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A PROPOSED APPROACH TO ENHANCE SAFETY LEVELS OF CRANE HANDLING ONBOARD SUPPLY VESSELS

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ABSTRACT

It is very common to see an Offshore Supply Vessel (OSV) operating along-side different types of fixed and floating platforms. These OSVs operations include transfer of personnel, equipment and cargo to and from platforms. Cranes are one of the main tools used in handling cargo and equipment between supply vessels and offshore installations. Crane handling operations between supply vessels and platforms are among the operations that need very good communication between various parties including: crane operators, supply vessel crew and platform operators. Catastrophic results; such as, hoisting failure, load failure or the crane itself collapsing could be the outcome of many circumstances going wrong at any moment during crane operations. The number of accidents recently monitored during crane operations has increased vigorously; for example, according to Health and Safety Executives (HSE), 519 lifting incidents took place in the period between 1991 to 1997; while 1439 incidents occurred in the period 1997 to 2009, according to Sparrows (Sparrows Offshore Services Ltd, on behalf of the Health and Safety Executive Offshore Safety Division) database. Therefore, it has become important to analyze more deeply the root causes behind such incidents. This paper illustrates the different operations performed by the various forms of crane handling between offshore supply vessels and installations. However, the paper focuses on the operations carried out onboard supply vessels as well as navigational aspects by applying the frequency analysis findings. The final part of the paper presents some recommendations on how to raise safety standards, prevent the re-occurrence of problems and overcome them.

KEYWORDS: Crane, Offshore Supply Vessel (OSV), Safety, Rigger, Human Error, Training

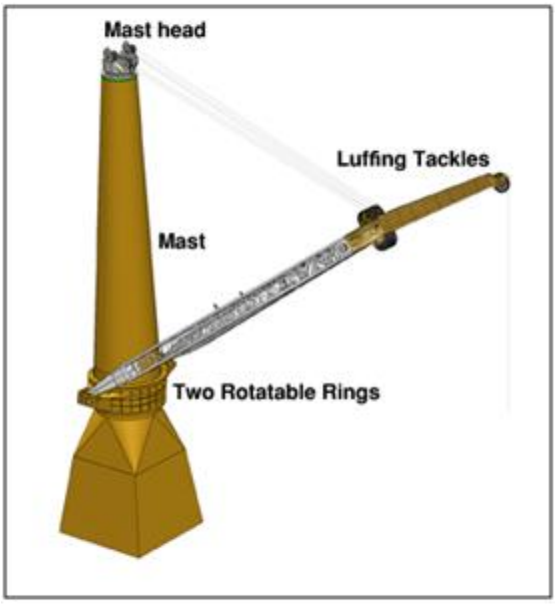
INTRODUCTION

When it comes to offshore cranes, they can be generally divided into cranes that are placed on a platform whether fixed or floating, and cranes that are mounted on vessels. Offshore cranes include production platform cranes, drilling platform cranes, Floating Production, Storage and Offloading (FPSO) cranes in addition to cranes for multi-purpose service vessels. Offshore cranes also come in different types; for instance, mast cranes, pedestal cranes, derrick cranes, gantry cranes and bridge cranes. Each of the crane types has different usages and where similar functions come in common between them, each will have advantages and disadvantages. Perhaps the most commonly used are two types whether in vessel to vessel or vessel to platform lifting operations. These are mast cranes and pedestal cranes. It is also worth mentioning that these two types of cranes appear among the highest accident lists; thus, the next section sets a comparison between them.

- **Mast Crane:** As the name implies, a mast crane consists mainly of a steel mast welded to the deck. Only the jib and mast head rotate. Around the mast, there are two rotatable rings – the slew platform which has the jib and its pivots, the control cabin and tugger winches if required - and the masthead with the connection for the luffing tackles and the main hoists. The masthead is fitted on a slew bearing and is free to rotate to follow the direction of the luffing tackles.

The advantages/disadvantages of a mast crane are:

- The load moment is transferred through the mast construction rather than the slew bearing, which makes the slew bearing less critical.
- A mast crane will be slightly heavier than a similar sized pedestal crane.
- Smaller installation area for larger cranes because a large diameter slew bearing is not needed but more headroom is needed.
- Vertical lashing of jib is possible.
- Limited tail swing.
- The additional costs of a mast crane due to the extra steelwork in the mast mean that the savings to be made in the slew bearing may only become apparent as the size of the crane increases. [1]



Source: http://www.leenaars-bv.nl/index.php/kingpost-mast-crane.html (2006)

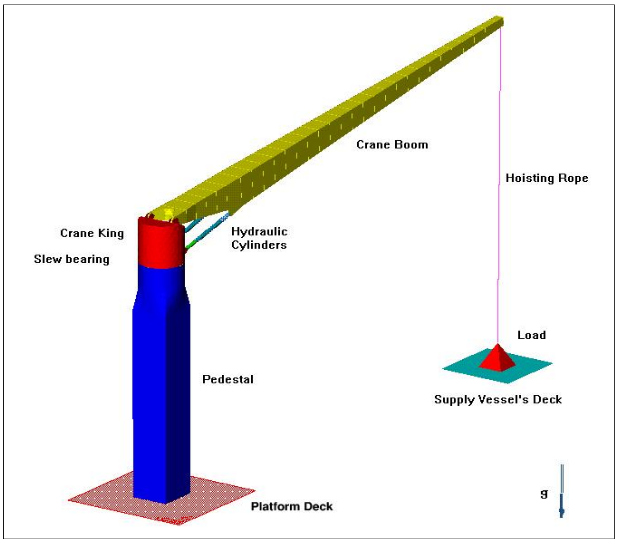
Figure 1: Mast Crane Model [2]

- **Pedestal Crane:** The most common type of crane consists of a steel crane house bolted to the pedestal via a slew bearing. The winches, hydraulic equipment, electrical cabinets, jib pivots, luffing tackles, hydraulic rams and control cabin are all attached either inside or outside the crane house. The slew bearing is a critical part of the pedestal crane and there are various measures that the customer can take in order to reduce the likelihood of having to routinely replace the bearing, an expensive and time consuming task. These include fitting of internal crack monitoring equipment, routine grease sampling and analysis and the fitting of load data recording equipment which will maintain a history of lift cycles, total loading and any overload conditions. Use of these measures can mean that it is possible for Classification Societies to allow the original slew bearing to last for the design life of a crane.

  The advantages/disadvantages of a pedestal crane are:

  - Equipment can be housed inside the crane house. (i.e.: no equipment within the hull or on deck).
  - Generally lighter than a similar sized mast crane.

- Simple interface with vessels structure.
- Can be mounted on the side of the hull due to simple interface.
- Generally less headroom is needed than with a mast crane. [1]



Source: Modeling and Simulation of Offshore Crane Operations on a Floating Production Vessel (2002)

Figure 2: Assembled Pedestal Crane Model [3]

CRANE HANDLING OPERATIONS AND ASSOCIATED JOBS

Offshore cranes perform various operations ranging from pipe laying, transferring personnel and heavy lifting. The various jobs required for completion of a lifting operation include: rigging, slinging, monitoring, crane operating and vessel maneuvering. Lifting operations can sometimes involve dangerous cargo such as chemical substances and this requires certain precautionary measures to ensure safety. In order to understand the risks associated with lifting operations light must be shed on the most important jobs necessary for operations and their needed entry criteria which cover various points including certification, safety, health and environment training, safety/risk awareness and communication skills:

- **Able-Seafarer- Deck:** An able-seafarer on deck is someone who carries out cargo and store operations; as well as, contributes to the safe operation of equipment and machinery on board and at sometimes carry maintenance and repair activities.

As for certification for able-seafarer, the job demands a minimum requirement of 500GRT or more: Valid certificate of competency or certificate of equivalent competency for the flag state of the vessel issued in accordance with STCW reg II/5 and appropriate seagoing service. Awareness of risk and safety is a must and a record of competence to be an able seafarer who needs to take cognizance of flag and coastal state requirements at an operational level is required. [4]

- **Rigger Foreman:** A rigger foreman is someone whose job is to supervise the rigging crew. A rigger foreman is usually required for heavy lifts, pipe laying (rigid or flexible) or well servicing operations. A rigger foreman's job functions also include: ensuring the safe handling of lifts/cargo, maintaining the safe conditions of lifts equipment, co-coordinating toolbox talks and shift handovers and planning and implementing a communication system throughout the work scope.

Experience is the controlling factor for the job as it demands appropriate supervisory experience to be rigger foreman and demonstrating knowledge of slinging and rigging offshore. A record of competence to be a Rigger foreman who needs to take cognizance of flag and coastal state requirements demonstrating relevant experience offshore is required. [4]

- **Rigging Personnel:** “A rigger is anyone who attaches or detaches lifting equipment to loads or lifting devices.”

The term rigger is sometimes used to describe the role of able seafarer; thus, similar criteria apply with the focus on knowledge and experience in slinging and rigging offshore. [4]

An important part of crane safety is proper training of rigger personnel. Accidents and injuries can occur as a result of rigging errors. Due to the frequency of accidental occurrences involving rigging personnel whether as error makers or victims of others’ errors, it is vital that all riggers have to receive proper training about:

Rigging Hardware

Such as Sheaves, hooks, latches, rings, links, cable clips, and other attachment points.

Slings

Such as sling configuration, sling angle, rated Load, sling types (synthetic, wire, chain, etc.), cargo nets, personnel baskets, and other basket types.

Procedures and Precautions

Such as load control/taglines, lift planning (load weight, center of gravity, etc.), sling inspection/rejection criteria and personnel transfer.

Rigging Basics

Such as pinch points/body position, personal Protective Equipment (PPE) and signals/communications.

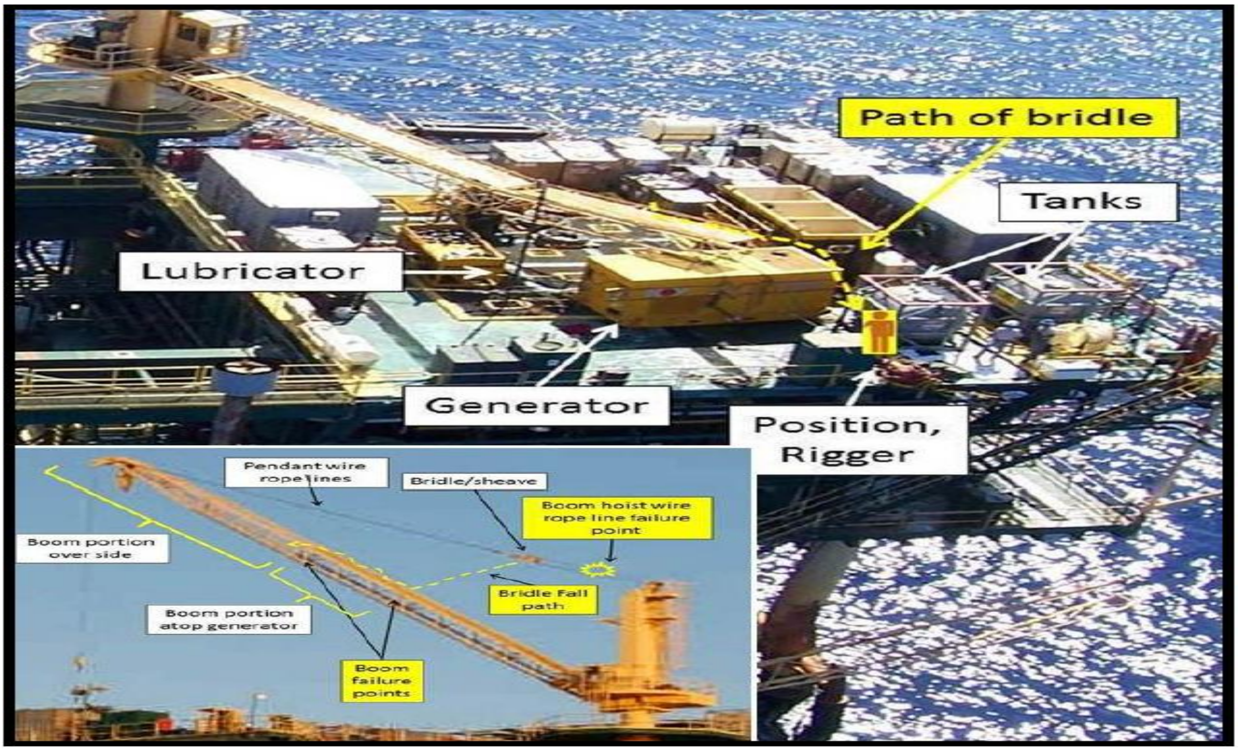
- **Crane Operator:** A person so designated by the employer who has appropriate offshore experience and training. Such appropriate experience and training must comprise minimum amounts of classroom-type sessions and hands-on field training, on cranes specific to the type of crane to be operated by the qualifying operator. [5]

One cannot pursue the job of crane operator unless equipped with proper certification in all areas of operation, emergency response, communication skills. Appropriate experience to be Crane operator must be acquired. Current and valid training certificate appropriate to Crane operator must be present and a record of competence to be a Crane operator which needs to take cognizance of flag and coastal state requirements at an operational level demonstrating relevant experience offshore. [4]

OVERVIEW OF CRANE HANDLING SAFETY

On 16 August 2011 at approximately 0815 hours, a fatal accident occurred on the offshore production platform, High Island A557 “A”, operated by Energy Resource Technology GOM, Inc. (ERT). Platform personnel were using the platform crane to move a rental generator from the platform onto a motor vessel. When the load was lifted, the crane’s boom hoist wire rope failed, the generator dropped to the deck, and the boom fell striking the generator. The boom subsequently broke into three sections; one section attached to the crane, the middle section resting on top of the dropped generator, while the nose section continued overboard. The crane’s main block hook subsequently disengaged releasing the connection between generator and boom nose.

The falling boom nose dragged the attached bridle/sheaves behind it as it fell overboard until its fall was arrested by the main load line and bridle pendant wire ropes. The 850-lb bridle/sheaves struck the fallen boom and pulled by the nose, ricocheted off of the end of the middle section, finally coming to rest against the platform toe-board. The rigger handling the left tag line was struck by the bridle and fatally injured. Figure [3] below illustrates the accident. [6]



Source: OCS Report BSEE 2013-01 (Bureau of Safety and Environmental Enforcement)

Figure 3: Overview of Accident

Improved safety in lifting operations involves many areas starting with the quality of design and manufacturing to skill and experience of personnel, and ending with effective maintenance and inspection. Being a top priority issue, safety becomes inevitably dependant on the following main points:

Design and Building up

The quality of the design of offshore cranes provides the basis for safe operations. It is essential that personnel responsible for the design and manufacture take into account the intended operational aspects of the offshore cranes and also the environment in which the offshore cranes are to be used. The design should take into account the requirements for ease of maintenance, inspection and expert verification during the operation phase.

All functions should, as far as reasonably practicable, be tested and verified as being fit for purpose by the manufacturer/supplier at his premises before the offshore crane is shipped and mounted to its final destination.

Skill and Experience of Personnel

All personel involved with lifting operations shall have the necessary training skills and experience in such operations. The Emergency Operations Center (EOC) or entity should regularly (during annual control) assess such skills utilizing international recognized standards and codes of practice for safe use.

A very important point that this paper highlights is that the standards for certifying personnel working in lifting operations specified by various associations; such as, The International Marine Contractors Association (IMCA), International Association of Classification Societies (IACS) and Offshore Petroleum Industry Training Organization (OPITO) are only optional and non compulsory to international application. There are only two organizations that enforce international application of standards. These two organizations are:

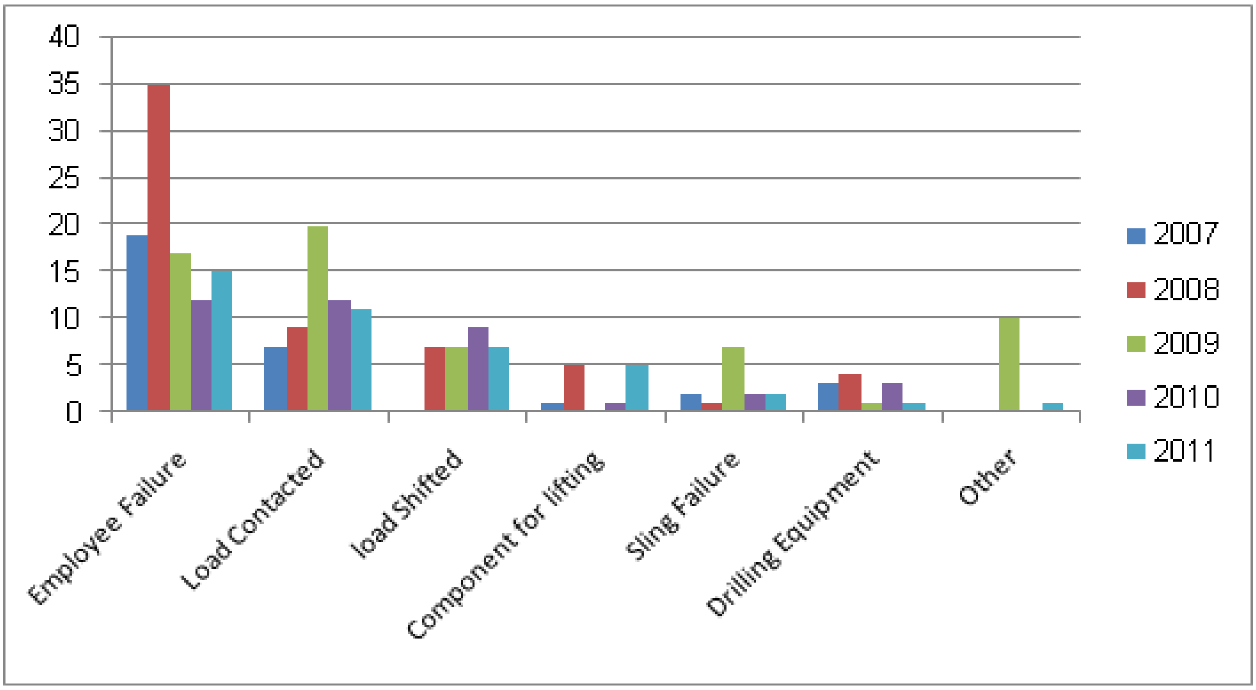
- The International Maritime Organization (IMO) represented in the Standards of Training, Certification and Watch keeping (STCW) and its amendments in Manila 2010 Chapter 5 part b that states the guidelines for certification and training of masters and officers on supply vessels. Apparently, these obligatory standards are not sufficient as they do not cover any areas specific to lifting operations.
- The International Labor Organization (ILO) represented in the Maritime Labor Convention (MLC) 2006. Yet, the convention merely covers the social life aspects of the personnel involved.

Maintenance and Inspections

Maintenance and inspection shall be carried out in accordance with a plan prepared on the background of e.g. information from the manufacturer, the use of the equipment, the environment at the worksite

Whenever the offshore crane has been modified, re-sited or subjected to a major repair, the EOC shall verify that the equipment is fit for use and in accordance with applicable regulations and applied standards. [7]

Crane operations pose risk as any other marine operation as they can cause injuries to crew involved or even fatalities. Figure [4] below shows the number of injuries on the Outer Continental Shelf (OCS) according to a review by the American Petroleum Institute (API) Offshore Lifting Safety Data Workgroup (OLSDW):



Source: http://www.drillingcontractor.org/ocs-safe-lifting-group-new-incident-reporting-format-to-aid-analysis-16772

Figure 4: Number of Injuries on the Outer Continental Shelf [8]

According to HSE, 519 lifting incidents took place in the period 1991 to 1997; while 1439 incidents occurred in the period 1997 to 2009, according to Sparrows database. The lifting incidents are generally divided into two sub categories: drilling handling equipment and mechanical handling incidents with each caused by either human factors or mechanical failures as presented in Figure 3 below. [7]

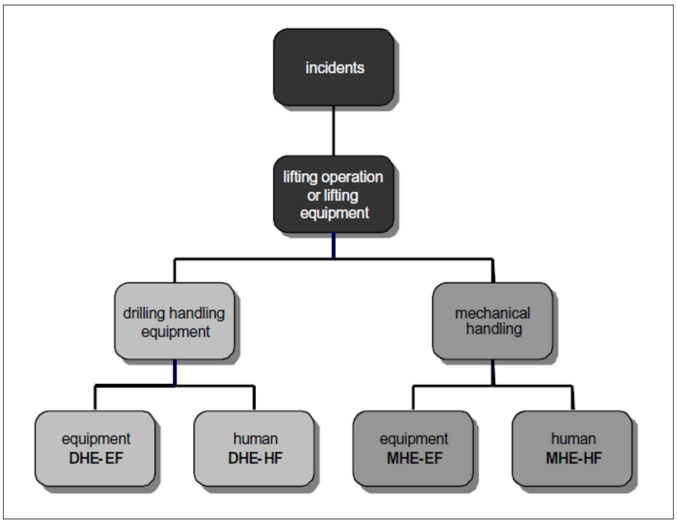


Figure 5: Second Level Categorization [9]

The databases proved that human factors came on top of the causes of lifting operations incidents with an average percentage of approximately 80% in the period 1991-1997, and 90% in the period 1997-2009 as illustrated in Figures 4 and 5 below, respectively. It is worth mentioning that the stated percentage covers the human errors on board installations or vessels or for maintenance reasons. Therefore, the study will focus on the human factors as the highest cause.

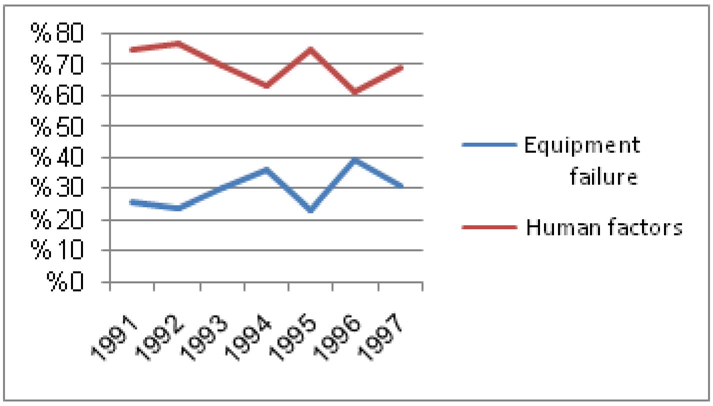


Figure 6: Percentage of Top Contributing Factors to Lifting Incidents (1991-1997) [9]

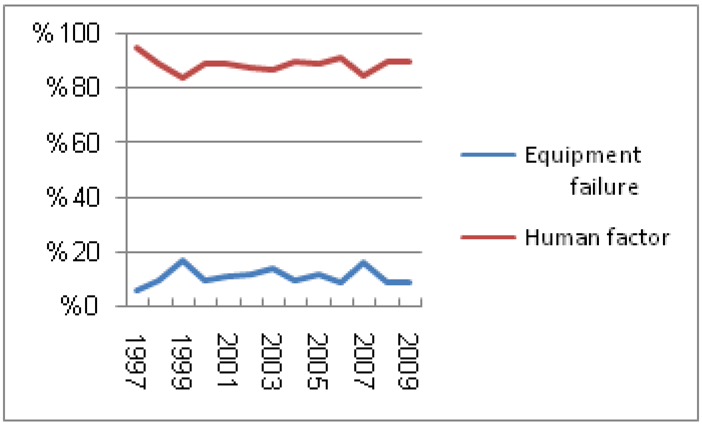


Figure 7: Percentage of Top Contributing Factors to Lifting Incidents (1997-2009) [9]

Since, the scope of the paper covers only the part of crane operations which is related to the offshore supply vessel; thus, the next section inspects the most common problems that take place on board supply vessels. However, let us first inspect the percentage of incidents through the graphs below. In the period 1991-1997 vessel-pedestal crane operations incidents caused amounted to 10% while the same percentage jumped to 19% in the period 1997-2009. Whereas, vessel lifts incident caused by human factors represented 6% in the period 1991-1997 compared to 13% in the period 1997-2009. To conclude that the total percentage of incidents caused by human factors and that involve supply vessels escalated from 16% in the period 1991-1997 to 32% in the period 1997-2009.

The latest detailed data available about lifting operations is that presented by the lifting incident review 1998 – 2003 provided by HSE. Figure 6 below illustrates the number of incidents divided by root causes of human factors. As the database determines 7 root causes being: banking, positioning, slinging, packing, procedures, operator errors and maintenance; the paper will disregard packing, operator errors and maintenance for being out of the study's scope.

SAFETY AS REGARDS HUMAN FACTORS

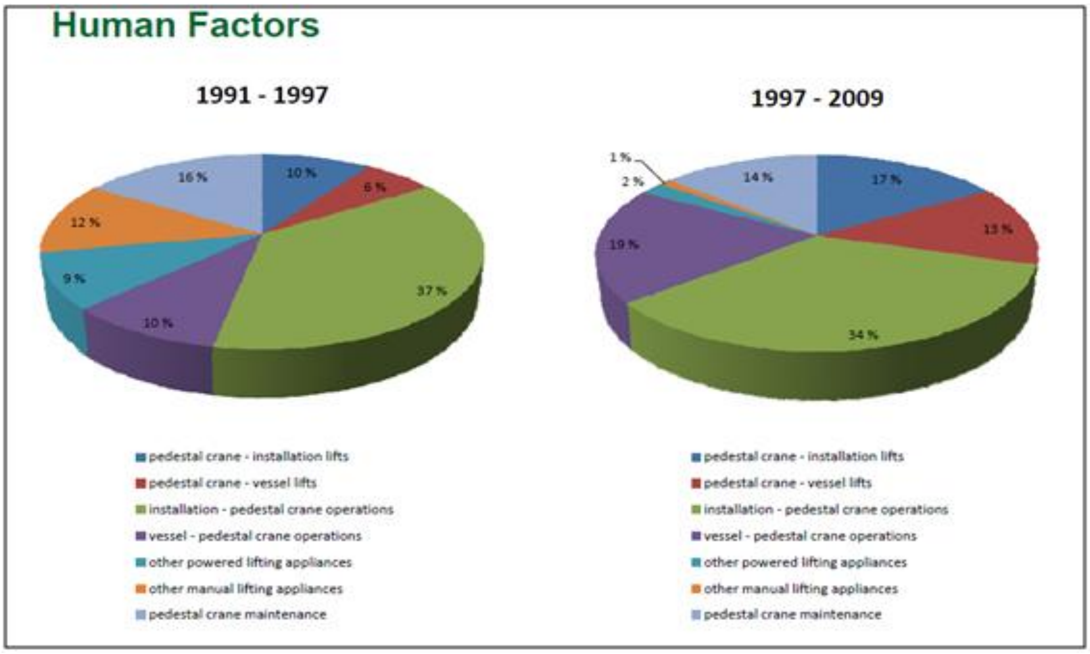


Figure 8: Number of Incidents Divided by Root Causes of Human Factors [7]

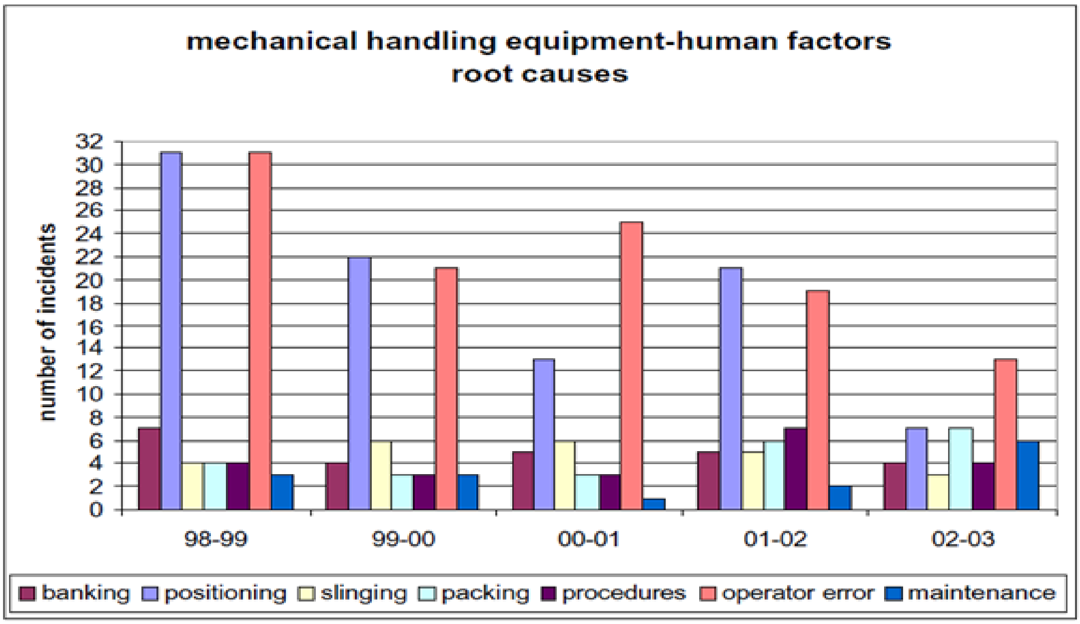


Figure 9: Human Factors Root Causes [10]

Positioning

Figure 7 above shows that "positioning" appears to come on top of the root causes in the years 1998-1999, 1999-2000, 2001-2002 and as the second from top in the years 2000-2001 and 2002-2003. Positioning of the vessel for a lifting operation is such a delicate matter that could lead to very significant consequences in cases of taking wrong position or failure to maintain position. The OSVs carrying out lifting operations should have high positioning capabilities. Human error in "Positioning", as a root cause of lifting incidents, is a complex matter; where many factors have to be taken into consideration. These factors start with the deficient making of cargo plans. According to the Norwegian Continental Shelf Operations Manual, "A cargo plan must be prepared before cargo is placed on board the vessel. The vessel's captain, or the captain's deputy, must participate in the preparation of this. It is important that the captain, or the captain's deputy, on their own initiative, actively contacts the base personnel, if they are not called in to a cargo meeting, or if such a meeting is not held." [11]

A bad cargo plan may force a vessel operator to change position several times in order to carry out a lifting operation. For instance, on Friday, February 17, 2012, an incident with major consequences took place when a 20 ft basket got snagged during offloading from the North Challenger to L10-E resulting eventually in the crane being pulled off the pedestal and falling into the North Sea. One of the under lying causes of the incident was that the vessel needed to reposition several times for offloading and backloading as illustrated in Figure 8 below as in position 1, the vessel approached the installation starboard side but the operation could not be completed thus the vessel had to approach port side as in position 2 and even move forward as shown in position 3:

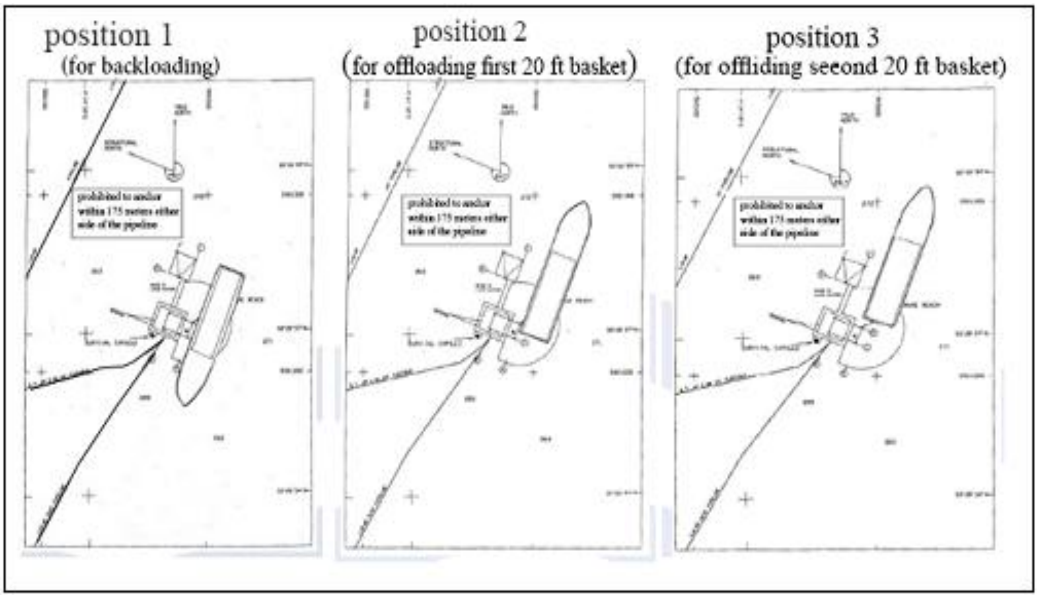


Figure 10: Vessel Changing Position to Allow Lifting Operation [12]

Other factors that may hinder the correct positioning of the vessel include mechanical failures that sometimes occur and lead to loss of position; such as, DP thruster failure, engine failure and clutch failure. Another very important factor is the weather. According to the NWEA Guidelines for the Safe Management of Offshore Supply and Rig Moving Operations, "Vessel Masters must pay special attention to weather conditions, sea state, movement and condition of vessel, and available free deck space to ensure transfer takes place in a safe controllable manner". Though crane operations are restricted during periods of bad weather, such as lightning, high winds or high seas, or when the Crane Operator's ability to see the signal person is impaired by darkness, fog, rain, etc, there are some other weather factors that also pose danger and do not restrict lifting operations as sea swell which can affect the vessels position. [11]

Positioning of personnel during lifting operations is another factor that must be considered when discussing "Positioning" as a root cause as many incidents occur because of the wrong positioning of the slinging or rigging crew as well as deck crew or signalers. According to Apache Offshore Crane Operation and Maintenance Program, "Loads shall not be moved over personnel"[12]; however, sometimes, personnel neglect such an important guideline resulting in fatal accidents in cases of dropped objects. As rigger, signalers and banksmen fail to comply with the rule by taking correct positions during lifting operations; they put themselves in maximum risk of being struck by loads, hooks or dropped objects. on August 16, 2011, on the offshore production platform, High Island A557 "A", operated by Energy Resource Technology GOM, Inc. At the time of the accident, personnel were using the platform crane to move a rental generator from the platform onto a motor vessel. When the load was lifted, the crane's boom hoist wire rope failed, the generator dropped to the deck and the boom fell striking the generator. As a result, one of the personnel handling a line was struck and fatally injured. [14]

Procedures Errors

There are many procedures that are involved in loading and backloading cargo operations. These procedures, which significantly highlight the human factor, include preparation of loads, inspection of slings, hooks and all securing gear, revising cargo plan and checking all equipment. Figure 7 above shows that years 2001-2002 witness the highest number of incidents amounting to 7 caused by procedures errors within the period 1998-2003. Procedures errors include:

- Bypassing incorrect manifest or invalid or expired certification
- Not protecting placards.
- Lack of communication between all parties involved (crane operator, rigging crew and vessel officers) especially during blind lifts.
- Carrying out operation if load weight is not marked or with load not secured properly.

Banking Errors

Offshore supply vessels usually carry three different types of cargo to be transported to offshore installations and these are: break bulk cargo, bulk cargo and containerized cargo. This is where crane operations become vital. However, accidents do sometimes happen because of the failure in preparing or following efficient cargo plans. Banking is one of operations that are necessary to maintain the application of a cargo plan. The analysis indicates that incidents during pickup are usually caused by a "pendulum swing effect" resulting from misalignment between the crane line and the transfer device. The dynamic motion of a vessel makes it difficult to ensure that a crane is centered directly over a load before making a lift. Off-centered lifts result in a pendulum motion, which can lead to collisions. [15]

As illustrated in Figure 7, banking caused 7 incidents in the years 1998/1999. Violation of safety guidelines in banking include:

- Backload space not given consideration.
- Vessel's cargo not properly secured.
- Operating with loads too close to each other or with no access to stacked loads.

These violations are already covered by guidelines provided by many associations and regulators such as the North Western European Area (NWEA) in their published "Guidelines for the Safe Management of Offshore Supply and

Anchor Handling Operations" and the UK Offshore Operators Association in their published "Guidelines for the Safe Management and Operation of Offshore Support Vessel". Nonetheless, failure to conform to these guidelines stems from human factors and low standard of inspection.

Slinging/Rigging Errors

Safety in crane operations is all about slinging/rigging; that is why slingers/riggers spend much time in training. The "Guidance for Packaging and Transportation of Cargo for U.S. Offshore Operations" issued by the International Association of Drilling Contractors States: "To promote safety of personnel and efficiency of cargo operations, all cargo should be pre-slung at the point of origin or prior to offshore transport.

Rigging should be designed so that personnel can hook/unhook cargoes from the deck, dock, rig or platform level without having to climb onto cargoes. Use of proper length slings will largely eliminate any need for personnel to climb or use ladders to hook / unhook cargo. Slings should be protected from damage during transport". [16]

Such Guidelines and others when applied efficiently could be sufficient to prevent incidents, but historical facts show that human errors occur and present a significant percentage of accident causes as presented in Figure 7. Some of the slinging/rigging errors are:

- Using defective slings.
- Lack of inspection of defective slings.
- Poor slinging practice.
- Not properly securing dangerous goods or loads with debris that may fall.
- Lack of awareness of new tools including hooks, slings, shackles, bulk hoses and other tools.

HUMAN ERRORS AND THE NEED FOR TRAINING

As derived from the description of the most common human factors leading to accidental events above, we can conclude that training plays an important role in mitigating the frequency of accidental events occurrence. Training is a continuous process that is not limited to the pre-certification phase; however, it should extend to all times. For the crew involved of this papers concern; i.e.: those onboard supply vessels during crane operations, training should be of practical nature and comprehensive covering all details related to execution of all scenarios.

Such training must be tested to ensure that the service is carried out in the best and safest possible manner. According to the **Operations Manual for Offshore Service Vessels Norwegian Continental Shelf** published by Norwegian Ship Owners' Association, "All training must be logged using training factors, participants, weather, sea and wind data, as well as information that is useful for the further development of the crew on board". [17]

Since the paper is only concerned with supply vessels aspects during crane operations, it is worth mentioning that this section about training will only be confined to deck crews training. In their training, deck crews are trained to manage, and, often, to control the lifting operations putting into consideration a number of variables involved such as: vessel motion, crane motion, and timing of lifts, sea and weather state. In an article published by Philip Strong, the managing director of Reflux Marine, he argued that 80% of all incidents could be avoided with better equipment and operational controls. [18]

Recommendations

- Training should be a continuous process and safety meetings should be conducted before operating on any job for the crew to explain the job and any associated risks. Moreover, crew must receive training for using newly introduced tools so as master their operation.
- Drills should take place and they must be recorded with all details in order to enhance future training.
- Verify that weather and sea conditions will permit safe crane operations. This shall be determined by all parties involved (Boat Captain, Riggers, Crane Operator or other personnel). STOP work authority can be exercised by anyone at any time.
- A complete cargo plan involving all loading and backloading processes on route of any voyage must be presented before sailing from port so as to avoid changing vessel position under platform cranes.
- The crane operator shall respond to signals only from the designated signal person(s), but shall obey any "STOP" signal from anyone whenever it is given. If a stop signal is given, crane operations shall cease until the appropriate designated signal person verifies that it is safe to resume operations.
- An official state authority should have the jurisdiction to inspect offshore supply vessels' certification, equipment, cargo plan, crew certification and all aspects ensuring safety.
- Further work can be done by comparing and contrasting the training standards of different renowned organizations and associations such as the Offshore Mechanical Handling Equipment Committee (OMHEC), the International Marine Contractors Association (IMCA), the Offshore Petroleum Industry Training Organization (OPITO) as well as others.

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