.3 DIRECT CAUSE

Table 10 Key factors for selected direct causes

Direct cause	***Issue***	***Key factors***	
Impact/ dropped object	Underlying causes	Hazard analysis/risk assessment	21
	Injury	Fracture	17
	Kind of accident	Hit by a moving, flying or falling object	17
	Work process	1811 - Offshore production	11
		1812 - Offshore drilling/ workover	6
		1814 - Offshore construction and maintenance	8
	Grouped agent involved	6.xx Lifting and storage	8
		9.xx Building materials and components	12
	Regulations and guidance	LOLER 1999	10
		None	9
		MHSWR 1999	12
		HSWA 1974	15
	Health and safety management system failing	Monitoring	6
		Audit and review	6
		Planning and implementation	8
		Unknown	7

9.4 UNDERLYING CAUSE

Table 11 Key factors for selected underlying causes

Underlying cause	***Issue***	***Key factors***	
Operating procedures	Kind of accident	Hit by a moving, flying or falling object	9
	Injury	Fracture	9
	Direct cause	Impact/dropped object	9
	Work process	1811 - Offshore production	7
		1814 - Offshore construction and maintenance	7
	Agent involved	-	-
	Regulations and guidance	LOLER 1999	5
		PUWER 1998	5
		MHSWR 1999	8
		HSWA 1974	12
	Health and safety management system failing	Monitoring	8
Hazard analysis/ risk assessment	Kind of accident	Hit by a moving, flying or falling object	17
	Injury	Fracture	26
	Direct cause	Impact/dropped object	21
	Work process	1811 - Offshore production	12
		1814 - Offshore construction and maintenance	14
	Agent involved	3.xx Pipes and pipe fittings	9
		9.xx Building materials and components	12
	Regulations and guidance	LOLER 1999	10
		None	11
		MHSWR 1999	23
		HSWA 1974	18
	Health and safety management system failing	Monitoring	14
		Planning and implementation	9

Underlying cause	***Issue***	***Key factors***	
Permit to work	Kind of accident	Fall from a height	4
		Hit by a moving, flying or falling object	7
		Injured while handling, lifting or carrying	6
	Injury	Fracture	12
	Direct cause	Impact/dropped object	10
	Work process	1814 - Offshore construction and maintenance	9
	Agent involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	5
		9.xx Building materials and components	6
	Regulations and guidance	MHSWR 1999	10
		HSWA 1974	12
	Health and safety management system failing	Monitoring	8
		Planning and implementation	5
Supervision	Kind of accident	Hit by a moving, flying or falling object	6
		Injured while handling, lifting or carrying	6
	Injury	Fracture	16
	Direct cause	Impact/dropped object	12
	Work process	1811 - Offshore production	9
		1814 - Offshore construction and maintenance	8
	Agent involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	6
		3.xx Pipes and pipe fittings	5
		6.xx Lifting and storage	5
	Regulations and guidance	LOLER 1999	6
		None	9
		MHSWR 1999	12
		HSWA 1974	10
	Health and safety management system failing	Monitoring	11

9.5 WORK PROCESS ENVIRONMENT

Table 12 Key factors for selected work processes

Work process	***Issue***	***Key factors***	
1811 - Offshore production	Direct causes	Impact/dropped object	11
	Underlying causes	Hazard analysis/risk assessment	12
	Injury type	Fracture	8
	Kind of accident	Hit by a moving, flying or falling object	9
	Grouped agent involved	3.xx Pipes and Pipe Fittings	6
		6.xx Lifting and storage	4
		9.xx Building materials and components	6
	Regulations and guidance	LOLER 1999	6
		MHSWR 1999	12
		HSWA 1974	10
	Health and safety management system failing	Monitoring	8
		Audit and Review	7
		Unknown	6
1812 - Offshore drilling/workover	Direct causes	Impact/dropped object	6
	Underlying causes	Hazard analysis/risk assessment	8
	Injury type	Fracture	7
	Kind of accident	Injured while handling, lifting or carrying	5
	Grouped agent involved	9.xx Building materials and components	6
	Regulations and guidance	None	5
		MHSWR 1999	5
		HSWA 1974	6
	Health and safety management system failing	Monitoring	3
		Unknown	4

Work process	***Issue***	***Key factors***	
1814 - Offshore construction and maintenance	Direct causes	Impact/dropped object	8
	Underlying causes	Operating procedures	7
		Hazard analysis/risk assessment	14
		Permit to work	9
		Supervision	8
	Injury type	Fracture	18
	Kind of accident	Hit by a moving, flying or falling object	8
	Grouped agent involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	7
		3.xx Pipes and pipe fittings	5
		8.xx Tools and Machines	6
	Regulations and guidance	None	11
		MHSWR 1999	7
		HSWA 1974	10
	Health and safety management system failing	Monitoring	9
1818 - Offshore deck operations and offshore transport, including all lifting and crane work, and all helideck and sea transport activities	Direct causes	Slip/fall	5
	Underlying causes	Hazard analysis/risk assessment	4
		Permit to work	3
		Supervision	3
	Injury type	Fracture	7
	Kind of accident	Slipped, tripped, or fell	3
	Grouped agent involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	5
	Regulations and guidance	MHSWR 1999	4
		HSWA 1974	4
	Health and safety management system failing	Unknown	4

9.6 AGENT

Table 13 Key factors for selected agents

Agent	*Issue*	*Key factors*	
1.xx - Surfaces at different levels: floors, ladders, scaffolding	Kind of Accident	Fall from a height	6
		Slipped, tripped or fell on the same level	6
	Direct Causes	Slip/fall	7
	Underlying Causes	Hazard analysis/risk assessment	7
		Permit to work	5
		Supervision	6
	Work Process	1814 - Offshore construction and maintenance	7
		1818 - Offshore deck operations and offshore transport, including all lifting and crane work, and all helideck and sea transport activities	5
	Injury Type	Fracture	12
	Regulations and Guidance	PUWER 1998	4
		None	7
		MHSWR 1999	6
		HSWA 1974	7
	Health and safety management system failing	Monitoring	6
		Unknown	4
3.xx - Pipes and pipe fittings	Kind of Accident	Hit by a moving, flying or falling object	7
	Direct Causes	Impact/dropped object	5
	Underlying Causes	Hazard analysis/risk assessment	9
	Work Process	1811 - Offshore production	6
		1814 - Offshore construction and maintenance	5
	Injury Type	Fracture	7
	Regulations and Guidance	MHSWR 1999	8
		HSWA 1974	7
	Health and safety management system failing	Monitoring	4

Agent	*Issue*	*Key factors*	
6.xx - Lifting and storage	Kind of Accident	Hit by object(s) free falling from lifting machinery, vehicles and other equipment. Include components of machinery which may fall but still attached.	3
	Direct Causes	Impact/dropped object	8
	Underlying Causes	Operating Procedures	4
		Hazard analysis/risk assessment	5
		Supervision	5
	Work Process	1811 - Offshore production	4
	Injury Type	Fracture	7
	Regulations and Guidance	LOLER 1999	3
		MHSWR 1999	3
		HSWA 1974	5
	Health and safety management system failing	Monitoring	3
		Audit and Review	3
		Planning and implementation	3
		Unknown	4
8.xx - Tools and machines	Kind of Accident	Contact with moving machinery or material being machined	4
	Direct Causes	Human error	3
	Underlying Causes	Operating Procedures	3
		Hazard analysis/risk assessment	4
	Work Process	1814 - Offshore construction and maintenance	6
	Injury Type	Fracture	5
	Regulations and Guidance	None	5
	Health and safety management system failing	Monitoring	4

Agent	*Issue*	*Key factors*	
9.xx - Building materials and components	Kind of Accident	Hit by a moving, flying or falling object	8
		Injured while handling, lifting or carrying	5
	Direct Causes	Impact/dropped object	12
	Underlying Causes	Hazard analysis/risk assessment	12
	Work Process	1811 - Offshore production	6
		1812 - Offshore drilling/ workover	6
	Injury Type	Fracture	8
	Regulations and Guidance	LOLER 1999	5
		None	5
		MHSWR 1999	7
		HSWA 1974	7
	Health and safety management system failing	Unknown	5

9.7 HEALTH AND SAFETY MANAGEMENT SYSTEM FAILING

Table 14 Key factors for selected health and safety management failings

Health and safety management failing	***Issue***	***Key factors***	
Monitoring	Kind of Accident	Fall from a height	4
		Hit by a moving, flying or falling object	6
	Direct Causes	Impact/dropped object	6
		Procedural violation	4
	Underlying Causes	Operating Procedures	8
		Hazard analysis/risk assessment	14
		Permit to work	8
		Supervision	11
	Work Process	1811 - Offshore production	8
		1814 - Offshore construction and maintenance	9
	Injury Type	Fracture	13
	Regulations and Guidance	PUWER 1998	8
		MHSWR 1999	14
		HSWA 1974	16
	Grouped agent involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	6
		3.xx Pipes and Pipe Fittings	4
		8.xx Tools and Machines	4
Audit and Review	Kind of Accident	Hit by a moving, flying or falling object	4
		Injured while handling, lifting or carrying	3
	Direct Causes	Impact/dropped object	6
	Underlying Causes	Hazard analysis/risk assessment	7
	Work Process	1811 - Offshore production	7
	Injury Type	Fracture	5
	Regulations and Guidance	MHSWR 1999	8
		HSWA 1974	7
	Grouped agent involved	-	-

Health and safety management failing	***Issue***	***Key factors***	
Planning and implementation	Kind of Accident	Hit by a moving, flying or falling object	6
	Direct Causes	Impact/dropped object	9
	Underlying Causes	Hazard analysis/risk assessment	9
	Work Process	1814 - Offshore construction and maintenance	5
	Injury Type	Fracture	8
	Regulations and Guidance	HSWA 1974	6
	Grouped agent involved	6.xx Lifting and storage	3
		9.xx Building materials and components	3

9.8 REGULATIONS AND GUIDANCE MENTIONED

Table 15 Key factors for selected regulations and guidance

Regulations and guidance mentioned	***Issue***	***Key factors***	
LOLER 1998	Kind of Accident	Hit by a moving, flying or falling object	10
	Injury	Fracture	8
	Direct Causes	Impact/dropped object	10
	Work Process	1811 - Offshore production	6
	Grouped Agent Involved	9.xx Building materials and components	5
	Underlying Causes	Hazard analysis/risk assessment	10
	Health and safety management system failing	Monitoring	4
		Planning and implementation	3
PUWER 1998	Kind of Accident	Hit by a moving, flying or falling object	5
	Injury	Fracture	5
	Direct Causes	Impact/dropped object	10
	Work Process	1811 - Offshore production	4
		1814 - Offshore construction and maintenance	4
	Grouped Agent Involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	4
		3.xx Pipes and Pipe Fittings	3
	Underlying Causes	Operating Procedures	5
		Hazard analysis/risk assessment	7
	Health and safety management system failing	Monitoring	8

Regulations and guidance mentioned	***Issue***	***Key factors***	
MHSWR 1999	Kind of Accident	Hit by a moving, flying or falling object	11
	Injury	Fracture	19
	Direct Causes	Impact/dropped object	12
	Work Process	1811 - Offshore production	12
	Grouped Agent Involved	1.xx Surfaces at different levels, floors, ladders, scaffolding	6
		3.xx Pipes and Pipe Fittings	8
		9.xx Building materials and components	7
	Underlying Causes	Operating Procedures	8
		Hazard analysis/risk assessment	23
		Permit to work	10
		Supervision	12
	Health and safety management system failing	Monitoring	14
		Audit and Review	8

10 APPENDIX B - HYDROCARBON RELEASES CAUSAL TABLES

The blue bold text indicates the top three causes in each category.

Table 16 Release causes per year – Equipment Cause

Equipment Cause	Year							Total
	2001	2002	2003	2004	2005	2006	2007	
Awaiting Investigation	5	0	4	2	0	0	0	11
External Corrosion	2	3	3	3	4	0	1	16
Internal Corrosion	9	6	10	7	9	5	4	50
Erosion	3	3	3	3	5	4	1	22
Manufacturing	0	0	1	0	0	0	0	1
Material Defect	2	1	2	1	3	0	1	10
Mechanical Failure	**58**	**26**	**35**	**30**	**27**	**22**	**14**	**192**
Mechanical Fatigue	**11**	**11**	**6**	**12**	**8**	**9**	**5**	**62**
Mechanical Wear	7	5	6	4	4	5	2	33
None	**34**	**30**	**23**	**22**	**16**	**15**	**9**	**149**
Not Known	0	2	0	0	0	0	0	2
Specification	2	3	0	1	0	1	0	7
Blanks	0	0	0	0	2	16	22	40
Total	113	90	93	85	78	77	59	595

Table 17 Release causes per year - Operational Cause

Operational Cause	Year							Total
	2001	2002	2003	2004	2005	2006	2007	
Adverse Weather	1	0	0	0	0	0	0	1
Awaiting Investigation	2	0	2	0	0	0	0	4
Dropped Object	2	1	4	0	1	0	0	8
Improper Inspection	3	5	2	2	2	0	1	15
Improper Maintenance	10	1	10	3	5	7	1	37
Improper Operation	**12**	**13**	**11**	**6**	**10**	**5**	**0**	**57**
Improper Testing	1	1	0	0	0	0	0	2
Incorrectly Fitted	**13**	**11**	**8**	**15**	**6**	**6**	**4**	**63**
Left to Open	7	9	7	9	8	10	6	56
None	**60**	**48**	**45**	**48**	**41**	**41**	**26**	**309**
Opened	1	1	4	1	4	2	2	15
Specification	1	0	0	1	0	2	0	4
Blanks	0	0	0	0	1	4	19	24
Total	113	90	93	85	78	77	59	595

Table 18 Release causes per year – Procedural Cause

Procedural Cause	Year							Total
	2001	2002	2003	2004	2005	2006	2007	
Awaiting Investigation	0	0	2	2	0	0	0	4
Deficient Procedure	**15**	**11**	**5**	**8**	**10**	**3**	**1**	**53**
Non-compliance with a Procedure	**13**	**10**	**11**	**10**	**5**	**9**	**4**	**62**
Non-compliance with a Permit to Work	2	1	2	1	3	1	2	12
None	**82**	**68**	**73**	**64**	**59**	**59**	**43**	**448**
Quality Control	1	0	0	0	0	1	0	2
Blanks	0	0	0	0	1	4	9	14
Total	113	90	93	85	78	77	59	595

11 APPENDIX C – GROUPED AGENTS

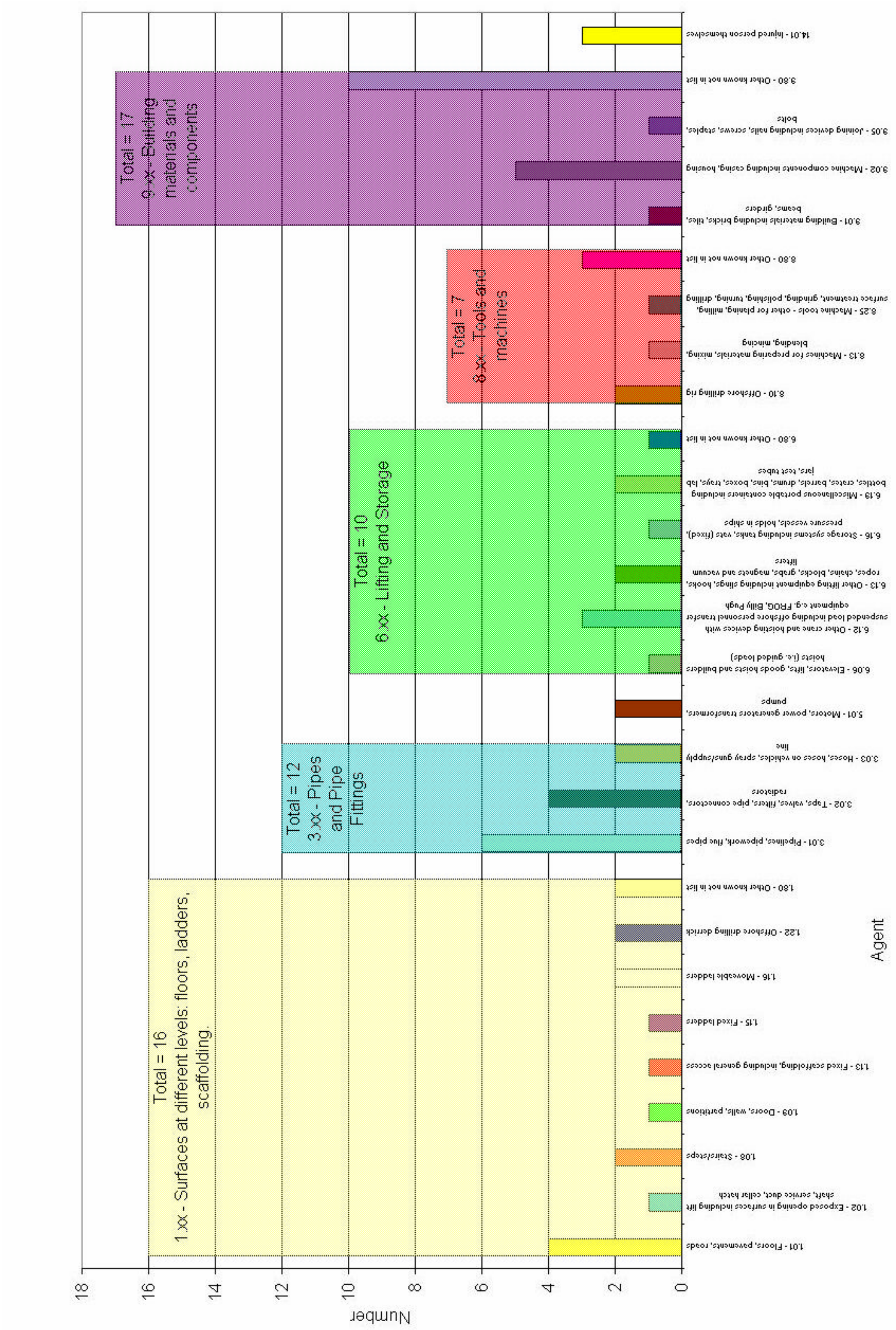


Figure 21 Grouping of agents involved in the incidents

12 APPENDIX D - INJURY TYPE AND AGE TABLES

Analysed data totals

Types	*Number*	*Percentage*
Major	62	92.54%
Fatality	5	7.46%

Number of incidents from each financial year	*Analysed*			*Total*		
	All	*Major*	*Fatal*	*All*	*Major*	*Fatal*
2004/2005	15	14	1	48	48	0 (1)
2005/2006	22	20	2	52	50	2
2006/2007	17	15	2	41	39	2
2007/2008	13	13	0	44	44	0
Total	67			137		

Age Ranges	*Number*
20 or under	0
21-30	11
31-40	18
41-50	17
51-60	15
61 or over	2
Unknown	4
Total	67

Did the IP work for a contractor?	*Number*	*Percentage*
Contractor	42	62.69%
Installation operator	25	37.31%

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14 NOMENCLATURE

ACOP	Approved Code of Practice
DHE	Drill handling equipment
DROPS	Dropped Objects Prevention Scheme
EF	Equipment failures
HF	Human factors
FP	Floating Production
FPSO	Floating Production, Storage and Offloading facility
FSU	Floating Storage Unit
HCR	Hydrocarbon Releases
HSE	Health and Safety Executive
HSL	Health and Safety Laboratory
HSWA	Health and Safety at Work Act
IMT	Inspector Management Teams
ICP	Independent Competent Person
IP	Injured Party
IRF	International Regulators Forum
KP2	Key Programme 2 (Deck and Drilling Operations)
KP3	Key Programme 3 (Asset integrity Programme)
LOLER	Lifting Operations and Lifting Equipment Regulations
MHE	Mechanical handling equipment
MHSWR	Management of Health and Safety at Work Regulations
NUI	Normally unmanned installation
OIAC	Offshore Industry Advisory Committee
OIM	Offshore Installations Manager
OMHEC	Offshore Mechanical Handling Equipment Committee
OSD	Offshore Safety Division - Topsides
OSD3	Offshore Safety Division 3

PUWER	Provision and Use of Work Equipment Regulations
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
SCE	Safety Critical Element
SMS	Safety Management System
SPC	Semi Permanent Circular
STF	Slips, trips and falls
TLP	Tension Leg Platform